POSSIBILITY OF SELECTION FOR HIGHER SEED VIGOUR OF BARLEY

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Abstract: Assessment methods for the seed germination are designed in an environment of ideal conditions, however, it is necessary to know the real behaviour in the field conditions. At this stage, on the series comes an important factor, which is based on the ability of germination – the seed vigour. The seed vigour is characterized ability by the seeds to emerge and create a basis for a new plant under real or stress conditions. The purpose of this study was to obtain general facts about the heritability of the seed vigour. Effect of drought stress on the observed characteristics of spring barley (*Hordeum vulgare* L.) was evaluated in the pot experiment. The root system size and seed vigour were evaluated in four genotypes. Seed vigour as the germination percentage under drought (-0.5 MPa) and temperature stress (10°C) was evaluated. It was also evaluated the relationship between seed vigour and the root system size of the parents and their progenies. Statistical significant correlations (r = 0.747–0.801) of the root system size in the stage of stem elongation and seed vigour in Variant III (moderate stress) were found. The root system size of parents at the stage of heading in unstressed variant (Variant II) statistically significantly (r = 0.730–0.939) influenced the length of the plumula and roots of the progenies in both variants of seed vitality testing (i.e. control and drought stress).

Key Words: root system size, seed vigour, stress conditions

INTRODUCITON

Climate models predict air temperature increase and change of precipitations regime accompanied by frequent episodes of drought in the future. However, water deficit may not be caused by lack of water solely. The reason may be salinity of the soil as well (Hirt, Shinozaki 2004). Although drought reduces the development of cereal crops in all stages of growth, the most critical impact has during flowering and grain filling and leads to substantial losses. The yield of the crop is therefore dependent on the intensity and also duration of droughts (Farooq et al. 2014). An important phase of growth in terms of drought is primarily seed germination. It is obvious that a certain environment and year has a significant impact on the germination or vigour respectively. Laboratory testing of seed germination simulates ideal conditions, but does not provide adequate results, which indicate the quality of seeds in natural or conditions burdened with increasing stress. For practical use, it is important to know the real behaviour of seeds outside the optimum conditions – the seed vigour (Hampton, TeKrony 1995). Seed vigour is the ability of seeds to germinate and form the basis for a future plant growth and development in standard and stress conditions (drought, low temperatures, a lack of nutrients). When the soil conditions were unfavourable, the results of field emergence for wheat were more closely correlated with the direct stress vigour tests than laboratory germination (Hampton 1981). Standard method that is used at this time for the seed vigour evaluation, is confined to simple physiological binary fact germinated/non-germinated. The seed vigour, however, should be viewed primarily as a quality feature for the possibility of selection of genotypes (or individual plants), that are tolerant to abiotic stresses (Klimešová et al. 2015, Rajjou et al. 2012). In general, seed vigour is the result of many factors. Tests which are based on researching of only one feature do not determine the vigour of seeds reliably, because only the combination can give a good field emergence forecast (Hampton, Coolbear 1990).

Plants represent integrated system unit, which is responsible for resistance to adverse environmental conditions on the basis of evaluation of characters at the aboveground parts and the root traits. The seed vigour, as well as the growth of the root system and the whole plant, can adversely affect a number of environmental factors, and thus significantly affect the activity of the whole plant. The genotypes with good seed germination under unfavourable conditions develop in filial generation larger root system in field conditions (Bláha, Středa 2016). The more vital seeds are then able to avoid any dryness in a period of stand establishment. In a case that it soon creates a sufficiently large root system it will be more resistant to drought and vegetation will be better emanate. Using many studies have been demonstrated stronger root growth, while the growth of aboveground plant parts is suppressed. This results in a decrease in plant transpiration while roots may grow into deeper soil layers and thus use more water supplies (Mohr, Schopfer 1995). Under the limited soil moisture conditions the roots may play an important role in relation to obtaining the yield stability of the active absorption of water from the soil. Targeted integration of the root system features into a breeding programs requires knowledge of the root diversity, its properties and also effective methods for its research. It's a very comprehensive understanding of the impact of drought on the crop, which is essential for increasing its resistance to drought.

