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

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Introduction

- Drought frequency and severity have increased in recent years, challenging worldwide wheat production.
- Identification of wheat genotypes that are resilient to drought conditions is critical for ensuring wheat production.
- Photo protective pigments play a crucial role in plants response to drought stress by protecting the photosynthetic apparatus and preventing the oxidative damage.
- However, pigment analysis is time consuming and labour demanding. Therefore, we are testing the use of spectral reflectance indices as non-destructive methods for assessing plant pigment composition.

Conclusions

- SRIs were well correlated to actual leaf pigment composition detected by HPLC analysis.
- SRIs are capable of differentiating wheat genotypes and their differential response to drought stress.
- PRI, PSRI, SRPI, and NDVI1 could be validated as effective proxies for leaf pigment composition, making them reliable non-destructive phenotyping indices for screening wheat under drought conditions.

Results and Discussion

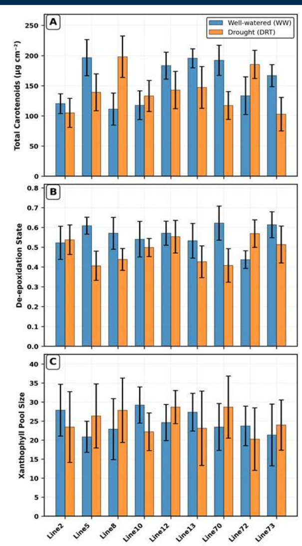

Figure 1: The total carotenoids (A), the de-epoxidation state (B), and xanthophyll pool size in wheat under DRT and WW conditions.

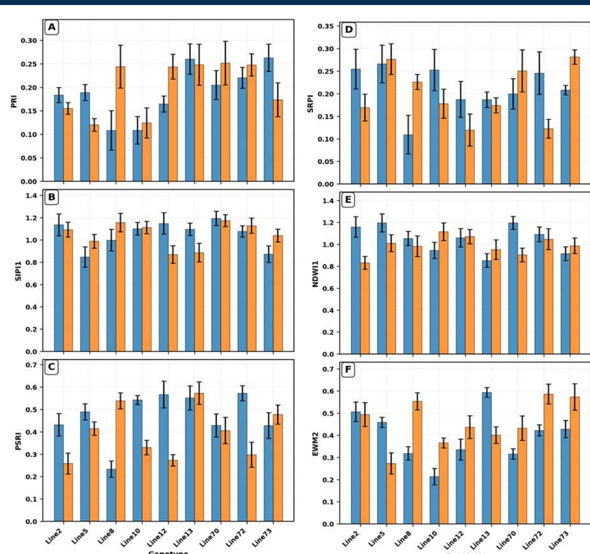

Figure 2: Changes in spectral reflectance indices, under well-watered and drought conditions, (A) PRI, (B) SIPI1, (C) PSRI, (D) SRPI, (F) DWI1, (F) EWM2

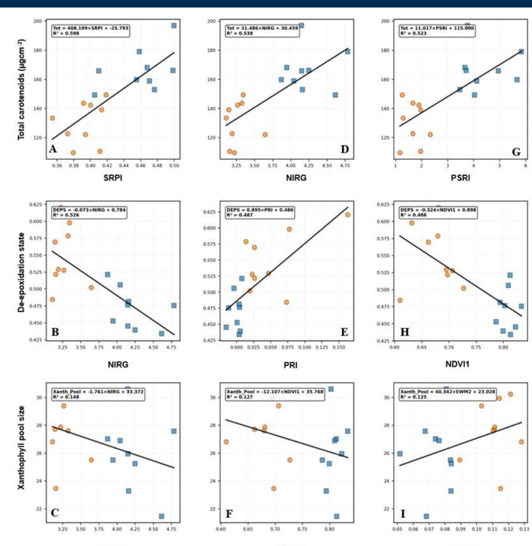

Fig 3: Linear regression analysis between the total carotenoids, de-epoxidation state, and xanthophyll pool size, (A) SRPI, (B) NIRG, (C) PSRI, (D) NIRG, (E) PRI, (F) NDVI1, (G) NIRG, (H) NDVI1, and (I) EWM2 B) and Anthocyanin Ratio Index (C, D) at the heading and grain filling stages under DRT and WW conditions.

- The results of laboratory pigment profiling revealed significant effects of genotype (G), environment (E), G × E, for the chlorophyll a/b ratio and total chlorophylls.
- Higher total carotenoids, de-epoxidation state and xanthophyll cycle pigments were found under DRT compared to WW.

- Contrary to typical patterns where PRI, SRPI, and PSRI increase under DRT due to accelerated chlorophyll degradation, our results showed lower values of these indices in DRT compared to WW.
- SIPI1 recorded higher values in DRT than WW, indicating higher carotenoid levels comparable to chlorophyll associated with stress, senescence, or photoprotection.

- SRRI, NIRG. and PSRI, positively correlated with the total carotenoids, suggesting carotenoids increase with increasing SRIs.
- PRI had a positive relationship with DEPS, implying that increasing PRI values corresponded to increased DEPS. An indication is that PRI is a good proxy for photoprotection under drought.
- However, NIRG and NDVI1 had a negative association with the xanthophyll pool size.

Materials and Methods

Step 1: Experimental setup

Field Spec 4 Hi-Resolution, portable spectroradiometer

Step 2: Spectral data acquisition

Spectral indices related to PRI, ARI, PSRI, SRPI, and MCARI were estimated.

Step 3: Spectral data processing

$$PRI = \left(\frac{R531 - R570}{R531 + R570}\right)$$

$$PSRI = \left(\frac{R680 - 500}{R750}\right)$$

$$SRPI = \left(\frac{R430}{R680}\right)$$

Step 4: HPLC pigment analysis