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Wheat breeding for tolerance to drought stress at the Cereal Research Non-Profit Company

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ABSTRACT As selection methods for drought tolerance of wheat, water retention ability, chemical desiccation tests, determination of water relation parameters and carbohydrate accumulation were applied in the breeding system from the start of the breeding among the crossing partners until the last steps on the advanced lines before entering them in official yield performance trials. **Acta Biol Szeged 46(3-4):25-26 (2002)**

KEY WORDS

carbohydrate accumulation
desiccation test
drought tolerance
water relation parameters
wheat

In Hungary abiotic stresses are the most limiting factors in wheat production. The improvement of the yields under stress conditions therefore must combine the high yield potential and specific factors, which are able to protect the crop against reductions due to different stresses. We have to apply simple, but reliable field screening tests by which we can select on certain physiological characteristics that could be advantageous under different abiotic environmental stress conditions. Wheat breeding deals with tens of thousands of lines each year so these tests must be fast, easy-to-apply and inexpensive too.

In our breeding system we have applied simple and widely used field screening tests like water retention ability test of excised leaves and chemical desiccation method. The water-retention test studies the cuticular resistance of the flag leaves (Clarke 1982), while by the chemical desiccation we can model a lethal post-anthesis water stress and check the plants‘ ability to support grain filling by translocated stem reserves (Blum 1988).

Materials and Methods

Breeding system is a modified pedigree method (Kertész et al. 1998) based on manual crossing, head selection from F2 generation until uniform head-rows are available. Generally from F4 generation information yields trials, later four-replicated yield trials, and at last multi-location performance tests help selecting the best ones among the advanced lines. From the generation of F5 quality tests and parallel scoring in rust and virus nurseries (under provocative conditions) give additional information for the successful selection.

Water retention ability was tested by the determination of the fresh weight, of 20 excised leaves of the 77 genotypes (registered varieties and candidates) harvested from the field early in the morning. After keeping them in a controlled environment room for 8 and 24 hours their weight was measured again and after a total desiccation the dry weight of the leaves was determined. From these data the total loss of initial water content could be defined. Studied the actual water relations of the different genotypes by the determination of their actual relative water content (RWC) three times (at late boot stage, after heading and two weeks after heading of the most genotypes). RWC was determined by their fresh weight (FW), turgid weight (TW-after a 24 hrs incubation on wet filter paper in Petri-dishes), and dry weight (DW) by this formula: (FW-DW)/(TW-DW) x 100 (%).

Chemical desiccation tests were done to evaluate the translocation ability of the stem reserves in 55 genotypes. Desiccant (2% $NaClO_3$ solution) spraying was done 14 days after anthesis of each entry. Kernels weight reductions due to the post-anthesis stress was assessed by comparing treated and control plots for each entry.

Water relation characteristics: The effects of different types of drought stress were studied on five wheat varieties in a four-replicated greenhouse experiment. The experiment had 3 treatments, the control without drought stress, the slow and mild stress that make the plants adapt, and a serious, terminal drought stress. Pressure - volume curves were drawn on the base of water potential data measured by pressure chamber, and relative water content (RWC) data. Determined the water potential, the osmotic potential at full turgor and

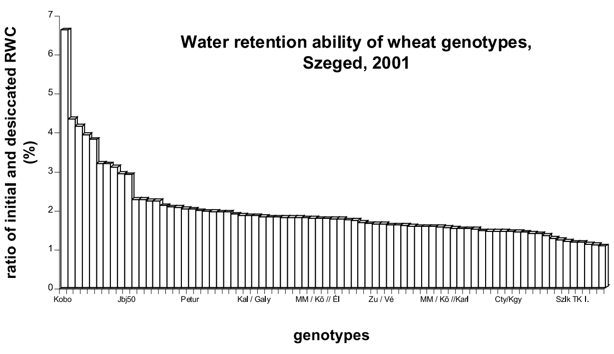

Figure 1.