In this connection essential is whether the seed vigour (the ability to create the basis for a new plant, the ability to response to a certain drought and other increasingly difficult conditions as a faster and increased biomass growth etc.) is in correlation with the size of the root system and also whether there is a statistically conclusive interconnection. If so, successful selection focused on vigour increase may lead to tolerance of progeny to drought.

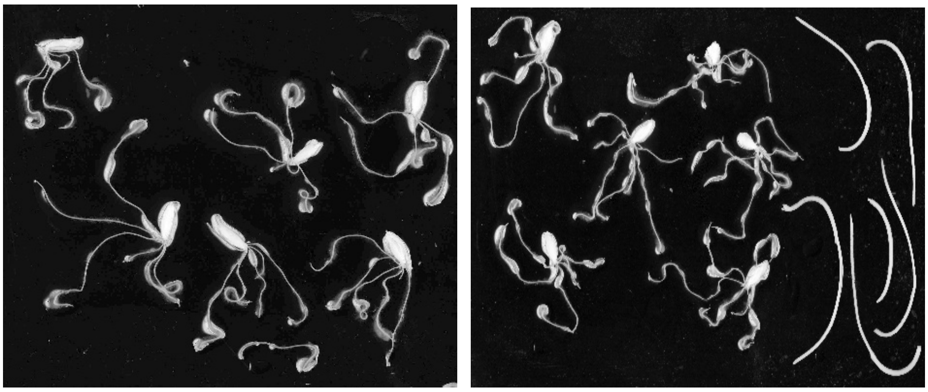
MATERIAL AND METHODS

The spring barley malting varieties *Diplom*, *Jersey*, *Prestige* and *Saloon* were mutually crossed in 2010 in a diallel manner; i.e., each variety was crossed with all others, including reciprocally (as both mothers and fathers). The resulting 12 combinations (mark as U1 – U12). These genotypes were reproduced in winter 2010/2011 in a glasshouse. F_2 and F_3 generation was sown on 2012 and 2013 in a field at the Hrubčice Plant Breeding Station and at the Želešice Plant Breeding Station. With four selected genotypes with the highest seed vigour (U2 – Prestige × Jersey, U9 – Jersey × Diplom, U11 – Diplom × Saloon, U12 – Diplom × Jersey) was founded a pot experiment in 2014. These plants were grown in plastic containers with a volume of 0.19 m^3 with dimensions of 72 × 54 × 51 cm. Inside the containers were kept four different moisture soil conditions: variant – natural rainfall (hereinafter referred to as variant I), unstressed variant at a level exceeding 65% of the available soil water holding capacity (AWHC) (hereinafter referred to as variant II), moderate-stressed variant at 65% AWHC (hereinafter referred to as variant III) and heavily stressed variant at wilting point (hereinafter referred to as variant IV), two samples from each variant. Subsequent moisture in the containers was continuously recorded with sensors VIRRIB (Amet Velké Bílovice).

The root system size of genotypes were measured with the aid of electrical capacitance (Chloupek 1972, Chloupek et al. 2010). The size of the root system was measured in the nanofarads (nF). It was used the impedance bridge ESCORT ELC-131D LCR meter (Escort Instruments Corporation, Taiwan), that was set up to parallel capacitance measured at a frequency of 1 kHz. The size of the root system (RSS) were measured as above and again in the most important phases of the vegetation – stem elongation, heading, grain filling (BBCH 30, 51, 71).

