POSSIBILITIES TO INCREASE STRESS TOLERANCE OF WHEAT

Borbála HOFFMANN [1] *– Nikolett ARANYI* [1] *– Sándor HOFFMANN* [2] *– Márta MOLNÁR-LÁNG* [3]

[1] Department of Plant Sciences and Biotechnology, Georgikon Faculty, University of Pannonia, 8360. Keszthely, Deák F. u. 16., e-mail: hoff-b@georgikon.hu
[2] Department of Crop Production and Soil Sciences, Georgikon Faculty, University of Pannonia,
[3] Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár

Abstract: Agricultural production is limited primarily by environmental stresses among those the most important is water deficiency. The safety of wheat production requires the propagation of drought tolerant cultivars. Hybridization between related species makes it possible to transfer desirable traits from one species into another. Barley - known to have good drought tolerance - is a potential gene source for wheat improvement. Lines developed from wheat/barley hybrids were investigated to determine how the added barley chromosomes (segments) influence drought tolerance in wheat. Data were obtained for anthesis- and maturity date, plant height, root/shoot ratio and components of grain yield. On the basis of our data new lines with valuable agronomic traits can be selected which could be used in wheat breeding programs–and consequently in wheat production.

Keywords: wheat-barley translocation, addition, substitution lines, drought tolerance

Introduction

Agricultural production is limited primarily by environmental stresses among those the most important is water deficiency. The efficient use of water stored in soil has special significance. Annual precipitation in Hungary will not be more in the future and its unfavorable spatial and time distribution will even be less favorable (Várallyay, 2008).
The primary approach for alleviation of environmental stresses focused on modification of the environment. These are, however, expensive and effective only in the short run, contemporaneously loading the environment. Economic and ecological constraints make the approach of genetic improvement of stress tolerance a viable alternative. Differences were found between genotypes regarding their tolerance to environmental stress, allowing selection to be made for better tolerance (Balla et al., 2006). Limited soil moisture influences nutrient availability for plants. Pepó and Balogh (2008) found that advantageous water supply decreased the optimum nutrient level of the cultivars.
Hybridization between related species makes it possible to transfer desirable traits from one species into another. Barley - known to have good drought tolerance - is a potential gene source for wheat improvement. The introgression of barley (*Hordeum vulgare* L.) chromosome segments into wheat (*Triticum aestivum* L.) may result in the transfer of new, useful traits, such as earliness, tolerance of drought and soil salinity or various traits for specific nutritional quality into wheat. Since the first successful hybridization between wheat and barley (Kruse 1973) only a few wheat-barley translocation and substitution lines have been developed (Islam and Shepherd 1992; Koba et al. 1997; Molnár-Láng et al. 2000a.) and were investigated regarding cytogenetic characteristics and fertility (D. Nagy et al. 2002; Szakács and Molnár-Láng, 2007.). Even less information is available on the ability of barley chromosomes to compensate for wheat chromosomes regarding agronomically important characteristics and there is no information available on the behaviour of wheat-barley derivates grown on the field.

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The aim of our study was to determine how the added barley chromosome (segments) influence various agronomic traits in wheat.

Materials and methods

Two wheat/barley addition (2H, 3H) and one translocation line (7D-5HS) produced from the 'Mv9kr1' × 'Igri' hybrid (Molnár-Láng et al. 2000b), and one substitution [4H (4D)] and two translocation lines (3HS.3BL, 6B-4H) orginating from the 'Chinese Spring' × 'Betzes' hybrid (Molnár-Láng et al. 2000a) developed in Martonvásár with the parental cultivars together were investigated.
The field experiment was carried out at UP Georgikon Faculty, Keszthely, during 2007-2008. The soil of the experimental site is a lessivated brown forest soil (FAO: Luvic phaosem) with low organic material, medium K- and P content. Row space was 30 cm. Each genotype was sown in a 15m long row. The half length of the rows were covered with a plastic folia on 21th of April (EC: 30-31) to protect plants from rain *(Picture 1)* indicating 180 mm difference in water supply between control (not cowered) and stress (cowered) treatment. Sowing and harvest was made with hand. Data were obtained for dates of ontogenesis (EUCARPIA decimal code for growth stages), plant height, root/shoot ratio at EC 30-31, leaf water potential (Ψ_L: was determined in a pressure chamber – PMS Instrument – with N_2 gas), ear length, thousand grain weight, number of kernels, and grain yield.

Results and discussion

At tillering (EC 30-31) 6 plants of each genotype were grubbed up and length and mass of root and shoot were measured. From point of drought tolerance root length and **root/shoot ratio** are important characteristics. The larger root biomass could contribute to an increased drought tolerance (Hoffmann and Burucs, 2005). All wheat-barley derivates had longer roots and shorter shoots than the wheat parent resulting in an even more increased root/shoot ratio *(Figure 1)*. The mean of lines was 47%, while the root/shoot ratio of the parents was 22- and 41% for wheat and barley respectively. The most favorable result was measured in case of 7D-5HS (65%) and 4H (4D) (55%).