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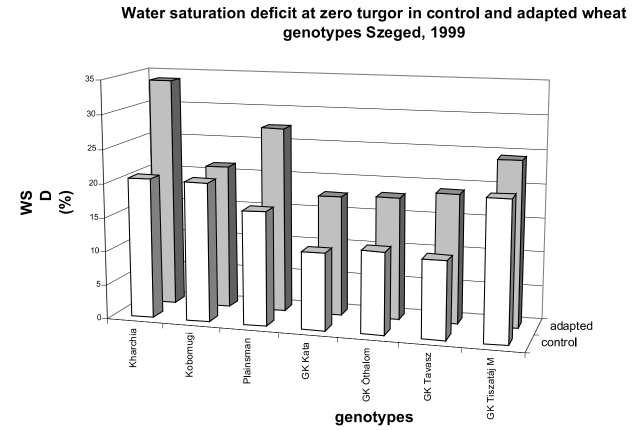

Figure 2.

zero turgor, and the water saturation deficit at zero turgor.

Accumulation of carbohydrates was determined in the flag leaves of plants treated as mentioned above.

Results and Discussion

In water retention ability we have found a variation of 93 - 99 % water loss in relative water content of the excised leaves after 24-h desiccation (Fig. 1). This method can test the cuticular resistance of the flag leaves only and no correlation was found with the results of the other tests.

Due to the desiccant treatment wheat varieties differed in a range of 11 - 61 % reduction of kernel mass and this response was correlated with the response to the late season drought among the genotypes tested. By these tests hundreds of lines can be evaluated relatively fast and easy. We have proved (Cseuz and Erdei 1994) that the mentioned simple field screening methods had high correlation with the results of the pressure-volume curve data in a series of wheat cultivars. Pressure - volume curves were drawn on the base of water potential data measured by pressure chamber, and relative water content (RWC) data. Genotypes that performed as tolerant ones in the field tests, had lower water potential (osmotic potential) and could reach the zero turgor point at a higher level of water saturation deficit (Fig. 2). We note, however, that drawing pressure-volume curves is quite time-consuming and not a real selection tool for large number of lines. Determination of the level of accumulated carbohydrates in the flag leaves of control and stressed plants were informative. It is seen (Fig. 3) that under slow and mild water drought stress (Treatment 1), the known drought- and salt-tolerant lines (Kobomugi, Plaisman and Kharchia, respectively) increased their carbohydrate concentration, while the sensitive controls did not show this form of adaptation.

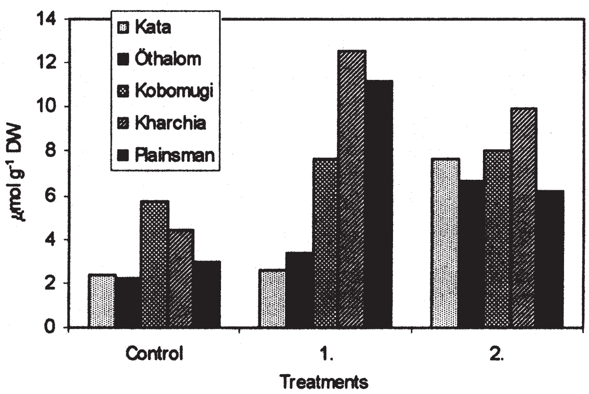

Figure 3.

These selection methods are applied in our conventional winter wheat breeding program (Cseuz et al. 1998). The above-mentioned tests are carried out at the very start of the breeding among the crossing partners and at the very end of it, namely among the advanced lines before entering them in official yield performance trials.

In younger, segregating generations (in head-rows of F3 - F5 generations) we select on the base of the visual scoring of morphological and phenological characteristics that are advantageous under dry conditions. This selection is running parallel with the yield tests. At the end of the breeding procedure not more than 40-50 lines are tested in our multi-location yield performance network. The collected and recorded information helps us in decisions to find the best genotypes. At last among the high yielding and stress tolerant lines we will find the most tolerant and productive ones which could perform well in official trials too.

Acknowledgments

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