Can SIF and NPQ be used in the photosynthesis rate simulation of plants subjected to drought?

Shaomin Shi[1], Sen Lu[1], Tianhong Zhao[2], Weiwei Cong[2], Feng Wang[3], and Qi Lu[3]

[1]Chinese Academy of Forestry Research Institute of Forestry
[2]Shenyang Agricultural University
[3]Chinese Academy of Forestry

July 20, 2022

Abstract

Solar-induced chlorophyll fluorescence (SIF) has been used to estimate leaf-level net CO_2 assimilation by a mechanistic light reaction (MLR-SIF) equation. However, the application of this model would be limited by the challenging measurement and estimation of input parameters (e.g. fraction of open PSII reaction centres, q_L). We modified the MLR-SIF model by replacing q_L by the easily obtained parameters (non-photochemical quenching [NPQ]) to facilitate its application. We employed synchronous measurements of gas exchanges, ChlF parameters and SIF for *Leymus chinensis*, *Populus tomentosa* Carrières and *Ulmus pumila* var. *sabulosa* under the soil–water deficit and rehydration process to test the robustness of the modified MLR-SIF model. Our results demonstrated that for *L. chinensis* the net photosynthesis rate dynamics under severe soil–water stress and saturated water condition were effectively captured by the modified MLR-SIF model ($R^2 = 0.75$–0.92, $RMSE = 1.11$–3.56) . For *P. tomentosa* Carrières and *U. pumila* var. *sabulosa*, the net photosynthesis rates were predicted by the modified MLR-SIF model with good accuracy ($R^2 = 0.86$, $RMSE = 9.44$; $R^2 = 0.88$, $RMSE = 4.16$) across the water deficit and rehydration condition . However, the electron transport rate estimated by the modified MLR-SIF model uncoupled with the photosynthetic capacity ($r^2 = -0.13$) and lowered the net photosynthesis rate simulation precision ($R^2 = 0.35$, $RMSE = 3.41$) for *L. chinensis* under mild drought stress and saturated light intensities. The electron transport rate estimated by the modified MLR-SIF model downregulated the photosynthetic capacity for *P. tomentosa* Carrières ($r^2 = 0.32$) and *U. pumila* var. *sabulosa* ($r^2 = 0.22$) under mild drought stress. The shift of the Rubisco and RUBP limited state cross-points, the dynamic photosynthesis parameters across the plant species and the alternative electron sinks under soil–water deficit and rehydration process influenced the simulation precision of the modified MLR-SIF model. Our modified MLR-SIF model provided a basis for understanding and inferring the photosynthetic rate by SIF and NPQ under water stress.

Hosted file

`SIF paper R20220613.docx` available at https://authorea.com/users/496414/articles/577794-can-sif-and-npq-be-used-in-the-photosynthesis-rate-simulation-of-plants-subjected-to-drought