Tropentag, September 10-12, 2025, hybrid conference

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Potential of hyperspectral sensing for rapid screening of spring wheat exposed to drought stress

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Abstract

There has been an increasing frequency and severity of drought events in recent years, making wheat production more challenging. Given this, there is a stronger need for rapid screening tools for the identification of drought-resilient wheat genotypes. Here, we evaluated the pigment profiles of nine spring wheat genotypes exposed to drought stress under field conditions at the CIMMYT Obregon experimental site for two growing seasons (2022/2023 and 2023/2024) under drought (DT) and well-watered (WW) conditions. The DT treatment was irrigated at sowing, 50 % emergency, and before initiation of booting, whereas the WW treatment was irrigated at sowing, 50 % emergency, and every fourteen days until late grain filling. Measurements for spectral reflectance indices (SRIs) were carried out at the heading and grain-filling stages on the flag leaf. Representative leaf samples were taken after the measurement for the laboratory profiling of chlorophylls and carotenoids. The pigments were profiled using high-performance liquid chromatography (HPLC), while indices were derived from the Field Spectroradiometer (ASD).

The results on laboratory pigment profiling showed a significant effect of genotype (G), environment (E), growth stage (GS), G × E, and E × GS on chlorophyll a/b ratio and total chlorophylls. For the carotenoids, differences were detected only due to the environmental effect, growth stage, G × E, and E × GS, except for zeaxanthin (ZE), for which the effect of G($p < 0.0002$), E($p < 0.02$), G X E($p < 0.03$), and E × GS($p < 0.001$). We found that SRIs (MCARI, PRI, PSRI, ARI) as proxies for leaf pigment profile from the chlorophylls, carotenoids, and xanthophylls showed positive correlation with the laboratory measurement of the pigments, while SRPI showed negative correlation with all the carotenoids. We have also found that the SRI's were able to detect changes across growth stages as reflected in the laboratory measurements.

Overall, our results indicate that SRIs are capable of differentiating wheat genotypes and their differential response to drought stress. Moreover, several SRIs such as (ARI, PRI, PSRI, SRPI, MCARI, SR1) could be validated as effective proxies for leaf pigment composition, making them reliable non-destructive phenotyping indices for screening wheat under drought conditions.

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Keywords: Abiotic stress, pigments, Spectral Reflectance Indices (SRI), xanthophyll cycle.