Proceedings of the 7th Hungarian Congress on Plant Physiology, 2002
S4-04

Volume 46(3-4):155-156, 2002
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

Does increased photorespiration protect the leaves of common reed living in fragmented patches from excess light?

Sándor Dulai[1]*, Ferenc Horváth[2], Attila Pécsváradi[2], Mónika Bondár[1], István Molnár[3], László Erdei[2]

[1]Department of Plant Physiology, Eszterházy College, Eger, Hungary, [2]Department of Plant Physiology, University of Szeged, Hungary, [3]Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár, Hungary

ABSTRACT The effects of non-photorespiratory conditions on some photosynthetic parameters were studied in the leaves of common reed from fragmented patches and closed stands at 1500 µmol m^{-2} AL intensity. At the steady-state photosynthesis level there was no significant difference in the effective quantum yield of PS II (DF/F_m') between untreated leaves from closed stands and fragmented patches. The application of phosphinothricin (PPT) and air containing 2% O_2 resulted in a substantial decrease in DF/F_m', which was more significant in leaves from fragmented patches. Both PPT and low oxygen tension produced a similar effect on DF/F_m'. In addition the photorespiration (R_P) was twice as high in leaves from fragmented patches than in closed stands and in parallel with this a linear regression ratio was found between R_P and *in vitro* GS activity. The results suggest that the leaves of fragmented patches and closed stands might have divergent defensive strategies against excess light.

Acta Biol Szeged 46(3-4):155-156 (2002)

KEY WORDS

closed stands
fragmented patches
Phragmites
photorespiration

It is commonly known that in C_3 plants, due to the double carboxylation/oxygenation function of RUBISCO, the photorespiratory loss of CO_2 is about 25% of the gross photosynthetic CO_2 fixation under normal conditions. With an increase in temperature and light intensity or in the case intercellular oxygen tension, the oxygenase function of RUBISCO increases resulting in an even higher loss of the previously fixed CO_2. It has a been reported that the leaves of reed from fragmented patches developing during the degradation and die-back of closed stands display altered stomatal conductance and higher phptorespiration rates compared to leaves from closed stands. (Erdei et al. 1999).

On the other hand, photorespiration (R_P) may act as a protection mechanism against excess light since the recycling of CO_2 proceeds at the cost of the excitation energy. This function of R_p has been confirmed by recent observations and may important in the case of common reed growing in fragmented patches where the level of excitation energy per leaf unit area is greater than in closed stands. In certain plants the application of phosphinothricin (PPT), which decreases R_P by the inhibition of glutamine synthetase (GS), caused a significant reduction in the efficiency of PS II photochemistry at high light intensity and induced strong photoinhibition (Streb et al. 1998). The role of R_p in photoprotection is also suggested by the fact that a severe photooxidative damage was detected in a transgenic tobacco with low GS activity compared to plants with high activity (Kozaki and Tabeka 1996).

This short study reports on the effects of PPT and low oxygen tension on the photosynthetic functions at high light intensity in leaves of *Phragmites australis* living in closed stands and fragmented patches.

*Corresponding author. E-mail: ds@ektf.hu

Materials and Methods

The sampling site was located in Lake Balaton near road No. 71 in Balatonfűzfő. The light responses of *in vivo* CO_2 assimilation in intact leaves of *Phragmites australis* were measured in a standard gas mixture of 345 ppm CO_2 and 21% O_2 in N_2 using an infrared gas analyser (LCA-2, Analytical Development Co. Ltd., Hoddesdon, UK). The photorespiration (R_P) was measured on the basis of the Warburg effect. The stimulation of net photosynthesis (P_N) by low O_2 concentration was determined in a standard gas mixture containing 345 ppm CO_2 and 2% O_2 in N_2.

The *in vivo* chlorophyll-a fluorescence measurements were carried out in dark-adapted leaves with a pulse amplitude modulation fluorometer (PAM 101-103, Walz, Effeltrich, Germany).

In vitro glutamine synthetase (GS, EC 6.1.3.2) activities were measured as described by Pécsváradi and Zsoldos (1996).

