Proceedings of the 8th Hungarian Congress on Plant Physiology and the 6th Hungarian Conference on Photosynthesis, 2005

Volume 49(1-2):141-142, 2005
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

Photosynthetic responses to drought stress in different *Aegilops* species

István Molnár[1]*, Sándor Dulai[2], Ágota Csernák[2], Judit Prónay[2], Márta Molnár-Láng[1]

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

ABSTRACT The effects of drought stress induced by withholding water in soil pot were investigated on processes related to CO_2 fixation of wheat, *Ae. tauschii*, *Ae. speltoides* and *Ae. bicornis* genotypes. A decrease in relative water content (RWC) of leaves from 95% to 85% resulted in intense stomatal closure and significant decrease in the net CO_2 fixation in wheat and *Ae. bicornis* genotypes, while in *Ae. tauschii* and *Ae. speltoides* genotypes, g_s and A parameters remained significantly high between 90% and 70% RWC. Despite the intense stomatal closure, the mesophyll limitation (L_m) to A, calculated from the A/C_i curves, dominated in wheat and *Ae. bicornis* genotypes, while the stomatal limitation (L_s) were typical of *Ae. tauschii* and *Ae. speltoides* genotypes during drought stress. These properties of *Ae. tauschii* and *Ae. speltoides* genotypes could be suitable for improving drought tolerance of wheat through intergeneric crossing.
Acta Biol Szeged 49(1-2):141-142 (2005)

KEY WORDS

Aegilops
drought stress
photosynthesis
stomatal limitation
mesophyll limitation

It has been documented that some genotypes of tetraploid goat grass (*Aegilops biuncialis* L., 2n = 4x = 28, $U^bU^bM^bM^b$) having good drought tolerance are suitable to improve wheat drought tolerance through intergeneric crossing (Molnár et al. 2004). For this purpose, diploid goat grasses, such as *Ae. tauschii* Coss. (DD), *Ae. bicornis* (Forssk.) Jaub. & Spach. (S^bS^b) and *Ae. speltoides* Tausch. (SS) would be more advantageous since the B and D genome of wheat are originated from *Ae. speltoides* and *Ae. tauschii* (Jauhar and Chibbar 1999) species. Consequently, the chromosome mediated gene transfer from these species to hexaploid wheat is easier than from *Ae. biuncialis*. Moreover, the several PCR based molecular markers specific to B or D genome could facilitate both genetic mapping and the isolation of genes responsible for drought tolerance in these *Aegilops* species (Röder et al. 1998). The aim of the present study was to find accessions of various *Aegilops sp.* with good drought tolerance that are more closely related to wheat than to *Ae biuncialis*. Therefore, the photosynthetic responses to drought stress were compared in three *Aegilops* species (*Ae. bicornis, Ae. speltoides, Ae. tauschii*) and in two wheat genotypes with different levels of drought tolerance.

Materials and Methods

The experiments were carried out on accessions of *Ae. bicornis, Ae. speltoides* and *Ae. tauschii* and on two winter wheat genotypes Mv9kr1 (moderately drought tolerant) and Plaismann (drought tolerant). These *Aegilops* accessions were selected previously from thirteen accessions from the three species by germinating ability in 15% (w/v) PEG solution. Plants were grown in an unheated greenhouse with natural sunlight. Seeds of five genotypes were sown in 1.5 kg soil pots. Drought stress was induced by withholding water after five weeks of germination. The water status of plants was traced by determining relative water content. Gas exchange parameters (A, g_s, C_i) were measured between 0 and 1000 ppm CO_2 concentration at saturating light intensity using an infrared gas analyser (ADC, LCA-2) and were determined as described by von Caemmerer and Farquhar (1981). The relative limitation of light saturated CO_2 fixation by stomatal and mesophyll factors (L_s and L_m) were calculated on the basis of A/C_i curves as described by (Lawlor 2002).

*Corresponding author. E-mail: imolnar@mgki.hu

Results and Discussion

During drought stress, the stomatal conductance (g_s), which is proportional to the closure of stomatal aperture, decreased in all the genotypes parallel with the decrease in relative water content (RWC) of plants (Fig. 1A). The most intensive stomatal closure was observed for wheats, especially for Mv9kr1, which exhibited almost 90% decrease in g_s as a result of 10% water loss in leaves. The stomata of *Ae. tauschii* and *Ae. speltoides* genotypes remained more widely open even at severe drought stress (70-80% RWC) than those of wheat. The net CO_2 assimilation (A) was strongly inhibited as RWC falls in case of wheats and *Ae. bicornis* (Fig. 1B). However, A remained significantly high in *Ae. tauschii* and *Ae. speltoides* genotypes over a range of RWC from 90 to 70%. These results indicate that *Ae. tauschii* and *Ae. speltoides* accessions, similarly to some *Ae biuncialis* accessions (Molnár et al. 2004), could retained their photosynthetic activity in spite of high water loss.

