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EDITORIAL TO:

"A CHALLENGE FOR THE ANALYSIS OF ENVIRONMENTAL STRESS: THE MEASUREMENT OF CHLOROPHYLL *a* FLUORESCENCE (ChlF) FROM PLANTS TO ECOSYSTEMS"

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Climate changes are expected to increase the conditions of aridity in many regions of the world and, therefore, water and heat stress events that affect natural vegetation and cultivated plants (Manes & Blasi, 1995; Hoerling et al., 2001; IPCC, 2013; Diffenbaugh & Field, 2013; Mariotti et al., 2015). The EU Biodiversity Strategy to 2020 promotes also the recovery of degraded ecosystems, in order to improve their Ecosystem Services (ES) provision. It is known that Ecosystem Services are closely related to the ecosystems health, therefore it is crucial to evaluate the occurrence of stress phenomena on vegetation.

In this context, the application of non invasive, non destructive techniques for field studies and laboratory instrumental analyses is needed, in order to monitor the occurrence of stress conditions that could reduce the functional performance of species in the ecosystems, thus causing a reduction of their ES provision. At this regard, the measurement of Chlorophyll "a" Fluorescence (ChlF) represents a relatively fast and low-cost approach, that can be easily applied *in vivo* both under controlled conditions and in natural environments, allowing the detection of the stress effects on intact leaves/plants before the appearance of any visible sign of injury (Oukkarroum & Strasser, 2004; Salvatori et al., 2014; Gottardini et al., 2014). For this reason, it is extensively used in plant physiology researches, both to study the mechanism of light harvesting and electron transport between and beyond the two photosystems (photosystem II, PSII and photosystem I, PSI) and in applied studies to assess the mechanisms and effects of biotic and abiotic stresses on the photosyntetic efficiency and performances of plants (Papageorgiou and Govindjee, 2004). Furthermore, ChlF is a useful tool for experimental research in ecophysiology, agriculture, forestry and arboriculture (for reviews, see Ball et al., 1994; Maxwell and Johnson, 2000; Mohammed et al., 2003; Bussotti et al., 2010; Kalaji et al., 2014), and can be also measured in remote sensing studies carried out at different spatial and temporal scales (Manes et al., 2001).

In this collection of papers of Annali di Botanica – Coenology and Plant Ecology, several aspects of the current researches in this topic have been highlighted, involving the application of different ChlF techniques (Prompt, Modulated, Imaging and Sun-Induces) on forest, crop and urban green species.

Guidi et al. (2016) have reviewed the theoretical bases of ChlF, the use of the most important ChlF parameters to estimate changes in plant photosynthetic activity, as well as the relation between actual PSII photochemistry and CO_2 assimilation. In particular, insight on the application of modulated ChlF and ChlF Imaging to study heterogeneity of leaf lamina has been provided under the following

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environmental stress factors: water availability, nutrients, pollutants, temperature and salinity. Some ChlF imaging applications for the determination of the quality, chemistry and physical characteristics of fruits, as well as for the determination of the (in)-compatibility between rootstocks and scions in herbaceous plants, have been also discussed.

Two papers (Pollastrini et al., 2016 and Salvatori et al., 2016) have investigated the field application of Prompt ChlF, measured on dark-adapted samples, in forests ecology studies. Pollastrini et al. (2016) have considered a European-wide assessment of 1596 trees growing in 209 forest ecosystems distributed in six countries, from Mediterranean to boreal sites. Their findings have shown that the photochemical responses of forest tree species, analyzed with ChlF parameters, were influenced by the ecology of the trees (i.e. their functional groups, continental distribution, successional status, etc.), tree species' richness and composition of the stands. The least variable ChlF parameter within and between the trees was the maximum quantum yield of primary photochemistry (F_V/F_M). Salvatori et al. (2016) instead applied Prompt ChlF to investigate the drought response of two coexisting deciduous tree species (*Quercus cerris* L. and *Fraxinus ornus* L.) in a natural mixed forest in the Mediterranean area, showing that the measurement of ChlF with the JIP-test application is particularly suitable for phenotyping the drought stress response of adult trees in the field. In particular, among the phenotypic traits investigated, the Total Photosynthetic Performance Index (PI_{TOT}) has proven to be the most suitable non-invasive marker of plant response to drought, which is able to provide reliable, fast and synthetic information on plant ecophysiological status.

The paper of Cotrozzi et al. (2016) has focused on urban plant physiology, by reviewing the literature (1994-2015) concerning the use of different ChlF techniques (Prompt, Modulated and Solar-Induced steady-state fluorescence) for the detection of photosynthetic efficiency in urban green spaces. In particular, their work has pointed out that ChlF is increasingly used in researches performed in urban environments, being suitable for several experimental conditions and for every types of vegetation, thus allowing the screening of species and genotypes with tolerance to the urban environment.

As for crop species, Bosa et al. (2016) have analyzed the photosynthetic productivity of *Pyrus communis* cv Conference, an orchard species of increasing interest in Poland, budded on different rootstocks. Their results have highlighted that changes in ChlF parameter reflect the different suitability of the two rootstocks, although this different photosynthetic efficiency was not reflected in the fruit yield. Colombo et al. (2016) investigated the fluorescence emission in a thinning experiment in a corn field, by remote Sensing of Sun-Induced ChlF. This innovative technique is particularly promising, since it can be used to estimate canopy fluorescence from space at global level. Their work highlighted that fluorescence and apparent fluorescence yield are well related with Leaf Area Index and vegetation fractional cover, but when fluorescence is divided for a spectral vegetation index (considered as a proxy of vegetation structural parameters) the correlation is lost. This points out that fluorescence indexes should be considered in the study of spatial and temporal variability of biophysical parameters, for satellite studies and, more in general, for basic and applied studies of plant morpho-functional responses in a changing environment.

The contents of the papers collected in this Special Issue are evidence of the increasing interest in ChlF based methods for the analysis of the physiological responses of plants subjected to varying ecological conditions. The transposition of these methods from experimental controlled conditions to ecosystems poses new problems and challenges, including the higher variability of the responses and the need of an adequate sampling strategy. Moreover, the simultaneous presence of many different environmental features (related both to the structure of the ecosystem and to the multiple stress factors) claims for a more complex statistical approach. It was our intentions to contribute, with the present collection, to this debate raising some of the most relevant problems still open.

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