Results and Discussion

On the basis of the data in Figure 1 the following conclusions can be drawn. (i) At high (1500 µmol m^{-2} s^{-1}) AL intensity the effective quantum yield of PS II (DF/F_m') showed practicall difference between the two groups. Similar results were found for other quenching parameters (data not shown). (ii) In the gas mixture containing 2% O_2, which inhibited photorespiration by reducing the oxygenase activity of RUBISCO, DF/F_m' decreased in leaves from both populations, but this decrease more significant in leaves from fragmented patches than in leaves from closed stands. (iii) The PPT treatment (2 mmol dm^{-3}), through the specific inhibition of glutamine synthetase (GS) activity, resulted in the same effects on DF/F_m' as low oxygen tension. (iv) In

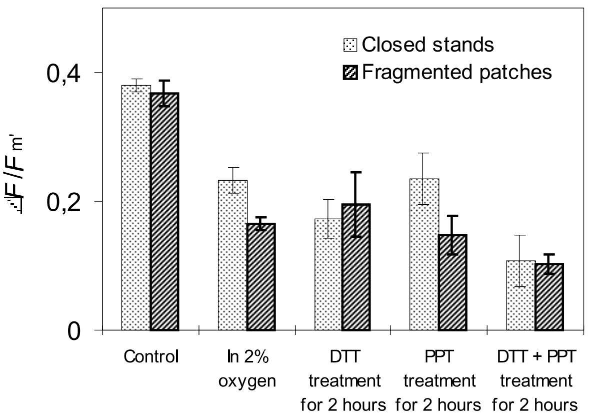

Figure 1. Changes in effective quatum yield (DF/F_m') of PS II measured at 1500 µmol m^{-2} s^{-1} AL under photorespiratory (at 21 % oxygen) and non-photorespiratory (2% oxygen, or treatment with PPT) conditions in the leaves of *Phargnites australis* collected from fragmented patches or closed stands in Lake Balaton.

both stands DF/F_m' was also sensitive to DTT (10 mmol dm^{-3}). Although, the difference was not significant, the decrease was more pronounced in leaves from closed stands. (v) In addition it also be seen in Figure 1. that the combined treatment with PPT and DTT caused a drastic reduction in DF/F_m', which was practically the same in both groups.

These data clearly show that the leaves from closed stands and fragmented patches respond differently to high light intensity under non-photorespiratory conditions. The inhibition of photorespiration causes a considerable slowing down of the electron transport through PS II, which is probably related to the harmful effects of excess light (not detailed here). This decrease in DF/F_m' is more pronounced in leaves from fragmented patches than from closed stands. In this context there is no difference between the effects of PPT (specific inhibitor of GS) and low oxygen tension.

Additionally, at medium and strong light intensities the photorespiration was nearly twice as high in leaves from fragmented patches than in leaves from closed stand, and a linear regression ratio was found between R_p and GS activity (data not shown). It can thus be assumed, that high R_p operates as an efficient protective mechanism against excess light and photooxidation in leaves growing in fragmented patches, as reported by other authors (Wu et al. 1991; Heber et al. 1996; Kozaki and Tabeka 1996), but is of less relevance in the leaves of closed stands. This argument is supported by the fact that the leaves of fragmented patches are exposed to higher irradiation in the daytime than the leaves of closed stands while the values of non-photochemical quenching (NPQ) do not differ either at high or low AL intensities in the untreated leaves of the studied groups (data not shown).

Based on the above results it would appear that the high level of R_P provided a major electron sink which played a deffensive role against the harmful effects of excess light (Kozaki and Tabeka 1996; Streb et al. 1998) in leaves from the fragmented patches and, operating in parallel with other well-known regulating mechanisms, esured effective protection against photoinhibition.

According to the results the divergent strategies of photoprotection in reed belts, *e.g.* higher R_P in the fragmented patches leading to changes in the C/N metabolism (Erdei et al. 2001), might be partly connected with the altered light climate developing due to the fragmentation of closed stands. Although the fundamental reasons for die-back in reed belts have still not been clarified, they are accompanied by the above phenomena which may enhance the process through the modified functions.

Acknowledgment

This work was supported by research grant OTKA T 032524 to E. L.

References

Erdei L, Szegletes Zs, Horváth F, Tari I, Pécsváradi A, Dulai S (2001) Differences in photorespiration, glutamine synthetase and polyamines between fragmented and closed stands of *Phragmites australis* in lake Balaton. Aqu Bot 69:165-176.

Heber U, Bligny R, Streb P, Douce R (1996) Photorespiration is essencial for the protection of the photosynthetic apparatus of C_3 plants against photoinactivation under sunlight. Bot Acta 109:307-315.

Kozaki A, Tabeka G (1996) Photorespiration protects C_3 plants from photooxidation. Nature 384:557-560.

Pécsváradi A, Zsoldos F (1996) Nitrate reductase and nitrite reductase activity in nitrite- and chlorate-stressed rice seedlings. Plant Physiol Biochem 34:659-663.

Streb P, Shang W, Feierabend J, Bligny R (1998) Divergent strategies of photoprotection in high-mountain plants. Planta 207: 313-324.

Wu J, Neimanis S, Heber U (1991) Photorespiration is more effective than the Mehler reaction in protecting the photosynthetic apparatus against photoinhibition. Bot Acta 104:283-291.