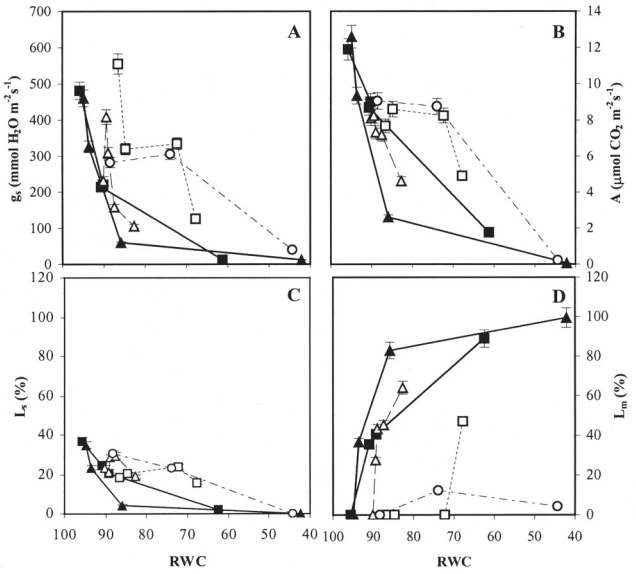

Figure 1. Stomatal conductance (g_s) (A), net CO_2 assimilation rate (A) (B), stomatal limitation (L_s) (C) and mesophyll limitation (L_m) (D) of Mv9kr1 wheat (▲), Plaismann wheat (■), *Ae. bicornis* (△), *Ae. speltoides* (○) and *Ae. tauschii* (□) genotypes in relation to relative water content (RWC).

The factors affecting net photosynthesis during drought stress have been analysed in terms of 'stomatal' (L_s) and 'mesophyll' (L_m) limitations (Lawlor 2002). The former indicates the resistance of stomata to CO_2 diffusion to intercellular leaf spaces and the latter is assumed as the combined effect of the decrease in CO_2 diffusion to chloroplasts and the inhibition of the metabolic processes of photosynthesis (Lawlor 2002). As demonstrated in Figure 1C, the relative importance of stomatal limitation to A decreased intensively parallel with the decrease in RWC of wheats and remained almost unaffected for *Aegilops* genotypes between 90 and 70% RWC. Below the RWC value of 90%, wheat and *Ae. bicornis* genotypes showed a progressive increase in L_m (Fig. 1D) reflecting its dominant role in the inhibition of photosynthesis (see Figs. 1C and D). In case of *Ae. tauschii* and *Ae. speltoides* the relative importance of L_m remained below its L_s till the RWC value of 70%. These results indicate that in the case of wheat and *Ae. bicornis* the mesophyll limitation of CO_2 fixation was dominant at severe drought stress, however, these processes are not considerable in the case of *Ae. tauschii* and *Ae. speltoides* accessions. A small metabolic limitation was also reported in *Ae. biuncialis* accessions originating from dry habitat based on the O_2 sensitivity of photosynthesis by Molnár et al. (2004). The similar responses in g_s, A, stomatal and mesophyll limitation of *Ae. tauschii* and *Ae. speltoides* to *Ae. biuncialis* indicate that besides some *Ae biuncialis* accessions, some genotypes of *Ae. tauschii* and *Ae. speltoides* are also suitable to improve drought tolerance of wheat through chromosome mediated gene transfer.

Acknowledgements

This work was supported by OTKA grant T043120.

References

Jauhar PP, Chibbar RN (1999) Chromosome-mediated and direct gene transfers in wheat. Genome 42:570-583.

Molnár I, Gáspár L, Sárvári É, Dulai S, Hoffmann B, Molnár-Láng M, Galiba G (2004) Physiological and morphological responses to water stress in *Aegilops biuncialis* and *Triticum aestivum* genotypes with differing tolerance to drought. Funct Plant Biol 31:1149-1159.

von Caemmerer S, Farquhar GD (1981) Some relationships between the biochemistry of photosynthesis and the gas exchange of leaves. Planta 153:376-387.

Lawlor DW (2002) Limitation to photosynthesis in water-stressed leaves: stomata *vs*. metabolism and the role of ATP. Ann Bot 89:871-885.

Röder MS, Korzum V, Wendehake K, Plaschke J, Tixier MH, Leroy P, Ganal MW (1998) A microsatellite map of wheat. Genetics 149:2007-2023.