The seed vigour of harvested seeds was then tested after the dormancy period (i.e. six months after harvest). The germination was carried out in Petri dishes, after 6 caryopsis (each dish duplicated), 4 variants measured. Seed vigour of barley as the germination percentage under drought (-0.5 MPa) and temperature stress (10°C) was evaluated. Drought stress -0.5 MPa was induced using Polyethylene Glycol (PEG 6000) at a concentration of 193 $g.l^{-1}$. Control variant (without drought stress) was established in parallel. Seed vigour was evaluated using software WinRHIZO (Régent Instruments Inc., Quebec, Canada) after scanning of germinated caryopsis (see Figure 1). The caryopsis was scanned after 7, 11 and 18 days, the result was independent size of the length (cm) of plumula and roots. The results were processed using the program STATISTICA.

Figure 1 Scanned caryopsis before the evaluation of vigour, after 11 days of germination



RESULTS AND DISCUSSION

The results of correlation analysis relationship of root system size and the selected parameter vitality seeds (length of plumula and roots) see in Table 1. Statistical significant correlations of the root system size in the stage of stem elongation and seed vigour in Variant III (moderate stress) were found. It is likely that the rapid increase of the root system of parents in drought stress conditions has enabled the rapid growth of the roots of progenies at the beginning of vegetation. However, statistically significant relationship was found only in the control variant (i.e. without drought stress - 0.5 MPa).

The root system size of parents at the stage of heading in unstressed variant (Variant II) statistically significantly influenced the length of the plumula and roots of the progenies in both variants of seed vitality testing (i.e. control and drought stress). This indicates that the genotypes with higher root system size, from the optimal conditions, provide vigorous progeny for stress conditions.

High correlation coefficients (statistically insignificant) in Variant I (natural conditions) were found. It is thus likely that under natural conditions the higher root system size of parents brings greater seed vigour of progenies.

Table 1 The relationship of root system size of parental plants, measured as the electrical capacity in three phenological stages and seed vigour of their progeny (n = 8), measured as the length of roots and plumula after 7, 11 and 18 days in wet (Control) and drought stressed variant (Stress)

Term of RSS measurement	Seed vigour parameter	Variant I		Variant II		Variant III		Variant IV	
		Control	Stress	Control	Stress	Control	Stress	Control	Stress
RSS stem elongation	length 7 days	0.297	0.178	0.649	-0.163	0.314	-0.110	0.310	0.317
	length 11 days	0.174	0.666	0.563	0.169	0.747*	-0.010	0.222	0.048
	length 18 days	0.250	0.748*	0.141	-0.082	0.795*	-0.314	-0.194	0.318
	length average	0.236	0.700	0.488	-0.004	0.801*	-0.174	0.107	0.211
RSS heading	length 7 days	0.383	0.156	0.510	0.601	-0.214	0.014	-0.035	0.023
	length 11 days	0.305	0.570	0.843**	0.939**	-0.500	-0.394	-0.131	0.007
	length 18 days	0.327	0.702	0.730*	0.852**	-0.553	-0.132	-0.022	0.455
	length average	0.338	0.636	0.881**	0.899**	-0.549	-0.260	-0.087	0.211
RSS grain filling	length 7 days	0.346	0.346	0.246	0.103	0.341	0.349	0.086	0.089
	length 11 days	0.429	0.590	0.574	0.572	-0.416	-0.166	-0.104	0.069
	length 18 days	0.412	0.696	0.133	0.370	-0.509	0.169	-0.269	0.367
	length average	0.419	0.652	0.374	0.420	-0.398	0.041	-0.162	0.212

Legend: statistically significant P<0.05; statistically significant P<0.01***

CONCLUSION

Effect of drought stress on the observed characteristics of spring barley (*Hordeum vulgare* L.) was evaluated in the pot experiment. The root system size and seed vigour were evaluated in four genotypes. Thanks to the digital images of the roots appointed four varieties of maternal plants, sown in 2014 in containers in four variants of the water regime (variant with natural rainfall, drought unstressed variant at the level of the field water capacity of soil, drought stressed variant and highly drought stressed variant at soil wilting point), evaluated with a program WinRHIZO, has been proved a positive correlation between the root system size of the maternal plants and vigour of their seeds. It means, plant breeding could contribute to resolving problems associated with shortages of water for cereal cultivation.

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