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Extending physiological screening beyond the flag leaf: A canopy-wide approach to Wheat resilience under contrasting field conditions

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ABSTRACT

Understanding wheat's response to drought requires more than focusing on the flag leaf. In this study, 72 elite genotypes were assessed under irrigated and drought field conditions in Obregón, Mexico, using high-resolution phenotyping tools to quantify physiological responses across the full canopy including flag, second, and third leaves. Parameters such as SPAD chlorophyll content, PRI, quantum yield, stomatal conductance, light interception, and pigment-specific spectral indices were measured, alongside soil moisture profiles. Results revealed distinctive patterns in each canopy layer, with lower leaves playing a supplementary yet measurable role in maintaining canopy function under stress. This study highlights the need for integrating full-canopy physiological evaluations into breeding strategies for climate resilience.

KEY WORDS: *Wheat*; *Drought resilience*; *Canopy physiology*; *SPAD*; *PRI*

1. Introduction

Breeding drought-resilient wheat genotypes has traditionally emphasized top canopy leaves, particularly the flag leaf, as the dominant source of assimilates for grain filling (Araus & Cairns, 2014). However, under stress conditions where leaf senescence or accelerated resource reallocation may occur the middle and lower leaves can contribute to biomass production and sink strength maintenance (Zhou *et al.*, 2016). Despite this potential, phenotyping methodologies rarely include full-canopy evaluations, and the roles of second and third leaves remain poorly characterized.

Here, we present physiological and spectral data from a comprehensive field experiment assessing wheat genotype × environment interactions across the canopy using a diverse set of phenotyping tools. Our objective was to quantify variations in photosynthetic performance, pigment composition, and soil-coupled moisture dynamics to better understand whole-canopy contributions to stress adaptation (Mathangi *et al.*, 2024).

2. Materials and Methods

The experiment was conducted during the 2023–2024 wheat season at CIMMYT's experimental station in Ciudad Obregón, Sonora, Mexico. A total of 72 elite bread wheat genotypes were evaluated under two conditions; full irrigation throughout crop development and in drought

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single irrigation at sowing; no further watering (Mathangi *et al.*, 2024). Data were collected at booting, heading, and grain-filling stages using the following instruments:

SPAD 502 Plus: chlorophyll content (flag, second, and third leaves)
PlantPen PRI: photochemical reflectance index (PRI)
LI-600 Porometer: stomatal conductance, transpiration, and PSII efficiency
ASD FieldSpec Spectroradiometer: spectral reflectance for pigment analysis
AccuPAR LP-80: light interception across the canopy
Delta-T PR2 Probe: soil moisture at various depths

Measurements were repeated weekly. Leaf-level traits were analyzed in relation to genotype performance, environment, and canopy position.

3. Result

Canopy Layer Differentiation:

Flag leaves consistently showed higher SPAD values, stomatal conductance, and quantum yield under both environments. However, second and third leaves retained physiological function longer than expected, particularly under drought conditions, indicating that their photosynthetic contributions may become proportionally more important under stress.

Spectral Pigment Profiles:

Spectroradiometric data revealed genotype-specific variation in pigment absorption across the 400–700 nm range. Red edge shifts and reflectance ratios correlated with SPAD and PRI values, providing a robust proxy for real-time pigment content and photosynthetic dynamics.

Soil-Plant Interaction:

Soil moisture measurements confirmed rapid depletion in the upper 60 cm under drought plots. Yet, stomatal conductance readings indicated that some genotypes sustained physiological activity, suggesting deeper rooting or delayed stress response. Canopy temperature and light interception patterns further supported these findings.

Stage-Specific Trends:

While all leaves showed declining conductance and transpiration towards physiological maturity, chlorophyll indices (SPAD, PRI) increased slightly over time possibly reflecting stress-induced pigment adjustments or lower leaf senescence lag (Mathangi *et al.*, 2024b).

4. Conclusion

This study presents strong evidence that evaluating only the flag leaf under represents the physiological complexity of wheat under stress. A canopy-wide approach reveals nuanced genotype × environment interactions, with potential implications for selecting traits like pigment stability, quantum yield efficiency, and soil-coupled transpiration strategies. Breeding programs aiming at drought resilience must expand trait screening across canopy layers to capture the full range of plant adaptation.

4. References

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