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May 2019

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OptoLeaf: Measure Photosynthetic Photon Flux Density using a Light Sensitive Film

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OptoLeaf attached to *Posidonia australis*

Photosynthetic photon flux density (PPFD) plays a pivotal role in the growth and survival of photosynthetic organisms. Light is often strongly attenuated in coastal aquatic and marine environments where macroalgae, seagrasses and corals are commonly found. Understanding light availability in these submerged environments is key in interpreting growth rates, photosynthetic performance and determining the capacity to tolerate stress.

Direct measurements of PPFD can be achieved using quantum sensors. However, this approach is expensive, obtrusive and impractical for simultaneously sampling multiple locations.

- ✓ *A colour acetate film treated with azo dye offers a useful alternative where multiple unobtrusive measurements need to be made, as the thin film can be easily attached to small leaves.*
- ✓ *The absorbance of the dye gradually fades with light exposure, and the rate of fading correlates well with PPFD. Ideally, multiple pieces of film are deployed in the field along with a few samples directly adjacent to a logging quantum sensor.*
- ✓ *Fading rates of the reference samples can then be compared with measured quantum dose derived from the quantum sensor. This relationship is then used to convert fading rates of all samples in the field to total photon dose.* ***The film is available as "OptoLeaf".***

Underwater applications

The film can be used underwater (e.g. Hirano et al. 1996). Small strips (1 x 2 cm) can be attached to seagrass blades or macroalgae with stainless steel staples or clips. As the film is thin (~0.1 mm), and light (<1 g per strip) it has minimal impact on the movement and buoyancy of a seagrass blade or macroalgal thallus. Therefore, samples can be placed in a multitude of orientations and depths within the canopy. By measuring the absorbance of each sample prior and post deployment, one can determine the rate of change of absorbance. This rate of change can then be expressed in terms of total photon dose by use of a reference curve. Reference curves can be generated independent of a field experiment as long as the temperature and light conditions are similar. Systems where the film could be usefully used include:

- Seagrass meadows
- Macroalgae beds
- Benthic microalgae mats
- Coral reef systems
- Suspended in the water column (downwelling and upwelling irradiance)
- Horizontal and vertical surfaces, etc.

Case studies – terrestrial

Numerous studies have been conducted with terrestrial plants, for example:

- A method for evaluating the interaction between individuals competing for light in a monospecific stand (Hikosaka et al. 2001) – this method could be directly relevant in assessing how seagrass blades shade one another.
- An assessment of forest understory PPFD over a 12-month period including changes in ambient temperature over the year (Kawamura et al. 2004) – the study concluded that the accuracy and low cost of the film made it a good option for estimating the integrated PPFD in a forest understory.

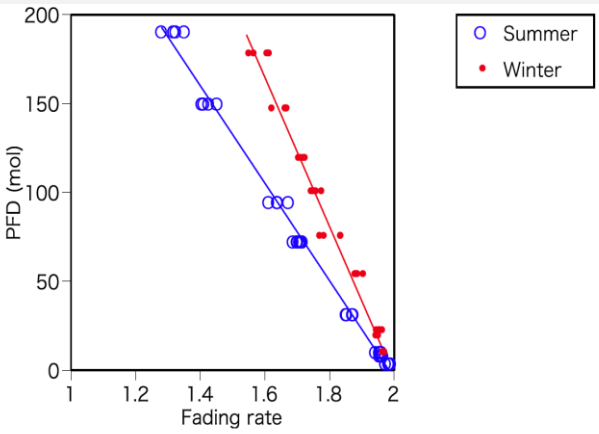


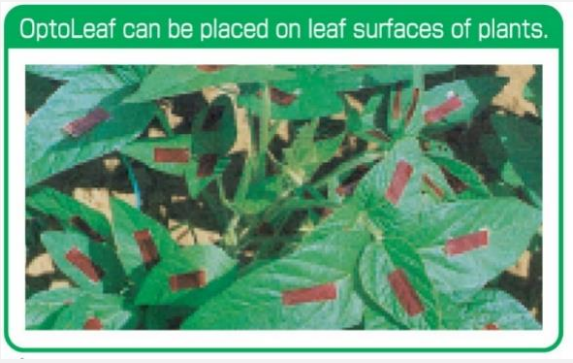
Fig. 2. Calibration lines to estimate PFD from fading rate of the film. The lines differ significantly between summer and winter in Kyoto, Japan (summer, r = 0.99; winter, r = 0.98).

Image from http://prometheuswiki.publish.csiro.au

- The detection of novel quantitative trait loci controlling photosynthesis by increasing leaf nitrogen content and analysing its effect on leaf and canopy photosynthesis (Hirotsu et al. 2017)

Availability

Aquation Pty Ltd now distributes OptoLeaf for Taisei Fine Chemical. Co., Ltd. (Japan). Three different films are available (1 to 3 days, 3 to 7 days, 1 to 3 weeks). While the 1-3 day tape is more accurate, some users prefer the 1-3 week tape for longer integration intervals. Handheld readers are available, or a spectrophotometer can be used. https://aquation.com.au/products/optoleaf/.



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