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1. Introduction

Chlorophyll (Chl) fluorescence is a tool which is widely used to examine photosynthetic performance in algae and plants. It is a non-invasive analysis that permits to assess photosynthetic performance in vivo (Baker, 2008; Baker & Rosenqvist, 2004; Chaerle & Van Der Straeten, 2001; Woo et al. 2008). Chl fluorescence analysis is widely used to estimate photosystem II (PSII) activity, which is an important target of abiotic stresses (Balachandran et al., 1994; Baker et al., 1983; Briantais et al., 1996; Calatayud et al., 2008; Chaerle & Van Der Straeten, 2000; Ehlert & Hincha, 2008; Gilmore & Govindjee, 1999; Guidi et al., 2007; Guidi & Degl’Innocenti, 2008; Hogewoning & Harbinson, 2007; Krause, 1988; Lichtenthaler et al., 2007; Massacci et al., 2008; Osmond et al., 1999; Scholes & Rolfe, 1996; Strand & Oquist, 1985).

It is known that the energy absorbed by Chl molecules must be dissipated into three mechanisms, namely internal conversion, fluorescence and photochemistry (Butler, 1978). All of these downward processes competitively contribute to the decay of the Chl excited state and, consequently, an increase in the rate of one of these processes would increase its share of the decay process and lower the fluorescence yield. Typically, all processes that lower the Chl fluorescence yield are defined with the term quenching.

Kaustky and co-workers (1960) were the first which observed changes in yield of Chl fluorescence. These researchers found that transferring a leaf from the dark into the light, an increase in Chl fluorescence yield occurred. This increase has been explained with the reduction of electron acceptors of the PSII and, in particular, plastoquinone Q$_A$: once PSII light harvesting system (LCHII) absorbs light and the charge separation occurs, Q$_A$ accepts electron and it is not able to accept another electron until it has been passed the first one onto the subsequent carrier, namely plastoquinone Q$_B$. During this time the reaction centers are said to be closed. The presence of closed reaction centers determines a reduction in the efficiency of PSII photochemistry and, consequently, an increase in the Chl fluorescence yield.

Transferring the leaf from the dark into light, PSII reaction centers are progressively closed, but, following this time, Chl fluorescence level typically decreases again and this phenomenon is due to two types of quenching mechanisms. The presence of light induced the activation of enzymes involved in CO$_2$ assimilation and the stomatal aperture that determines that electrons are transferred away PSII. This induced the so-called photochemical quenching, q$_P$. At the same time, there is an increase in the conversion of light energy into
heat related to the non-photochemical quenching, q_{NP}. This non-photochemical quenching q_{NP} can be divided into three components. The major and most rapid component in algae and plants is the pH- or energy-dependent component, q_{E}. A second component, q_{T}, relaxes within minutes and is due to the phenomenon of state transition, the uncoupling of LHCIIIs from PSII. The third component of q_{NP} shows the slowest relaxation and is the least defined. It is related to photoinhibition of photosynthesis and is therefore called q_{I}.

To evaluate Chl fluorescence quenching coefficients during illumination we must determine minimal and maximal fluorescence yields after dark adaptation, F_{0} and F_{m} respectively. This is important because these values serve as references for the evaluation of the photochemical and non-photochemical quenching coefficients in an illuminated leaf by using the saturation pulse method. The concept on the basis of this method is extremely simple: at any give state of illumination, Q_{A} can be fully reduced by a saturation pulse of light, such that photochemical quenching is completely suppressed. During the saturation pulse, a maximal fluorescence F_{m}' is achieved which generally shows value lower that the dark reference values (F_{m}). With the assumption that non-photochemical quenching does not change during a short saturation pulse, the reduction of F_{m} is a measure of non-photochemical quenching.

In Figure 1 the calculation of Chl fluorescence parameters by using the saturation pulse method is reported. The photochemical quenching coefficient q_{P} is measured as

$$q_{P} = \frac{(F_{m}' - F_{0}')}{(F_{m}' - F_{t})}$$

where F_{m}' is the maximum Chl fluorescence yield in light conditions, F_{t} is the steady-state Chl fluorescence immediately prior to the flash. For determination of F_{0}' in the light state, the leaf has to be transiently darkened and it has to be assured that Q_{A} is quickly and fully oxidized, before there is a substantial relaxation of non-photochemical quenching. In order to enhance of oxidation of the intersystem electron transport chain, far-red light is applied that selectively excited PSI. Usually the alternative expression of this quenching coefficient is used and it is (1- q_{P}), i.e. the proportion of centers that are closed and it is termed excitation pressure on PSII (Maxwell & Johnson, 2000).

An other useful fluorescence parameter derived from saturation pulse method is the efficiency of PSII photochemistry, which is calculated as:

$$\Phi_{PSII} = \frac{(F_{m}' - F_{t})}{F_{m}'}$$

This parameter has also termed ΔF/F_{m} or, in fluorescence imaging technique, F_{q}'/F_{m}' and it is very similar to the q_{P} coefficient even if its significance is somewhat different. The Φ_{PSII} is the proportion of absorbed light energy being used in photochemistry, whilst q_{P} gives an indication of the proportion of the PSII reaction centers that are open. A parameter strictly related with both q_{P} and Φ_{PSII} is the ratio F_{t}/F_{m} determined as:

$$F_{t}/F_{m} = \frac{(F_{m} - F_{0})}{F_{m}}$$

This third parameter is determined in dark adapted leaves and it is a measure of the maximum efficiency of PSII when all centers are open. This ratio is a sensitive indicator of plant photosynthetic performance because of it has an optimal values of about 0.83 in leaves of healthy plants of most species (Bjorkman & Demmig, 1987). An other useful parameter which describes energy dissipation is F_{q}'/F_{m}', an estimate of the PSII quantum efficiency if all PSII reaction centers are in the open state. It is calculated as reported in equation 4:
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World population is growing at an alarming rate and is anticipated to reach about six billion by the end of year 2050. On the other hand, agricultural productivity is not increasing at a required rate to keep up with the food demand. The reasons for this are water shortages, depleting soil fertility and mainly various abiotic stresses. The fast pace at which developments and novel findings that are recently taking place in the cutting edge areas of molecular biology and basic genetics, have reinforced and augmented the efficiency of science outputs in dealing with plant abiotic stresses. In depth understanding of the stresses and their effects on plants is of paramount importance to evolve effective strategies to counter them. This book is broadly dived into sections on the stresses, their mechanisms and tolerance, genetics and adaptation, and focuses on the mechanic aspects in addition to touching some adaptation features. The chief objective of the book hence is to deliver state of the art information for comprehending the nature of abiotic stress in plants. We attempted here to present a judicious mixture of outlooks in order to interest workers in all areas of plant sciences.

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