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

Volume 49(1-2):97-98, 2005
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

Greenhouse testing of new wheat cultivars compared to those with known drought tolerance

László Gáspár[1]*, Czövek Pálma[1], Ferenc Fodor[1], Borbála Hoffmann[2], Péter Nyitrai[1], Király István[1], Éva Sárvári[1]

[1]Department of Plant Physiology and Molecular Plant Biology, Eötvös Loránd University, Budapest, Hungary, [2]Georgikon Faculty of Agriculture, Institute for Plant and Environmental Sciences, University of Veszprém, Keszthely, Hungary

ABSTRACT Drought causes huge losses in crop production. With global climatic changes in prospect the extension of drought-prone areas is likely to grow in the future which will require the growing of drought resistant cultivars. In this study some physiological parameters of newly bred Hungarian cultivars were compared with those of drought tolerant or sensitive cultivars. The connection of these physiological parameters to the yield of the cultivars was also evaluated. Drought treatment decreased soil water content from 49-55% (control) to 13-17% (treated) of its water-holding capacity. As a result, there was a significant increase in midday water saturation deficiency (from 10-20% in control plants to 30-45% in treated ones) and a parallel decrease in transpiration rates and net CO_2 assimilation. Analysis of averaged data of 3 consecutive years suggests that there is some correlation between net CO_2 assimilation and sugar accumulation in flag leaves during the grain filling period with the yield of the different cultivars, however, there are other important factors influencing the yield which were not analysed in this study. The lowest yield reduction was found in Gk Pántlika, Mv Mariska, Mv Mambo and Mv Emese (7-10%), which proved to be drought tolerant cultivars from an agronomical point of view.
Acta Biol Szeged 49(1-2):97-98 (2005)

KEY WORDS

CO_2 assimilation
drought stress
yield
wheat

Changes in global climate are forecast to increase the extension of drought-prone areas. Central Europe, amongst other wheat producing areas, will also be affected. Under Hungarian climatic conditions drought stress of wheat mainly occurs during anthesis and the grain filling period causing considerable yield losses. Consequently, one of the main aims of wheat breeding is the improvement of drought resistant cultivars. Understanding the mechanisms underlying drought tolerance could facilitate the work of wheat breeders.

Photosynthesis, which is the most significant process influencing crop production, is also inhibited by drought stress (Chaves and Oliveira 2004). The major effect of water deficiency is the closure of stomata that leads to a lowered internal concentration of CO_2, which in turn inhibits the Calvin-cycle even at moderate water deficits. Consequently, a shortage of reducible coenzymes facilitates the arising of photoinhibitory conditions (Horton et al. 1996). Photosynthetic production of plants in shortage of water further diminishes as a consequence of their limited growth rate which has been suggested as an adaptive feature for plant survival under stress, because it allows plants to divert assimilates and energy, otherwise used for shoot growth, into protective molecules to fight stress (Zhu 2002) and to maintain root growth, improving water uptake (Chaves et al. 2003). To counter the inhibiting effect on growth by drought, the ability to remobilize stem reserves is likely to be an important factor to maintain reproductive growth under water deficits.

The aim of this study was to compare some physiological parameters of newly bred Hungarian cultivars with those known to be drought tolerant or sensitive, and to evaluate the connection of these parameters to the yield (drought tolerance from an agronomical point of view) of these cultivars.

Materials and Methods

The plants were grown in an unheated glasshouse with natural sunlight. Seeds of the genotypes were sown in plastic pots filled with 8.5 kg of soil composed of 750 g eutric cambisol kg^{-1} and 250 g sand kg^{-1} (water-holding capacity: 340 g kg^{-1}). After sowing, each pot was brought to water-holding capacity. Control plants (well-watered) were irrigated daily until full ripening. The drought stress (dry treatment) was induced by adding only 50% of the water given to the control pots. This water shortage equals to a midsevere-severe drought occurring regularly in Hungary. Stress treatment was started at the mid-flowering stage and continued till maturity. Treatments were arranged in a randomised complete block design with six replicates.

Eight genotypes were examined to make comparison of their response to drought. Among the examined material there were newly bred Hungarian cultivars:, Mv Mambó, Mv Mariska, Mv Emese, Mv Magma, Mv Emma 1B/1B, Mv Emma 1B/1R, Mv Fatima, Gk Nyár, Pántlika; well known drought tolerant cultivars: Plainsman, Kobomugi, Sakha-8

