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RESEARCH REGARDING THE APPROACH OF DROUGHT TOLERANCE OF TWO-ROW SPRING BARLEY

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Abstract

Drought is one of the abiotic stress factors which affects the global production of grain cereals and is an important risk factor even for consecrated cultivation sites. This is even more acute for spring grains which are the most vulnerable to drought. This is the case for two-row spring barley which is highly sensitive to heat, especially in the post-anthesis phenophase. To monitor drought tolerance, we assess a number of 27 genotypes from the germplasm collection to identify the tolerant ones, to turn them into valuable genitors for cultivars adaptable to the new climate changes. In order to evaluate drought tolerance was used the principle of inducing this phenomenon through the use of chemical desiccants ($NaClO_3$). The method is based on sprinkling the plants with desiccants ($NaClO_3$) with a 2% concentration, 14 days after the anthesis. The genotypes that constitute the objective of this study are analysed through the prism of some components of production that are most significantly affected by the effects of drought appearing in the post-anthesis phenophase, such as grain weight/spike and thousand grain weight (TGW). The most pronounced effect of the treatment is highlighted by the case of the genotypes Concerto and Vienna which reacts very favourably.

***Key words**: drought tolerance, grains weight, TGW, two-row spring barley.*

INTRODUCTION

Of all the abiotic stress factors that reduce crop productivity, drought is the most devastating and more resistant to the efforts of breeders (Tuberosa and Slavi, 2006). The complexity of this factor is determined by the number and diversity of the factors involved in plant response to stress.

From a practical point of view, drought tolerance is related to final yield rather than to plant's ability to survive under water-poor conditions (Tuberosa and Slavi, 2006). On the other hand, it can also be described as a culture's ability to maintain constant yield, regardless of environmental conditions, a concept known as yield stability (Cattivelli et al., 2002).

There are studies that reveal that in case of wheat, an increase in the average temperature by 1°C above the optimal value has caused a 3-4% reduction in yield, worldwide. In this context, even when water is not a limiting factor, the yields of cereals that go through high temperature periods towards the end of the growing season have lower yields, especially due to the negative impact of heat during the grain filling period (McDonald et al., 1983; Tewolde et al., 2006).

Development of wheat and cereal grains in general is influenced by: carbohydrates produced by the anthesis and translocated directly into the grains; carbohydrates produced after anthesis but temporarily stored in the stalk, then remobilized to the grains; carbohydrates produced before the anthesis, stored mainly in the stalk and remobilized to the grains during the filling of grains (Ehdaie et al., 2006).

Regarding the critical period for growing and filling of grains, usually in June, the year 2017 distinguish by increases of average monthly temperatures by 2.8°C and 54.2 mm deficit of rainfall compared to the multiannual average. Contrary to 2017, the year 2018 records closer values to thermal and rainfall normal level, with temperature increases of 1.5°C and rainfall increases of 3.4 mm compared to multiannual values.

MATERIALS AND METHODS

A total of 27 genotypes were selected from the two-row spring barley collection, which is represented by valuable genitors commonly used in breeding work:

- 9 genotypes of native origin (5 from ARDS Turda and 4 from ARDS Suceava);
- 18 genotypes of Western European origin (Germany, Holland and England) and Eastern European origin (Czech Republic and Estonia).

The ability to use stored reserves in the stalk for grain filling when the photosynthetic source is completely inhibited by stress factors can be assessed by destroying the photosynthesis source at the beginning of the grain filling period. It is determined the weight of grains in the absence of a current photosynthesis compared to the untreated control (Blum, 1998). Treating plants with oxidizing chemicals, such as sodium chlorate ($NaClO_3$), has the effect of destroying the photosynthetic device. This method was proposed by Blum et al. (1983). The treatment is applied by spraying the entire plant or just the flag leaves and the spike, two weeks after the anthesis, taking as reference the heading date. In parallel, untreated plants are kept as controls.

The study is presented like a polyfactorial experience of A×B×C type, where: A factor is the experimental year, with two graduations (2017, 2018); B factor is the treatment, with two graduations (untreated and treated); C factor is the genotype (with 27 varieties).

