ON THE CONTRIBUTION OF PHOTOSYSTEM I TO CHLOROPHYLL FLUORESCENCE IN INTACT LEAVES AT ROOM TEMPERATURE AND ITS IMPACT ON THE DETERMINATION OF PHOTOSYSTEM II EFFICIENCY

Fabrice FRANCK[1], Philippe JUNEAU[2] and Radovan POPOVIC[2]

[1]Laboratory of Photobiology, B22, University of Liège, B-4000 Liège, Belgium
[2]Laboratory of Environmental Toxicology, UQAM, H3C3P8 Montréal, Canada

Variable chlorophyll fluorescence is extensively used as an indicator of the photosynthetic activity of plant leaves in various conditions (1). It is generally assumed for simplicity that most of the fluorescence is emitted by PSII. At the start of illumination, the fluorescence rise from a low level F_0 to a maximum F_M reflects the increase of fluorescence quantum yield of PSII chlorophylls due to the closure of the reaction centers. The relative variable fluorescence $F_{V,rel} = (F_M-F_0)/F_M$ is frequently taken as an indirect measurement of the PSII quantum efficiency (1). It is known since early studies, however, that the fluorescence emitted at room temperature has a complex wavelength dependence, which probably reflects the contribution of both PSI and PSII: two broad emission bands occur around 685 nm and 740 nm, and shoulders are observed around 705 and 720 nm (2). Therefore, $F_{V,rel}$ only approximates PSII quantum efficiency. This study was carried out in order to evaluate the wavelength dependence and relative contributions of PSI and PSII to room temperature chlorophyll fluorescence, and the resulting effects on PSII efficiency determination.

We investigated the wavelength dependency of $F_{V,rel}$ by measuring F_0 and F_M spectra of barley leaves with a sensitive diode array system using blue excitation light. The F_0 and F_M spectra showed the same maximum position at 684 nm. The long-wavelength emission band around 735 nm was relatively higher in F_0 than in F_M. Shoulders at 705 and 720 nm were clearly visible in the F_0 spectrum, but were attenuated in F_M. $F_{V,rel}$ varied between 0.69 and 0.81 depending on wavelength, with maxima at 684 nm and 745 nm and a minimum at 720 nm. These variations of $F_{V,rel}$ were due to PSI/PSII heterogeneity of the fluorescence emission, since they were not observed in isolated PSII particles. To interprete the results, we used a model which considers two components in the fluorescence emission : one constant PSI component (FI_0), and one variable PSII component (FII_0 to $FII_0.k$). For any emission wavelength, one can write:

$F_0 = FI_0 + FII_0$ and $F_M = FI_0 + FII_0.k$, k being equal to $1/(1-\phi_{PSII})$ where ϕ_{PSII} is the PSII quantum efficiency. A reference PSI emission spectrum was obtained by exciting the same samples with 700 nm light. It was used in combination with the above equations to estimate FI_0 ,FII_0 and ϕ_{PSII}. The resulting FI_0 spectrum had a main band at 722 nm and shoulders at 683 and 705 nm. The FII_0 spectrum had a main band at 684 nm and a vibrational band at 738 nm. The integrated contribution of PSI to the fluorescence signal at F_0 was 29.3 ± 2.7 %. The value of ϕ_{PSII} was 0.84 ± 0.07. PSI fluorescence caused a 10 to 15% error on PSII efficiency estimated as $F_{V,rel}$, depending on the detection wavelength.

References

1. Dau H (1994) Photochem. Photobiol. 60: 1-23
2. Lavorel J (1962) Biochim. Biophys. Acta 60: 510-523