Remote sensing techniques and stable isotopes as phenotyping tools to assess wheat yield performance: effects of growing temperature and vernalization needs

F. Z. Rezzouk\textsuperscript{1}, N. Aparicio Gutiérrez\textsuperscript{2}, S.C. Kefauver\textsuperscript{1}, A. Gracia-Romero\textsuperscript{1}, M.D. Serret\textsuperscript{1}, J. L. Araus\textsuperscript{1}* 

\textsuperscript{1}Section of Plant Physiology, University of Barcelona, Barcelona and AGROTECNIO (Center of Research in Agrotechnology), Lleida, Spain

\textsuperscript{2}Agro-technological Institute of Castilla y León (ITACyL), Valladolid, Spain
Introduction: Phenotyping approaches

- Genetic gain
- Genetic variation
- Cycle time
- Selection intensity
- Field variability

On plots level

On individual plants level

Laboratory analysis
Objectives

Compare efficiency of different phenotyping approaches under contrasting temperature conditions (present and predicted in the future)

- Normal planting
- Late planting

Compare efficiency of different phenotyping approaches under different vernalization needs

- Winter genotypes
- Facultative genotypes
Germplasm

✓ 38 Wheat genotypes

Maintainance
✓ Irrigation
✓ Fertilizers
✓ Phytosanitary treatment

Field visits

Heading

Grain filling
Materials & methods: Remote sensing

Remote sensing techniques

Ground platform

Aerial platform

Canopy greenness
Light efficiency
Water status
Senescence
Pigments
1. Grinding dried samples

2. Weighing pulverized samples in tin capsules

3. EA-IRMS analysis

Stable isotopic composition and elemental analysis

δ^{13}C or δ^{15}N (‰) = \left[\frac{R_{\text{sample}}}{R_{\text{standard}}} - 1\right] \times 1000

Grain filling

Maturity

Universitat de Barcelona

II Simposio Español de Fisiología y Mejora de Cereales, 6-7 March 2019, Cordoba, Spain
Materials & methods: Field conditions

- **Average temperature (°C)**
  - Normal: (b)
  - Late: (a) +1.5°C

- **Growth cycle**
  - Normal: (a) -67 days
  - Late: (b)

---

II Simposio Español de Fisiología y Mejora de Cereales, 6-7 March 2019, Cordoba, Spain
Results: Yield components

Winter genotypes exhibited poor flowering behavior in the late planting as a result of lack of vernalization.
Results: Yield components

Days to heading

Winter: ↓28.29%
Facultative: ↓37.06%

Number of spikes

Winter: ↓22.51%
Facultative: ↓18.84%
### Results: Remote sensing indices

**RGB and Multispectral indices**

<table>
<thead>
<tr>
<th>Heading</th>
<th>RGB indices</th>
<th>Multispectral indices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hue&lt;sub&gt;gr&lt;/sub&gt;</td>
<td>a*&lt;sub&gt;gr&lt;/sub&gt;</td>
</tr>
<tr>
<td>Normal planting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>0.151</td>
<td>-0.033</td>
</tr>
<tr>
<td>Winter</td>
<td>0.211</td>
<td>-0.174</td>
</tr>
<tr>
<td>Facultative</td>
<td>0.352</td>
<td>0.041</td>
</tr>
<tr>
<td>Late planting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facultative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal planting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>0.610**</td>
<td>-0.616**</td>
</tr>
<tr>
<td>Winter</td>
<td>0.503*</td>
<td>0.477**</td>
</tr>
<tr>
<td>Facultative</td>
<td>0.595**</td>
<td>0.599**</td>
</tr>
<tr>
<td>Late planting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>0.103</td>
<td>0.023</td>
</tr>
<tr>
<td>Winter</td>
<td>0.275*</td>
<td>0.013</td>
</tr>
<tr>
<td>Facultative</td>
<td>0.409*</td>
<td>-0.377*</td>
</tr>
</tbody>
</table>
Canopy temperature

**Grain yield**

High temperature affects final yield

**δ¹³C_{grain}**

Plants transpire more

Results: Remote sensing indices
Results: Analytical traits

Effect stay green in leaves

Nitrogen partitioning in grains

N content
Lower carbon isotope composition is associated to higher grain yield.
In both planting dates, lower carbon isotope composition values are associated with better water status and higher grain yield.
Results: Stepwise multiple regression models

**RS assessed during heading**

- **Analytical traits**
- **All parameters**

**RS assessed during GF**

- **Analytical traits**
- **All parameters**
Elevated temperature decreased crop duration and affected negatively yield, particularly in the winter genotypes given their delayed and poor flowering.

RGB, thermal and multispectral vegetation indices are promising tools to assess crop performance, particularly in grain filling during which differences in stay green across genotypes are well evident.

Remote sensing techniques performed better in normal planting than late planting.

Carbon isotope composition and nitrogen content performed well regardless of planting dates.

Combination of remote sensing indices and analytical traits improved grain yield prediction for both planting dates.
Acknowledgments

Integrative Ecophysiology group members

José Luís Araus Ortega
M. Dolors Serret Molins
Rut Sanchez Bragado
Adrian Gracia-Romero
Omar Vergara Díaz
Fadia Chairi
José A. Fernandez Gallego
Ma. Luisa Buchaillet
Shawn C. Kefauver
Melissa Chang
Jordi Bort
Thomas Vatter
Ruben Vicente
Thank you very much