

Leaf movements, photo inhibition and heat resistance in *Oxalis acetosella* L.

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Introduction

Oxalis acetosella is a small herbaceous plant which populates shady forest grounds on acidic soils in temperate and northern regions of Eurasia. On the base of each of three leaflets, turgor controlled pulvinar cells can be found, which function as a hinge to increase or decrease the leaf angle of the leaflets (Fig. 1). Such protective leaf movements can be triggered by a number of exogenous factors such as light (nastasy), temperature (thermonasty) but also by internal factors (SCHUBERT 2001).

Assuming that this safety mechanism is directly linked to potential impairment of the photosystem II, we examined the critical intensities and durations of light and temperature for PS II functioning.



Fig. 1: *O. acetosella* with erect (left) and lowered (right) leaflets.

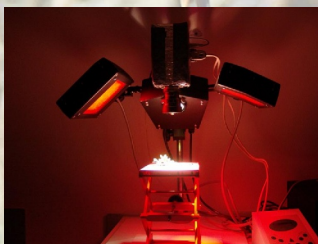


Fig. 3: Device setup for chlorophyll fluorescence measurements (Fv/Fm).



Fig. 4: Device setup for chlorophyll fluorescence measurements (Fv/Fm).

Results

Leaf movements: *In situ*, exposure to direct sunlight triggered a quick response of the pulvinar cells, causing them to decrease the angle of the leaflets to close to 0° within 7 minutes ($-9.0^\circ / \text{min.}$ at $740 \mu\text{mol photons} / \text{m}^2 \cdot \text{s}$). At an intensity of $1700 \mu\text{mol photons} / \text{m}^2 \cdot \text{s}$, leaflet movements were slightly faster ($-10.33^\circ / \text{min.}$). Once shaded, the opening process took disproportionally longer ($+0.43^\circ / \text{min.}$, $n = 1$).

Photoinhibition: At a duration of 5 minutes, the leaves of *O. acetosella* did not show any photoinhibition at intensities up to $810 \mu\text{mol photons} / \text{m}^2 \cdot \text{s}$. With higher irradiation intensities extending up to $3000 \mu\text{mol photons} / \text{m}^2 \cdot \text{s}$ there was only a slight decrease in chlorophyll fluorescence. At 15 minutes and intensities above $700 \mu\text{mol photons} / \text{m}^2 \cdot \text{s}$, there was a slight effect (Fig. 5).

Heat resistance: At the critical temperature of 42.5°C , leaves of *O. acetosella* showed a significant decrease of PS II capacity (Fv/Fm, Figs. 6, 7), indicating that there was damage to the photosynthetic apparatus.

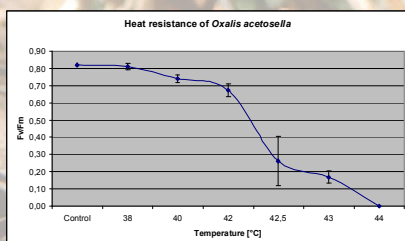


Fig. 6: Leaves of *O. acetosella* after treatment in a water bath (42.5°C , 5 min.) and Characteristic colour pattern after heat damage.



Fig. 7: Characteristic colour pattern after heat damage.

Methods

Leaf movement: Leaf movements were examined *in situ* using time-lapse recordings. Selected plants that had been shaded beforehand were exposed to direct sunlight for a defined length of time in order to document the nastic movements of the leaves.

Photoinhibition: Under controlled conditions (18°C , 100 % relative humidity), leaves of *O. acetosella* were fastened under a glass plate and exposed horizontally to different intensities of artificial irradiation (halogen spots) for either 5 or 15 minutes (Fig. 2). Afterwards, the level of photoinhibition was determined by chlorophyll fluorescence measurements (Fv/Fm, Fig. 3).

Heat resistance was investigated using water baths (exposure time: 5 minutes, Fig. 4) at $38, 40, 42, 42.5, 43$ and 44°C and subsequent chlorophyll fluorescence measurements.

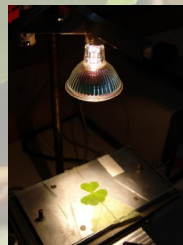


Fig. 2: Exposition to artificial irradiation under a glass plate.

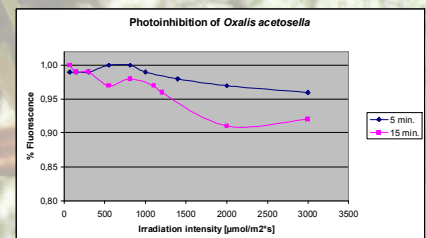


Fig. 5: Photoinhibition of *O. acetosella*.

Discussion

In connection with direct sunlight, nastic leaf movements can take place so fast that they are visible to the naked eye. The reopening process is more than 20 times slower, and is preceded by a lag phase. The critical intensity for photonastic movements was shown to be below $740 \mu\text{mol photons} / \text{m}^2 \cdot \text{s}$. Higher intensities result in minimally faster movements. The effect of photoinhibition was much weaker than expected. This suggests that photoinhibition may not be the primary factor responsible for the leaf movements.

It was suggested in recent publications that the reason lies rather in lowering transpiration by increasing the boundary layer around the stomata (DÜLL 1992).

Being an occupant of moist, shady habitats, *O. acetosella* does not show a very high degree of heat resistance, in contrast to alpine plants growing under more extreme conditions, such as *Saxifraga paniculata*.

Our experiments confirm that an environmental factor should always be seen as a combination of both dosage and intensity.

References

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