Monitoring maize N status with airborne and ground level sensors

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Outline

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   - Maize N dynamic
   - Available N sensors

II. Experimental setup

III. Results:
   - Fertiliser rate vs. N uptake
   - Remote sensor predicting N content
   - Scale resolution effect

IV. Conclusions

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I. Maize N dynamic

Maize yield:
- vs. crop N uptake
- vs. N applied as fertilizer

\[ y = 0.0497x - 0.349 \]
\[ R^2 = 0.93 \]

\[ N \text{ applied} \leq 160: \quad \text{Yield} = 5.12 + 0.045 \text{ N applied} \]
\[ N \text{ applied} > 160: \quad \text{Yield} = 12.32 \]
\[ R^2 = 0.96 \]

From: Quemada et al. 2014. Remote Sensing 6, 2940-2962
I. Maize N dynamic


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I. Available N sensors

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II. Experimental setup

Field Station “La Chimenea”
Zone: Tajo river basin
Climatic conditions:
- Mediterranean semiarid
- Monoxeric with 4 dry months (June to September)
- Average annual temperatures:
  - 20.5 ºC maximum
  - 14 ºC mean
  - 6.5 ºC minimum
- Average annual rainfall: 350 mm
- ETo 753 mm

Classification

Typic calcixerept (Soil Survey Staff, 2003)
Haplic calcisol (FAO-UNESCO, 1988)

- Silty clay loam texture  pH≈8  OM≈2%
- Polygenic origin soil appropriate for irrigation
- Friable structure and porous along the profile
- Without erosion, compaction, inundation, and with low stone content throughout the profile
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II. Experimental setup
# II. Experimental setup

## Index Definition

<table>
<thead>
<tr>
<th>Index</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPAD</strong></td>
<td>Ratio of transmitted light at the red and infrared wavelengths</td>
</tr>
<tr>
<td><strong>Dualex® Scientific</strong></td>
<td></td>
</tr>
<tr>
<td>Chl</td>
<td>Ratio of transmitted light at two infrared wavelengths</td>
</tr>
<tr>
<td>Flav</td>
<td>Log of the fluorescence emission ratio at the red and UV wavelengths</td>
</tr>
<tr>
<td>NBI</td>
<td>Nitrogen Balance Index = Chl / FlavI</td>
</tr>
</tbody>
</table>

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## II. Experimental setup

<table>
<thead>
<tr>
<th>Index</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normalized difference vegetation index (NDVI)</strong></td>
<td>$NDVI = \frac{(R_{800} - R_{670})}{(R_{800} + R_{670})}$</td>
</tr>
<tr>
<td><strong>Renormalized difference vegetation index (RDVI)</strong></td>
<td>$RDVI = \frac{(R_{800} - R_{670})}{(R_{800} + R_{670})^{0.5}}$</td>
</tr>
<tr>
<td><strong>Optimized soil-adjusted vegetation index (OSAVI)</strong></td>
<td>$OSAVI = (1 + 0.16) \times \frac{(R_{800} - R_{670})}{(R_{800} + R_{670} + 0.16)}$</td>
</tr>
<tr>
<td><strong>Red edge reflectance index (DCNI)</strong></td>
<td>$DCNI = \frac{R_{750}/R_{710}}{(R_{720} - R_{700})/(R_{700} - R_{670})/(R_{720} - R_{760} + 0.16)}$</td>
</tr>
<tr>
<td><strong>Transformed Chlorophyll absorption in reflectance index (TCARI)</strong></td>
<td>$TCARI = 3 \left[ \frac{(R_{700} - R_{670})}{R_{700} - R_{550}} \right] - 0.2 \left( \frac{R_{700} - R_{550}}{R_{700}/R_{670}} \right)$</td>
</tr>
<tr>
<td><strong>Combined TCARI/OSAVI</strong></td>
<td>$TCARI/OSAVI$</td>
</tr>
<tr>
<td><strong>Photochemical reflectance index (PRI)</strong></td>
<td>$PRI = \frac{(R_{570} - R_{539})}{(R_{570} + R_{539})}$</td>
</tr>
<tr>
<td><strong>Normalized photochemical reflectance Index (PRI norm)</strong></td>
<td>$PRI \ norm = \frac{(R_{515} - R_{531})}{(R_{515} + R_{531})}$</td>
</tr>
<tr>
<td><strong>Blue/green/red ratio indices</strong></td>
<td></td>
</tr>
<tr>
<td>$BGI_1$</td>
<td>$BGI_1 = \frac{R_{400}}{R_{550}}$</td>
</tr>
<tr>
<td>$BGI_2$</td>
<td>$BGI_2 = \frac{R_{450}}{R_{550}}$</td>
</tr>
<tr>
<td><strong>Fluorescence retrieval</strong></td>
<td>$FLD3$ method using 2 reference bands (750; 762; 780)</td>
</tr>
</tbody>
</table>

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III. Fertiliser rate vs. N uptake


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III. Remote sensor predicting N content


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III. Scale resolution effect


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• Proximal and airborne sensors provided useful information for the assessment of maize N nutritional status.

• Higher accuracy was obtained with indexes combining chlorophyll estimation with canopy structure (i.e. TCARI/OSAVI for airborne sensors) or with polyphenol indexes (NBI for proximal sensors, avoiding index saturation).

• The spatial resolution (SR) of the acquired image had an effect on the indexes performance: Structural indexes (NDVI, RDVI or OSAVI) presented low dependency of image SR, whereas pigment indexes (as TCARI) were highly influenced by SR because of the background and shadow effect.

• Further research is needed to identify robust indexes across species and stress levels related to plant N concentration for better monitoring crop N nutritional status.
Thank you for your attention
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