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ENABLING MICROSCALE RESEARCH

Studying the effects of leaf gas film using microsensors

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Internal aeration of paddy field rice (Oryza sativa) during complete submergence - importance of light and floodwater O_2. New Phytol 197 (4):1193-1203, 2013.

O. Pedersen, S. M. Rich, and T. D. Colmer.

Surviving floods: leaf gas films improve O_2 and CO_2 exchange, root aeration, and growth of completely submerged rice. The Plant Journal 58 (1):147-156, 2009.

Flooding of vegetation introduces a number of challenges to the plants. Reduced oxygen solubility combined with slower diffusion of gases restricts photosynthesis under water as O_2 and CO_2 exchange between the plant and the environment is limited. Some plants have developed smart ways to survive flooding. The referred two articles focus on the function of leaf gas film formed on the superhydrophobic leaf.

There has been suggestions of improved CO_2 uptake during submergence of plants with leaf gas films; however, the function of leaf gas films is not well-understood. In Pedersen et al. (2009) this function is investigated by setting up laboratory experiments and in Winkel et al. (2013) the studies are repeated in paddy field rice in the Philippines. This research summary will focus on the data the researchers obtained using microsensors in laboratory and in situ experiments.

Laboratory Setup

The dynamics of root pO_2 in light and darkness were investigated using O_2 microsensors. Four-week-old plants (Oryza sativa L.) were kept in a chamber that allowed for separate medium for root and shoot of the plant. The roots were incubated in deoxygenated medium, whereas the shoots were incubated in a medium containing 200 mmol m^{-3} free CO_2 and O_2 in air equilibrium. The chamber was covered with PVC foil to prevent possible contact between leaves and air. This setup mimicked in situ conditions and allowed for studying the internal aeration of the plant.

Laboratory setup with double chamber, the sensor is positioned into root cortex. Photo: Ole Pedersen

Unisense O_2 microsensors with a tip diameter of 25 µm were connected to a Unisense amplifier, mounted on a micromanipulator and positioned into the root cortex. The effect of leaf gas film was studied by measuring root pO_2 before and after brushing the leaves with a diluted Triton-X-100 solution, to remove the gas film.

Field Setup

Root pO_2 of paddy field rice was measured during two days of complete submergence. Four-week-old rice plants were planted into a paddy field. Roots were exposed and the microsensors were placed 200 µm into the root tissue. Hereafter both root and microsensor were covered with soil, placing the sensor tip approx. 4 cm below soil surface. To investigate the function of the leaf gas film, leaves of selected plants had their gas film removed 3 hours prior to flooding. Light status was monitored by a weather station placed approx. 440 m from the paddy field.

Brushing leaves with a diluted Triton-X-100 solution to remove leaf gas film. Photo: Ole Pedersen

Conclusion on lab and field data

Leaf gas films are hypothesized to improve internal aeration of the plant during the day, as leaf gas films enhance CO_2 uptake and thereby promote photosynthesis. This is seen as higher root pO_2 in plants with intact gas film compared to plants without. The two studies described in this flyer investigate gas film based on laboratory experiments and experiments in the field.
In the laboratory, root pO_2 increase in light periods in submerged plants, probably due to reduced outward diffusion of photosynthetically produced O_2. Removal of gas film resulted in a decrease in root pO_2 to just below the initial level (see fig 1A). This can be explained by decreased O_2 production by photosynthesis as a result of impeded CO_2 entry. In darkness, root pO_2 rapidly decreased to 25% (see fig. 1B) of when submerged in light and declined to close to zero when the gas film was removed.

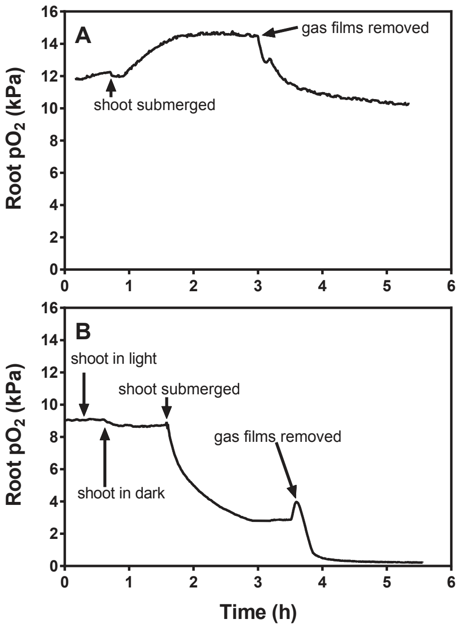

Fig. 1 Root pO_2 measured in light (A) or darkness (B) before and after submerge and with or without removal of gas film. Figure adapted from Pedersen et al 2009.

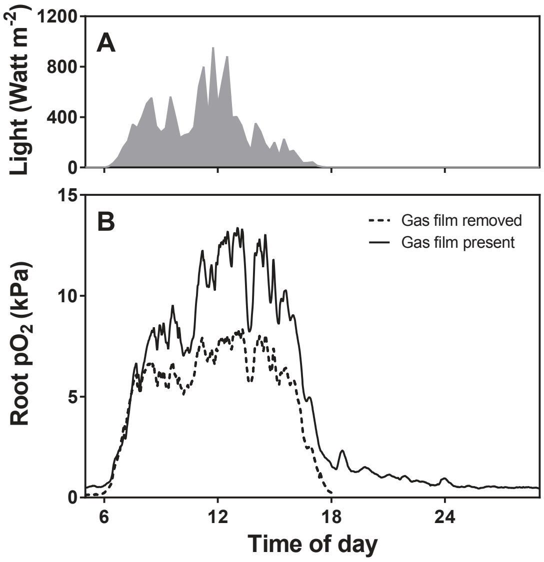

Fig. 2. (A) surface light was measured approx. 440 m from field location using a weather station. (B) Root pO_2 measured in completely submerged plants with or without gas film. Adapted from Winkel et al. 2013.

In the field, plants with intact leaf gas films had higher daytime root pO_2 compared to plants without leave gas film during the first day of measurements (fig. 2B), supporting laboratory data. The difference in root pO_2 of plants with or without leaf gas film was, however, not significant on the second day (data not shown), suggesting that the leaf gas film had either been reestablished or that emerging new leaves with intact gas film had masked the effect of the gas film removal on the leaves from the day before.

Although data obtained in the field were only significant on the first of day of measurement, the in situ data support the findings obtained in the laboratory experiments by showing a positive correlation between leaf gas film and increased root pO_2. Combining laboratory and in situ measurements thus contributed to understanding how leaf gas films help the rice plant survive flooding.

Recommended Unisense Products

	LABORATORY PRODUCTS	FIELD PRODUCTS
SENSOR	O_2, H_2S, H_2, NO, N_2O, pH, Redox Temperature Oxygen MicroOptode	O_2, H_2S, H_2, NO, N_2O, pH, Redox Temperature Oxygen MicroOptode
AMPLIFIER	fx-6 UniAmp Opto-F1/Opto-F4 UniAmp	Field Microsensor Multimeter UnderWater Meter
SYSTEMS	MicroProfiling System MicroRespiration System	Field MicroProfiling System MiniProfiler MP4/8 Eddy Correlation System
SOFTWARE	SensorTrace Suite	SensorTrace Suite

Version: November 2024