Combining Solar-Induced Chlorophyll Fluorescence (SIF) with Functional Phenotyping Systems: Assessing Limitations in Estimating Photosynthesis Under Stress

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October 30, 2023

Abstract

High-throughput measurements of photosynthesis across various cultivars/genomes and environmental conditions are crucial for understanding plant photosynthetic adaptability. Advanced remote sensing techniques, such as solar-induced chlorophyll fluorescence (SIF), facilitate field-based, high-throughput photosynthesis assessments. Our research explored whether combining SIF measurements with whole-plant water relation data during standardized drought experiments could effectively quantify photosynthetic activity and early-stage water stress detection. We employed the functional-phenotyping PlantArray system for controlled drought treatment and simultaneous monitoring of growth and water balance in 72 tomato plants from four different introgression lines (ILs).

We introduced a SIF-derived index, electron transport rate (RS-ETRi), and found it negatively correlated with whole-plant stomatal conductance (Gsc) under normal conditions, and positively during drought. Surprisingly, no substantial links were found between SIF and either plant biomass or Gsc. Among various vegetation indices (VIs), SIF 687 was the earliest drought indicator but presented detection challenges due to its weak signal. Interestingly, while SIF parameters failed to differentiate between ILs, significant differences were observed through gravimetric water-relation measurements.

Our findings suggest that while SIF is a valuable tool in photosynthesis studies, its correlation with photosynthetic activity is complex. Thus, using SIF alone to quantify photosynthetic activity might be an oversimplification. We concluded that SIF does not offer advantages over traditional methods in detecting physiological variations among ILs, highlighting the complexity and limitations of SIF in plant physiological research.

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Keywords: SIF, Whole-canopy stomatal conductance, Photosynthesis, Functional phenotyping, High-throughput, Plant water relations, Drought stress