Volume 55(1):69-71, 2011
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

ARTICLE

Investigation of physiological responses and leaf morphological traits of wheat genotypes with contrasting drought stress tolerance

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ABSTRACT Drought sensitive Cappelle Desprez, GK Élet and drougt tolerant Plainsman V, Mv Emese winter wheat (*Triticum aestivum*) genotypes were subjected to water deprivation at anthesis. Gas exchange measurements showed depletion of internal CO_2 in the leaves of the tolerant but not in the sensitive cultivars. Tolerant genotypes had lower stomatal density and significantly smaller leaves than the sensitive ones. The potential contribution of these traits to drought tolerance is discussed.
Acta Biol Szeged 55(1):69-71 (2011)

KEY WORDS

drought tolerance
gas exchange
flag leaf morphology
wheat

Inadequate water supply may impose severe abiotic stress on plants. Its consequences impair the growth of crop plants and decrease yield. The extent of damage depends on both severity and duration of drought stress (Araus et al 2002; Bartels and Souer 2004). Tolerance to this environmental condition is complex and may be activated by several different signalling pathways. A well chacterized effector function activated by these signalling steps is an increase of stomatal resistance due to fast closure. Other potential responses include changes of root growth and accumulation of osmolytes (Parsons and Howe 1984; Bartels and Nelson 1994; Bohnert, Nelson and Jensen 1995). The potosynthetic apparatus is relatively well protected, but may get damaged if the stress is severe or long lasting. This study investigates drought sensitive Cappelle Desprez, GK Élet and drougt tolerant Plainsman V, Mv Emese winter wheat (*Triticum aestivum*) genotypes. Gas exchange parameteres were measured through a drought treatment period with some morphological traits also recorded.

Materials and Methods

Plants were grown in a soil-sand-peat mixture (3 : 1 : 1, v/v/v) after 7 weeks of vernalisation at a temperature of 2°C, in phytotron chambers (Conviron, Winnipeg, Canada) using the spring climatic programme T1 (Tischner et al. 1997). Full deprivation of water supply was started 3 days prior to anthesis and was applied twice (until the volumetric water content of the soil dropped in both treatments to 10%) with one watering (150 mL) in between. Along with the treated plants a control group was grown with normal water supply. The whole experiment was repeated 2 times in 2010. Gas exchange parameters were detected by a Li-Cor 6400 Portable Photosynthesis System instrument. This equipment records rate of photosynthesis, stomatal conductance, transpirational rate and intercellular CO_2 concentration (Ci) among others. The flag leaves of plants were measured every other day and then the data were analysed.

For morphological studies leaves were collected after re-irrigation following the second stress treatment, cleared overnight in a solution containing 41% ethanol, 21%chloroform, 17% lactic acid, 21% phenol and 3.63 M chloral hydrate, washed, and stored in 50% ethanol. The cleared epidermal peels were manually dissected from various parts of the tip, middle and base of the flag leaves, flattened in distilled water, mounted on microscope slides in 50% glycerol and examined with an Olympus B51 microscope (Olympus Corp., Tokyo Japan). Determination of the leaf area and stomatal density was performed using a CellP image analysis system (Olympus, Tokyo, Japan)

Results and Discussion

Of the data recorded by the Li-Cor 6400 instrument here we present the Ci values measured. In case of the two tolerant genotypes (cvs. Plainsman and Mv Emese) a decrease in the Ci rate could be observed at the end of the first stress treatment. This decline of Ci did not occure in the sensitive cultivars (cvs. GK Élet, Cappelle Desprez) (Fig. 1).

The contrasting values of Ci at the end of the first drought period may be explaned by faster stomatal closure and sustained photosynthetic activity of the drought tolerant plants, which depletes the leaf interior of CO_2. Flag leaves were fully

