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Selection for drought resistance of wheat using electrical capacity measurements as indicators for root system size

Anna Hermanska[1*], Ladislav Blaha[2] and Irena Bizova[3]

Abstract

Root system size (RSS) of wheat is a selection criterion for drought tolerance. Wheat with a better root system can better exploit soil water resources and realize higher yields. Varieties with a good water management can be donors for the creation of new breeding material more resistant to drought. Results from root system size measurements at Czech locations from 2009-2012 are presented.

Keywords

Climate change, *Triticum aestivum*

Introduction

Globally drought is a main limiting factor for crop production. Global warming already affected the climate in Czech Republic in recent years: drought periods became more frequent and rainfalls were short and heavy resulting in a less sufficient use of water by crops. Contrary, the average air temperature increased and groundwater levels declined. The growing season 2012 was one of the driest in the last 60 years. Some fields were affected that much by drought that the crops were ploughed.

Root system size (RSS) of wheat could be a selection criterion for drought tolerance. During dry periods most plants expand with their roots to deeper soil regions. Plants are able to change their morphology during dry periods, e.g. the aboveground mass is reduced whereas the mass of roots is increased. Varieties react to drought in different ways, some of them expand into deeper soil horizons while others increase the volume of roots. Wheat varieties with a more effective water management are able to realize higher yields in drought prone environments (MANSCHADI et al. 2006). Varieties with good water management could be donors for the creation of new breeding lines and varieties with improved drought tolerance. An easy method for measuring root system size is electrical capacity of roots. The premise is a variety with a larger root system size would have a higher electrical capacity.

Material and methods

37 spring wheat (*Triticum aestivum* L.) genotypes were sown at two sites at a distance of 500 m at Uhretice (Czech Republic) in 2009. Every variety was sown by hand in 1 m rows (10×15 cm distances within and between rows). Per row ten grains were sown. Each variety was sown in four replications. During the vegetation period the electrical capacity of RSS, the main characteristics and diseases were evaluated for each row. Based on these results and on additional hydroponics experiments (*Figure 1*) seven varieties with different RSS, i.e. 'Amaretto' (DE), 'Bárbaro-B' (CL), 'Bhouth 4' (SY), 'Frontana' (BR), 'Granny', 'Septima' and 'Zuzana' (all CZ), were selected for further tests.

These seven varieties and 20 breeding lines of their crossing progenies were sown at three sites (Chlumec nad Cidlinou, Hustopece, Uhretice) from 2010 to 2012. Each variety and line had 40 plants. The electrical capacity of RSS was measured on 24 plants. The first measuring was carried out during stem extension (DC 34-43), the second during hea-

Figure 1: **Root system size of various spring wheat varieties in hydroponics experiments** (1, Zuzana; 2, Amaretto; 3, Septima; 4, Granny; 5, Frontana; 6, Bárbaro-B; 7, Bhouth 4)

[1] Selgen Ltd., Uhretice Plant Breeding Station, CZ-538 32 UHRETICE
[2] RCI, Drnovska 507, CZ-161 06 PRAHA 6 - RUZYNE
[3] Selton, Research Centrum, Stupice 24, CZ-250 84 SIBRINA
[*] Corresponding author: Anna HERMANSKA, hermanska@selgen.cz

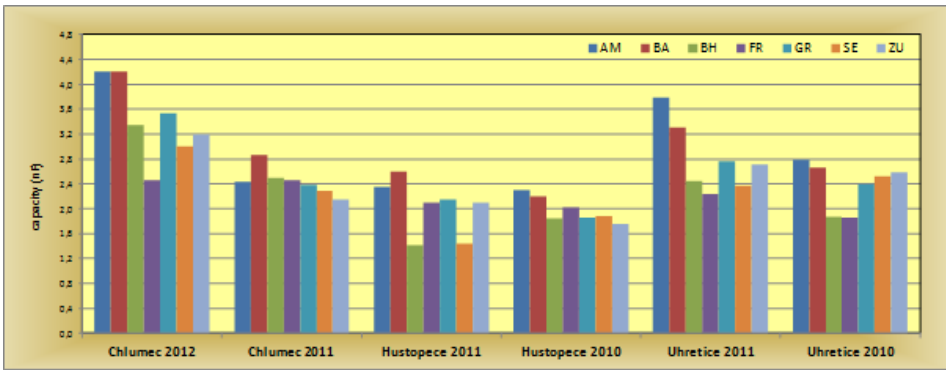

Figure 2: **Mean electrical capacity of spring wheat RSS measured during stem extension and heading at three Czech locations in 2010-2012** (AM, Amaretto; BA, Bárbaro-B; BH, Bhouth 4; FR, Frontana; GR, Granny; SE, Septima; ZU, Zuzana)

