MODELING OF DELAYED FLUORESCENCE FROM PHOTOSYSTEM II AND APPLICATIONS IN ASSESSMENT OF DROUGHT AND CHEMICAL STRESSES

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ABSTRACT

Photosynthesis is not only vital for plant growth and survival but also indicative of plant-environment interactions. This research was designed to analyze photoelectron kinetics and its dependence on environmental factors. The project included three parts.

In Part I, two models were developed for the photoelectron transport process in the early stage of photosystem II (PSII) with delayed fluorescence (DF) as a measurable output. The two models could effectively predict DF emission and the estimated parameters correctly reflected the expected changes induced by drought and chemical stresses.

In Part II, techniques were developed to overcome difficulties in biological system identification. The identifiability of linear time-invariant systems with only initial condition responses was analyzed for systems with only one measurable state and n measurable states. A non-iterative algorithm was developed to determine the system matrix from initial condition responses. A recurrent-pulse excitation method was devised to achieve perturbation richness by executing simple pulses, which allowed determination of model parameters that would otherwise be difficult to determine uniquely. Plant circadian effects on DF emission were investigated, which provided a way to minimize circadian effect on drought stress measurement.

In Part III, methodologies were developed to evaluate drought and DCMU stresses. DF dependence on the availability of electron donors (water) was modeled and analyzed. This yielded an effective way to define and measure drought stress. Both theoretical analysis and experimental results showed that long-term DF emission following an excitation pulse was proportional to reaction centers without DCMU binding, which resulted in an effective plant-based technique for measuring DCMU concentrations.