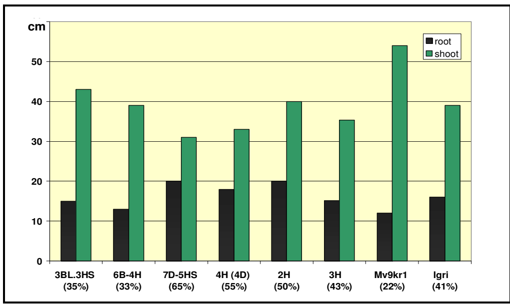

Figure 1. Root- and shoot length (cm) and root/shoot ratio (in parentheses under the sign of the line) of wheat-barley derivates in both treatments.

Picture 1. Half of the rows were covered with a plastic folia at EC: 30-31 to protect plants from rain. Each row (15m) is one genotype. Differences in plant height are visible.

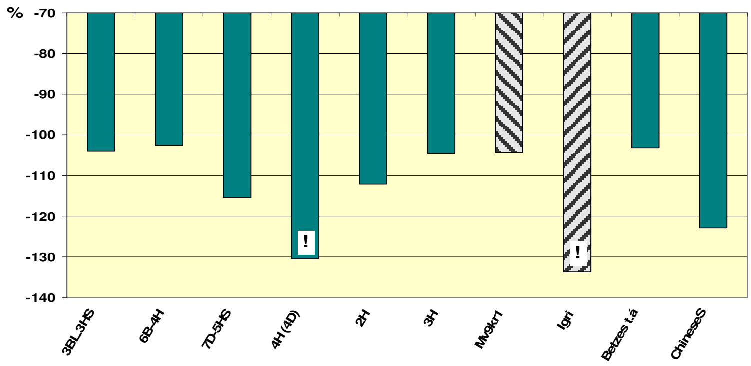

Figure 2. Leaf water potential (Ψ_L) of wheat-barley derivates and their parents in stress treatment expressed in percent (%) of the control treatment.

During drought stress the **water potential** of the plant decreases leading to the strengthening of suction force, that can be considered as the result of osmotic adaptation, depending on the drought tolerance strategy of the genotype (Hoffmann et al. 2006). Leaf water potential (Ψ_L) in our experiment *(Figure 2)* was only reduced by 3-5 % in stress treatment in the case of 3BL.3HS, 6B-4H and 3H lines and the wheat parent and 12- 15% in the case of 2H and 7D-5HS lines while it was 30- and 34% in the case of 4H (4D) and the barley parent compared to their control plants.

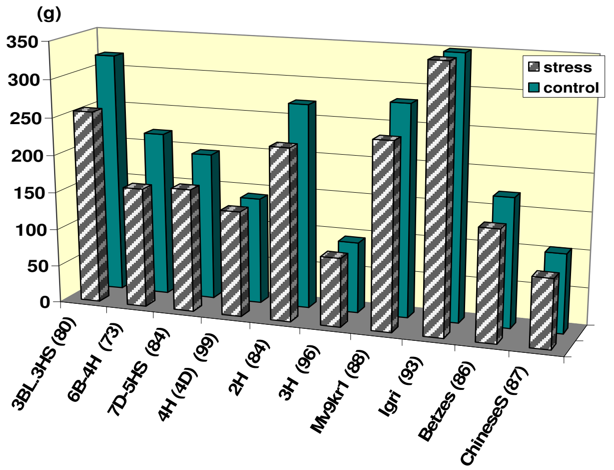

Figure 3. Grain yield (g) of wheat-barley derivates and their parents harvested on 1 m in control and stress treatments and the relative value (%) in parentheses behind the sign of the line.

Grain yield was reduced by 12,4 % in the mean of genotypes examined (*Figure 3*). The highest yield loss was measured in case of 6B-4H (27%), while there was no yield

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decrease in the case of 4H (4D). The barley parent Igri lost 7- and the wheat parent Mv9kr1 12% of its control's yield. But it is not enough to consider only the decrease of yield, we have to take into account the absolute values as well to become a more sophisticated conclusion. Lines 3H and 4H (4D) had the smallest yield in both treatment, while 3BL.3HS over yielded the wheat parent, though it has lost 20% of it's controls yield *(Figure 3).*

Conclusions

Six addition, substitution and translocation lines developed from wheat-barley hybrid were investigated in a field experiment to determine how the added barley chromosomes (segments) influence drought tolerance in wheat. Plants adapted to water deficiency by intensifying root growth and at the same time by the retention of shoot growth, resulting in a relative increase of root/shoot ratio. But the retention of shoot growth causes the decrease of assimilating leaf area which resulted in yield losses. During drought stress the water potential of the plant decreased, that can be considered as osmotic adaptation. The use of these genetic material in wheat breeding programs can result in new varieties with better drought tolerance.

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