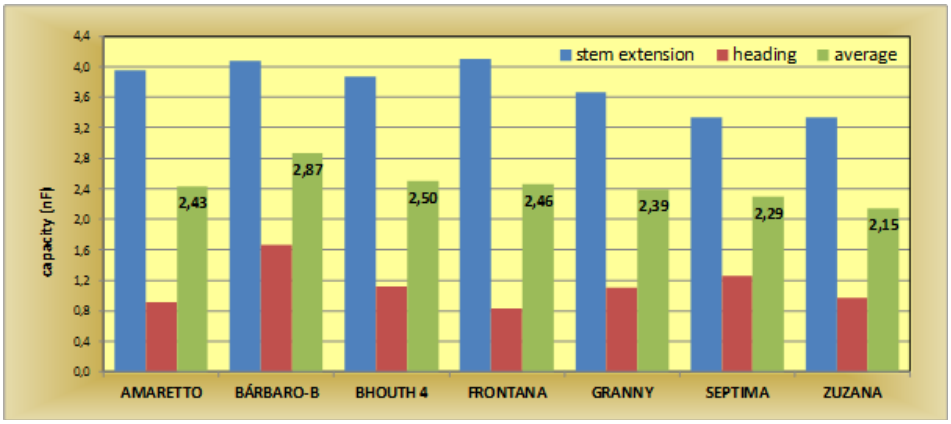

Figure 3: **Mean electrical capacity of spring wheat RSS measured during stem extension and heading at Chlumec nad Cidlinou in 2011**

Table 1: **Mean electrical capacity of spring wheat RSS measured during stem extension and heading at Uhretice in 2010**

Variety	Electrical capacity (nF)		
	Stem extension	Heading	Mean
Amaretto	4.57	1.00	2.79
Bárbaro-B	4.41	0.92	2.66
Bhouth 4	3.04	0.70	1.87
Frontana	3.19	0.52	1.86
Granny	3.87	0.93	2.40
Septima	3.98	1.08	2.53
Zuzana	4.35	0.83	2.59

ding and flowering (DC 59-69). Plants affected by viruses and border plants were not measured.

The principle of measuring RSS is based on the fact that the living part of the roots shows electrical activity on their membranes. The electrical interface between the internal and external environment is measured by a LCR Meter ELC-133A with a frequency of 1 kHz; the unit of measurement is nF. During the measurements one electrode is placed in the soil near the plant while the second electrode is connected to the plant at 1 to 2 cm above the soil. The LCR Meter measured the electrical capacity of roots by passing AC in the electrical circuit between RSS and soil (CHLOUPEK 1977).

Results

Differences in RSS among varieties were observed at all test sites (*Figure 2*). 'Bárbaro-B' and 'Amaretto' had the biggest RSS during all measurements, except at Chlumec in 2011 (*Figure 3*). These two varieties had the largest RSS values during all measurements except for the heading stage in 2010 (*Table 1*), where 'Septima' exhibited the highest value (1,08 nF). Thereby, 'Bárbaro-B' and 'Amaretto' were identified as donors of a bigger RSS. Further experiments on RSS will be carried out on F2 and F3 plants of crosses between these two varieties. The electrical capacity can be affected by weather conditions during the vegetation period and by soil properties of the test site. Some varieties did not respond to these influences and showed the same values of RSS across years and sites. The most stable variety in this respect was 'Frontana'.

There are many methods for the evaluation of RSS. We used a quick method which can be easily applied during the vegetation period for screening in the field. These and other results demonstrate that via electrical capacity it is possible to select genotypes with larger RSS (STREDA et al. 2009). Hence, this method can be used as secondary selection criterion in the breeding of drought tolerant varieties. Varieties with larger RSS should be more tolerant to drought and, therefore, more stable with respect to yield in years with limited rainfall.

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Note: *The online version of the proceedings includes figures in colour. It can be either downloaded from the homepage of the meeting (http://www.raumberg-gumpenstein.at/ - Downloads - Fachveranstaltungen/Tagungen - Saatzüchtertagung - Saatzüchtertagung 2012) or requested from the corresponding author.*