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Investigation of the homoiochlorophyllous desiccation-tolerant dicot *Haberlea rhodopensis* Friv. during dessication and rehydration

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ABSTRACT In this study the recovery of the photosynthetic activity during rehydration following dry stage was examined in the case of a homoiochlorophyllous desiccation-tolerant (HDT) plant, *Haberlea rhodopensis*. Although the majority of the DT plants are homoiochlorophyllous, we still do not have enough information about the HDT ones, especially information on flower DT plants are needed. Net CO_2 assimilation (Pn) in *Haberlea rhodopensis* was characterized using data from measurements of CO_2 gas exchange, the kinetics of chlorophyll fluorescence (variable Chl fluorescence ratio, Fv/Fm) in various hydration conditions. The pigment accumulation, thylakoid function and photosynthetic CO_2 assimilation were fully recovered after rehydration. Long-term experiments would be needed to make a confident forecast of the responses of desiccation tolerant plants to the global environmental changes.
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KEY WORDS

desiccation
rehydration
CO_2 gas exchange
chlorophyll fluorescence

Desiccation-tolerant (DT) plants capable of tolerating dehydration, the most extreme form of water stress. These plants are often referred to as resurrection plants, can survive total dehydration of various durations is an anabiotic state and will revive on rewetting. The dehydration process is characterized by fundamental changes in water relations, biochemical and physiological processes, membrane structure, and ultrastructure of subcellular organelles (Gaff 1977; Bianchi et al. 1991). DT plants may be subdivided into homoiochlorophyllous (HDT) and poikilochlorophyllous (PDT) types. The HDTs retain their chlorophyll on desiccation, whereas in PDTs desiccation results in the loss of chlorophyll, which must be resynthetized following rehydration (Tuba et al. 1998).

In this study the recovery of the photosynthetic activity during rehydration following dry stage was examined in the case of a homoiochlorophyllous desiccation-tolerant (HDT) plant, *Haberlea rhodopensis*.

Materials and Methods

Plant species investigated

Studying plant, *Haberlea rhodopensis* Friv. is a member of the Gesneriacaea. It is a native species to the Balkan Mountain region. It prefers more-or-less shady and high humidity habitats on rock surfaces under the shadow of loose free canopies (close to Bachkovo, Bulgaria, altitude 932 m).

Plants were transplanted into Hungary in air dried stage. Prior to desiccation experiments, detached leaves were hydrated and kept in full metabolic and photosynthetic activity.

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Desiccation and rehydration procedure

The fully photosynthetically active leaves were desiccated slowly over 8 days under indoor laboratory conditions (approx. 20°C, 50% relative humidity). Control leaves were kept in fully hydrated stage with frequent watering. Following desiccation the desiccated leaves were rehydrated by direct spraying (Tuba et al. 1994; Csintalan et al. 1996).

Measurements of CO_2 gas-exchange rate

CO_2 gas exchange rate was measured using a CIRAS-2 type IRGA system, operated in differential mode at 500 $\mu molm^{-2}s^{-1}$ (PAR) light intensity.

Chlorophyll-fluorescence measurements

Chlorophyll fluorescence was measured using a Hansatech (King' Lynn, UK) MFMS1 modulated or a portable Hansatech (PEA) fluorometer. Calculation of fluorescence parameters and conventions for symbols follow Schreiber & Bilger (1993), in equation: Fv/Fm = (Fm-Fo)/Fm.

Results and Discussion

Water relations

Water content of water-saturated and photosynthetically fully active *Haberlea rhodopensis* leaves began to decline immediately after suspending of water supply to the leaves. The

Table 1. Changes of relative water content (%) and their standard deviation in water saturated, photosynthetically fully active leaves of *H. rhodopensis* during desiccation and rehydration.

Relative water content (%)	Wet	Desiccated	1st day of rehydration	1st week of rehydration
Control	304.13±31.87	388.80±47.52	412.27±57.9	325.702±12.53
Desiccated and rehydrating	322.768±19.16	14.042±8.35	112.365±16.92	301.20±17.93

Table 2. Fv/Fm values and their standard deviation in water saturated, photosynthetically fully active leaves during the desiccation and after 3 and 24 hours of the rehydration in the previously desiccated leaves of *H. rhodopensis*.

Fv/Fm parameters (relative unit)	2nd day of desiccation	3rd day of desiccation	4th day of desiccation	5th day of desiccation	7th day of desiccation	8th day of desiccation
Control	0.829±0.008	0.825±0.015	0.84±0.004	0.835±0.005	0.837±0.003	0.839±0.007
Desiccated	0.732±0.042	0.742±0.015	0.8±0.007	0.782±0.018	0.119±0.148	0.04±0.018

Fv/Fm parameters (relative unit)	3rd hours of recovery	24th hours of recovery
Desiccated	0.129±0.06	0.712±0.06

decline in relative leaf water content was linear and after 8 days the leaves reached the completely desiccated stage. After a week of rehydration, the leaf water content of the previously desiccated leaves were restored and regained approximate the control plants' values (Table 1).

Chlorophyll-fluorescence responses

The characteristic ratio of fluorescence parameter Fv/Fm is suitable for the detection of desiccation/rehydration. At the beginning and in the first 2/3 part of the desiccation the fluorescence parameter Fv/Fm was relatively insensitive to desiccation (Table 2). The dramatic decrease of Fv/Fm ratio was observed after the 7th day of desiccation. On the 8th day after the start of desiccation the photochemical activity has ceased. The effect of rehydration on the recovery of photochemical activity was measurable already after 3 hours of the rehydration and 24 hours after the rehydration the photochemical activity of the previously desiccated leaves has reached the controls' values. This reflects a very probably very effective protection and a very fast repairing mechanism.

CO_2 gas exchange responses

After 8 days of desiccation the CO_2 assimilation rate was only cc. about 5% of the control leaves. After 1 day of the rehydration net CO_2 assimilation rate was similar to the rate of control plants (Table 3).

Table 3. Changes of CO_2 gas exchange rates and their standard deviation at 500 $\mu molm^{-2}s^{-1}$ radiation intensity in the control, the desiccated and after rehydrated leaves of *H. rhodopensis*.

CO_2 assimilation ($\mu molCO_2m^{-2}s^{-1}$)	500 PAR
Control	1.1±1.3
Desiccated (WC ~ 10%)	-0.1±0.4
24th hours of rehydration	0.8±0.7

Conclusions

From our data we can conclude that the HDT *Haberlea rhodopensis* has the ability to survive the desiccation itself. As HDT plant its' photosynthetic structure is well preserved during the desiccation which makes enable this plant for the rapid recovery of its' photosynthesis. Further, the *H. rhodopensis* native to the temperate climate, as a higher HDT plants seems to be adapted to longer and slower drying/wetting cycles than the smaller sized HDT bryophytes or lichens (Tuba et al. 1998; Proctor and Tuba 2002).

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