Accepted July 11, 2011
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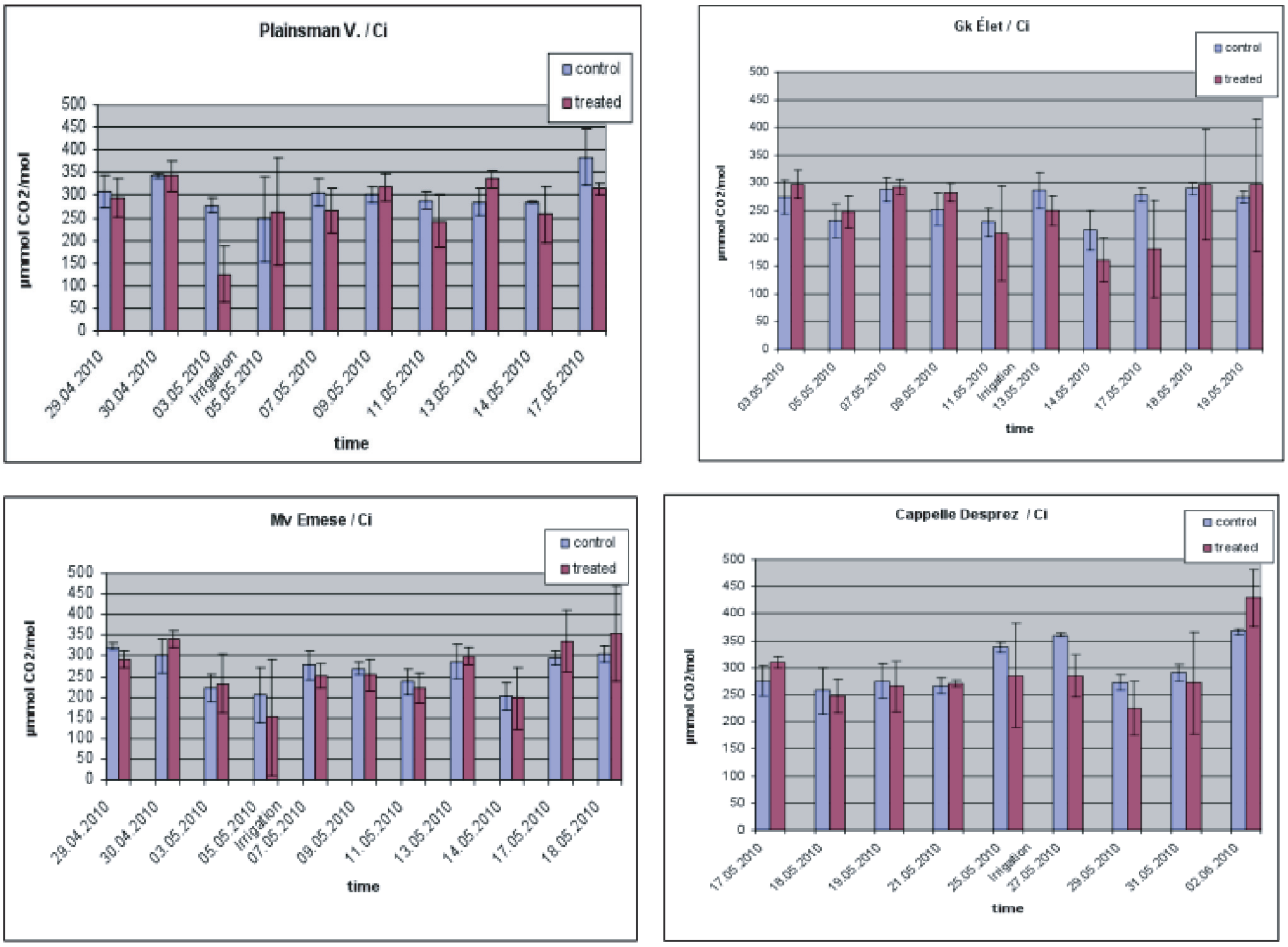

Figure 1. Ci values of the four wheat cultivars throughout the drought treatments.

expanded at the time of anthesis, thus water withholding had no effect either on the size of the leaves or on stomatal density (SD; data not shown). The area of flag leaves was significantly smaller in the drought tolerant cultivars (Table 1). SD was significantly higher on the adaxial surface of the flag leaves in all genotypes (Table 1). The total number of stomata per leaf was the lowest in drought tolerant Plainmsman V and the highest in drought sensitive Cappelle Desprez.

These features of physiological response and leaf morphology may contribute to drought hardiness of the tolerant cultivars in comparison with the sensitive ones.

Acknowledgements

We thank Tibor Janda for his help in measurements of gas exchange parameters. The work was supported by the grants

Table 1. Flag leaf areas, stomatal densities of adaxial and abaxial leaf surfaces and the total number of stomata per leaf of the drought tolerant Plainsman V and Mv Emese and, drought sensitive GK Élet and Cappelle Desprez wheat cultivars.

Genotype	Leaf area (mm^2)	SD adaxial (mm^{-2})	SD abaxial (mm^{-2})	Stoma/leaf
Plainsman V	2551±551 [a]	35±3 [a]	48±4 [a]	209748±39697 [a]
Mv Emese	3928±510 [b]	37±1 [b]	51±3 [b]	335832±52828 [b]
GK Élet	4536±823 [b]	41±4 [b]	57±5 [b]	417826±63977 [b]
Cappelle Desprez	5345±443 [c]	41±2 [c]	58±2 [c]	515503±45671 [c]

Within columns, means superscripted by the same letter are not significantly different at the $P < 0.01$ level of probability.

TÁMOP 4.2.1/B-09/1/KMR/-2010-0005, NKTH-OTKA CK80211 and CK80274. A part of this study was presented on the 10th Congress of the Hungarian Society for Plant Biology, August 31 - September 2, 2011, Szeged, Hungary.

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