POSIDONIA OCEANICA, A TOP PRODUCER OF DIMETHYLSULFONIOPROPIONATE AND DIMETHYLSULFOXIDE

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Abstract
We studied the dynamic of dimethylsulfoniopropionate and its derivative dimethylsulfoxide in *Posidonia oceanica*. The annual average concentrations in leaves were 129 ± 39 µmol.g_{fw}^{-1} for DMSP and 5.0 ± 2.1 µmol.g_{fw}^{-1} for DMSO. DMSP and DMSO concentrations decreased from a maximum in the fall to a minimum in the summer and were mainly correlated to the seagrass leaf size. The similar variation of the two molecule concentrations suggested that DMSO content results from oxidation of DMSP. The DMSP:DMSO ratio, considered as indicator of stress in *Spartina alterniflora*, remained constant around a mean value of 27.7 µmol:µmol. More research is now needed to investigate the functions of DMSP and DMSO in seagrasses, how the DMSP:DMSO ratio will vary under disturbance and whether it is useful as indicator of stress.

Keywords: Posidonia, Mediterranean Sea, Physiology

Dimethylsulfoniopropionate (DMSP) and its derivative, dimethylsulfoxide (DMSO) are precursors of dimethyl sulfide (DMS), a climatically active gas that could have a cooling effect on climate and could help to compensate for warming from 'greenhouse effect' [1]. DMSP plays physiological roles in marine autotrophs that has stimulated numerous studies on its production, especially on marine phytoplankton [2]. Among the short list of terrestrial and coastal angiosperms that have a high DMSP content, the marine magnoliophyte *Posidonia oceanica* is the only seagrass reported so far [3]. To extend our limited knowledge on the ecology of DMSP and DMSO in *P. oceanica* leaves, we investigated the temporal and depth variability of the two molecules and the potential role of light, temperature, photosynthetic activity and leaf size on their contents. We further assessed the potential of the DMSP:DMSO ratio as indicator of stress in *P. oceanica*, as previously suggested and observed for the salt march plant *Spartina alterniflora* [4,5].

The survey was conducted from April 2015 to July 2016 in a non-disturbed meadow in the Revellata Bay, Corsica (France), as part of the STARECAPMED project. Light and temperature were continuously monitored with autonomous loggers. *P. oceanica* third internal leaves (juvenile leaves excluded, n = 3) were sampled weekly to bimonthly at 10m depth and once early summer 2015 along a 3-36m depth gradient, after *in situ* analysis of leaf photosynthetic activity (ΦPSII). Supplementary leaf bundles were sampled for biometry analysis. Samples were stored frozen until analysis. The DMSP and DMSO concentrations were measured in fresh *P. oceanica* third leaf basal section (0-20 cm in height) after conversion into DMS with the headspace technique with a gas chromatograph [6]. Data were analysed by regression, correlation or variance analyses using RStudio.

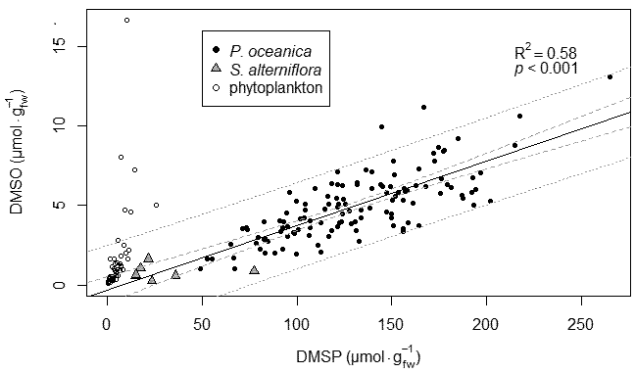

Fig. 1. Scatterplot of DMSP and DMSO concentrations (µmol.g_{fw}^{-1}) in *P. oceanica* (black dots), *S. alterniflora* (grey triangles) and marine phytoplankton communities (empty dots). *S. alterniflora* and phytoplankton data are from the literature. The full line models the linear relationship between *P. oceanica* DMSP and DMSO concentrations. 95% confidence and prediction intervals (dashed and dotted lines) are plotted.

Mean DMSP concentrations in *P. oceanica* third leaf ranged between 62 ± 17 and 205 ± 58 µmol.g_{fw}^{-1}. The highest leaf value reported in this study was 265 µmol.g_{fw}^{-1}. These concentrations make the plant the largest reported producer of DMSP among marine and inter-tidal autotrophs since dinoflagellates [2]. Mean DMSO concentration ranged between 1.5 ± 0.7 and 8.6 ± 2.0 µmol.g_{fw}^{-1}. Concentrations of the two organosulfured compounds varied with time: continuous linear decrease from fall to summer, but little with depth. Considering the similar distribution of both molecules (Fig. 1), we hypothesized DMSO content results from the oxidation of DMSP [4]. Of all physiological (ΦPSII), biometrical and environmental (light, temperature) parameters monitored, the lengthening and aging of *P. oceanica* leaf bundle during its annual growth cycle explained best the evolution of leaf DMSP and DMSO concentrations. Concentrations were strongly (*rho* = -0.75 for DMSP) and modestly (*rho* = -0.55 for DMSO) inversely correlated to the leaf size, *i.e.*, the leaf age ($p < 0.001$). We hypothesized two protective functions of DMSP to explain higher concentrations in young leaf tissues: antioxidant against reactive oxygen species and predator-deterrent. Finally, we observed a constant DMSP:DMSO ratio around a mean value of 27.7 µmol:µmol in *P. oceanica* leaves for the non-disturbed meadow under study. In the salt marsh plant *S. alterniflora* naturally or experimentally stressed, DMSP was converted to its oxidation product, DMSO, which resulted in a change of their ratio compared to healthy plants [4,5]. Similarly as for *S. alterniflora*, we hypothesized the DMSP:DMSO ratio could be useful as early warning indicator of stress in seagrasses independently of the season, the depth or the age of the leaf bundle. The constant ratio we observed in this study for a healthy *P. oceanica* meadow not subject to stressors can be considered as reference value for future work. In conclusion, the present study deepened our knowledge on the ecology of DMSP and DMSO in *P. oceanica* and brought new insights on the concentration dynamics of both molecules in coastal ecosystems overall.

References
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