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Leaf position dependent hyperspectral responses to drought in wheat

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Abstract

Understanding how drought alters plant physiological functioning across canopy positions is critical for improving phenotyping of drought resilience in wheat. Most spectral studies focus either on the flag leaf or on the canopy, assuming uniform responses and overlooking informative variation associated with leaf age and microclimate variation. This study tested the hypothesis that integrating spectral measurements from two canopy positions, flag leaf (FL) and bottom sixth leaf (BL; counting from the top), provides additional insight into drought responses not captured by flag leaf measurements alone.

Twenty-four wheat genotypes from CIMMYT's Best Physiological Traits panel were evaluated under irrigation and drought conditions during the 2023–2024 growing season. Spectral reflectance (400–2500 nm) was measured during grain filling using an ASD FieldSpec hyperspectral spectroradiometer. A series of indices was derived, representing chlorophyll content and canopy greenness, pigment composition and senescence, photosynthetic efficiency, canopy water status, and structural and biochemical traits.

Drought reduced grain yield by 53.8 % ($p < 0.001$) and significantly increased reflectance across all regions of the spectrum, indicating reduced pigment content and water status compared to irrigated plants. Under irrigation BLs showed higher reflectance than FLs, particularly in the visible range (400–700 nm). However, under drought, reflectance of FL and BL in the visible range could not be distinguished, indicating that the drought induced pigment degradation was much faster in FL than in BL.

After a two-way ANOVA (leaf position × environment), 77 of the 100 reflectance indices showed significant responses, mainly those related to chlorophyll pigments, vegetation greenness, water status, and epicuticular waxes were identified. Twenty-two were significant only in BLs and 55 only in FLs.

Spectral responses in wheat were leaf-position dependent. While the flag leaf is widely reported to be associated with yield formation, bottom leaves can also provide valuable information on drought response in wheat, as around 40 % of indices were statistically significant. These results suggest that leaf-position-specific spectral information can provide additional insight into the characterisation of drought responses in wheat.

Keywords: Canopy physiology, drought, leaf responses, physiological indices, spectral phenotyping, wheat

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