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Seasonal variations in photosynthetic irradiance response curves of macrophytes from a Mediterranean coastal lagoon

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Abstract

The main photosynthesis and respiration parameters (dark respiration rate, light saturated production rate, saturation irradiance, photosynthetic efficiency) were measured on a total of 23 macrophytes of the Thau lagoon (2 Phanerogams, 5 Chlorophyceae, 10 Rhodophyceae and 6 Phaeophyceae). Those measurements were performed in vitro under controlled conditions, close to the natural ones, and at several seasons. Concomitantly, measurements of pigment concentrations, carbon, phosphorous and nitrogen contents in tissues were performed. Seasonal intra-specific variability of photosynthetic parameters was found very high, enlightening an important acclimatation capacity. The highest photosynthetic capacities were found for Chlorophyceae (e.g. *Monostroma obscurum* thalli at 17 °C, 982 μmol O_2 g^{-1} dw h^{-1} and 9.1 μmol O_2 g^{-1} dw h^{-1}/μmol photons m^{-2} s^{-1}, respectively for light saturated net production rate and photosynthetic efficiency) and Phanerogams (e.g. *Nanozostera noltii* leaves at 25 °C, 583 μmol O_2 g^{-1} dw h^{-1} and 2.6 μmol O_2 g^{-1} dw h^{-1}/μmol photons m^{-2} s^{-1} respectively for light saturated net production rate and photosynthetic efficiency). As expected, species with a high surface/volume ratio were found to be more productive than coarsely branched thalli and thick blades shaped species. Contrary to R_d (ranging 6.7–794 μmol O_2 g^{-1} dw h^{-1}, respectively for *Rytiphlaea tinctoria* at 7 °C and for *Dasya sessilis* at 25 °C) for which a positive relationship with water temperature was found whatever the species studied, the evolution of *P*/*I* curves with temperature exhibited different responses amongst

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the species. The results allowed to show summer nitrogen limitation for some species (*Gracilaria bursa-pastoris* and *Ulva* spp.) and to propose temperature preferences based on the photosynthetic parameters for some others (*N. noltii*, *Zostera marina*, *Chaetomorpha linum*).

Keywords: Photosynthesis; Light response curve; Macrophytes; Oxygen method; Seasonal variations; Seagrasses; Chlorophyceae; Rhodophyceae; Phaeophyceae; Thau lagoon

1. Introduction

From bibliographic analysis and new collections, a total of 196 taxa and stadia (life-history phases) of macroalgae were numbered in Thau Lagoon (Mediterranean Sea, France, 43°24′N and 3°32′E) far above the other Mediterranean lagoons (Verlaque, 2001). This lagoon is the seat of an important marine species introduction (45 recently introduced macroalgae), with shellfish cultivation activity recognised as the main vector of introduction (Verlaque, 2001). The success of these exotic species is probably due to their physiological plasticity as well as to the Thau lagoon hydrological characteristics. The lagoon (surface 75 km^2, mean depth 4 m) is a semi-closed marine ecosystem, communicating with the Mediterranean Sea through two narrow openings (mean water residence time, 3.8 months) and showing wide variations in water temperature and salinity (5–29 °C and 27–40 PSU, respectively). The annual global solar radiations is 5483 ± 135 MJ m^{-2} (mean value and standard deviation for years 1994–1999, data from Météo-France) and the mean water extinction coefficient is 0.4 m^{-1}.

Studies on photosynthetic light-response curves are widely reported for macrophytes (King and Schramm, 1976; Jiménez et al., 1987, Henley, 1993; Pérez-Lloréns et al., 1996; Rodrigues et al., 2000). These studies developed the measurement techniques, under controlled conditions, of the photosynthesis and dark respiration parameters, which then can be compared among species or varying environmental conditions (temperature, light, salinity, nutrients, inorganic carbon, etc.). Furthermore, the parameters obtained in this way are very useful for modelling purposes, and macrophyte production calculations. However, these studies usually focus on a limited number of species.

Within the framework of the pluridisciplinary French National Program on Coastal Ecology (PNEC), the aim of this study was to determine, for all the most common macrophytes of the Thau lagoon, the photosynthesis parameters at several seasons, as well as their pigment and elemental contents, in order to relate to habitat conditions and to serve as a basis for the modelling of such macrophyte populations (Plus et al., 2003).

2. Material and methods

2.1. Study site

In spring 1998, the distribution and biomasses of macrophytes in the Thau lagoon was studied (Plus et al., 2003). Fifty-seven stations distributed all over the lagoon were sampled