*Corresponding author. E-mail: laszlo_gaspar@hotmail.com

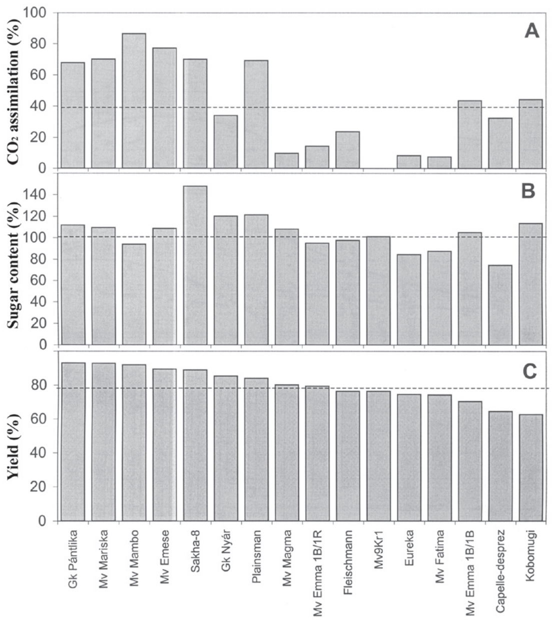

Figure 1. Net CO_2 assimilation (A) and sugar content of flag leaves during the grain filling period (B) and yield (C) of winter wheat cultivars in greenhouse experiments in the years 2002-2004. Data are presented as percentage of the control. Dashed lines represent mean values of all cultivars.

and the drought sensitive cultivars: Capelle-Desprez, Eureka. Two plants were grown up in each pot and harvested at maturity. Soluble sugar content of leaves was extracted with 80% ethanol, separated with thin layer cromatography (HPTLC, 60 F_{254}, MERCK). Chromatograms were developed with antron reagent (20 min, 80ºC) and analysed with Phoretix1D software. The rate of light-induced CO_2 fixation was studied in detached leaves, in an atmosphere containing $^{14}CO_2$ in a sealed glass chamber with Hg-blockade according to the method of Láng et al. (1985). The radioactivity of the samples was determined by means of the liquid scintillation technique (Beckman LS5000TD).

Results and Discussion

After reaching the mid-flowering stage the soil of well-watered control plants were kept at 49-55% of their water-holding capacity, while the water content of treated pots decreased to 13-17% of the water-holding capacity. As a result, midday water saturation deficiency (WSD) increased from 10-20% (control plants of the different cultivars) to 30-45% in treated plants.

In accordance to previous results transpiration rates were the most sensitive indicators of water deficiency. For this reason we selected a limited number of cultivars to follow the diurnal course of their gas exchange parameters. The transpiration rate of control plants increased from morning values of 4-6 mmol $m^{-2}s^{-1}$ and reached midday values of 8-10 mmol $m^{-2}s^{-1}$which was followed by a gradual decrease to 2-5 mmol $m^{-2}s^{-1}$ in late afternoon. In treated plants stomatal aperture did not follow this pattern as transpiration rates all day long remained in the 1-4 mmol $m^{-2}s^{-1}$ range. While no significant changes were observed in stomatal aperture between the selected genotypes (partly because of high standard deviation) the picture was somewhat different as far as CO_2 uptake is concerned. CO_2 assimilation rates were highest in the early morning hours in both control (12-18 μmol $m^{-2}s^{-1}$) and treated plants (2-5 μmol $m^{-2}s^{-1}$) and gradually decreased to values of 3-7 and –1- –3 μmol $m^{-2}s^{-1}$ in control and treated plants, respectively. It has to be pointed out that while treated plants of Mv Emese and Kobomugi retained a positive balance of CO_2 uptake, the same calculation gave negative values in the case of Plainsman, a cultivar generally thought of as drought resistant.

Data of experiments of 3 consecutive years was analysed to find correlation between yield and net CO_2 assimilation together with sugar (fructose+glucose+sucrose) accumulation in flag leaves during the grain filling period (Fig. 1). The lowest yield reduction was found in Gk Pántlika, Mv Mariska, Mv Mambo and Mv Emese (7-10%: drought tolerant cultivars from an agronomical point of view), while Capelle-Desprez and Kobomugi lost 35% and 37% of their controls yield, respectively. Although some correlation of both net CO_2 assimilation and sugar accumulation in the flag leaf with yield is apparent (the cultivars with higher yield show net CO_2 assimilation and sugar accumulation values higher than the average), it has to be mentioned that there are cultivars, which does not seem to fit in. One of the most notable exceptions is Kobomugi, a cultivar, which accumulates sugars to keep low its WSD, thus maintaining relatively high net CO_2 assimilation, yet having the most reduced yield of all the cultivars. These exceptions show that there are other yield influencing factors not discussed in this study (e. g. synthesis of protective molecules) and point to the complex nature by which these factors determine the yield.

Acknowledgements

This work was supported by NKFP (4/038/2001).

References

Chaves MM, Maroco JP, Pereira JS (2003) Understanding plant response to drought: from genes to the whole plant. Funct Plant Biol 30:239-264.

Chaves MM, Oliveira MM (2004) Mechanisms underlying plant resilience to water deficits: prospects for water-saving agriculture. J Exp Bot 55:2365-2384.

Horton P, Ruban AV, Walters RG (1996) Regulation of light harvesting in green plants. Annu Rev Plant Physiol Plant Mol Biol 47:655-684.

Zhu JK (2002) Salt and drought stress signal transduction in plants. Annu Rev Plant Biol 53:247-273.

Láng, F, Sárvári É, Szigeti Z (1985) Apparatus and method for rapid determination of photosynthetic CO_2 fixation of leaves. Biochim Physiol Pflanz 180:333-336.