Following the biometric measurements, the rate of grain weight reduction (r) was calculated using the below formula:

$$r = \frac{(untreated\ grain\ weight - treated\ grain\ weight)}{untreated\ grain\ weight} \times 100$$

RESULTS AND DISCUSSIONS

The weight of grains/spike is one of the most important components of yield; the analysis of this trait is presented in Table 1. Under normal conditions are remarked for high grain weight/spike (greater than 1.45 g) the following genotypes: Turdeana, Daciana, Jubileu, Romanița, Prima, Adriana, Bogdana, Vienna, Alexis, Scarlet, Elisa, Concerto, Sulilly, Salome, Emir Swabeth (for 2017) and Turdeana, Daciana, Romanița, Adina, Bogdana, Scarlet, Concerto, Emir Swabeth (for 2018), along with the Belgravia genotype that is particularly evidenced by the stability of this trait in both experimental years. Under the influence of the stress factor are remarked the genotypes: Turdeana, Romaniţa, Prima, Adriana, Bogdana, Vienna, Victoriana, Alexis, Scarlet, Elisa, Concerto, Sulilly and Salome in 2017 and Belgravia and Concerto in 2018, all of them register values of the grain weight above 1.3 g/spike.

Relative values for the rate of grain weight reduction by using the desiccant register a significant variation in both genotypes and between the two experimental years, thus significant oscillations of both the minimum and maximum values from one year to the next suggests the major involvement of the environment in the control of the grain weight/spike. Regarding the fluctuations in the rate of grain weight reduction, it can be said that there are obvious differences between genotypes under the influence of stress factor.

The genotypes Adina, Victoriana, Salome and Concerto are noted for a low rate of grain weight reduction for 2017 experimental year, and the genotypes Chronicle, Salome, Concerto and Victoriana for 2018.

Most of the breeders' beliefs lead to the idea that the grains weight is a character of low heritability, so that the phenotypic expression of this trait can be greatly influenced by both climatic and technological factors. But taking into account that the same cultivation technology is used in the breeding field, the differences between genotypes in the two experimental years regarding the averages and the coefficients of variation under normal conditions, would be due to climatic factors (Table 1).

At the same time, it can be noticed that at the level of the 27 genotypes there is a small to moderate variability, the values of the coefficients of variation oscillating from 8.20 to 12.51 (Table 2).

Higher values of the variation coefficients under the influence of treatment indicate a greater fluctuation of the values around the average relative to normal conditions.

Table 1. Genotypes behaviour on grain weight/main spike (g) and the reduction rate

Cultivars	Untreated		Treated		Reduction rate (%)	
	2017	2018	2017	2018	2017	2018
Turdeana	1.58	1.53	1.36	1.25	14.04	18.21
Daciana	1.72	1.60	1.25	1.19	27.00	26.03
Capriana	1.38	1.21	1.02	0.84	26.33	30.40
Jubileu	1.52	1.34	1.25	1.25	17.45	6.65
Romanița	1.69	1.65	1.43	1.10	15.01	33.32
Prima	1.53	1.37	1.40	1.07	8.38	21.80
Farmec	1.29	1.25	1.10	1.04	14.57	16.55
Adina	1.62	1.50	1.58	1.20	2.13	20.45
Bogdana	1.60	1.53	1.40	1.26	12.57	17.88
Sidney	1.40	1.28	0.92	1.11	33.98	13.24
Steward	1.42	1.14	1.16	1.05	17.94	7.48
Mauriția	1.38	1.40	1.22	1.21	11.09	13.09
Marlen	1.42	1.36	1.27	1.23	10.29	9.43
Vienna	1.57	1.41	1.42	1.26	9.32	10.38
Victoriana	1.42	1.21	1.35	1.11	4.78	8.62
Marthe	1.28	1.23	1.07	1.11	15.88	9.52
Alexis	1.58	1.20	1.39	1.06	12.31	11.58
Scarlet	1.66	1.45	1.44	0.95	13.12	34.33
Jubilant	1.41	1.12	1.10	0.99	22.24	11.71
Elisa	1.48	1.30	1.43	0.90	3.49	30.87
Chronicle	1.43	1.22	1.29	1.21	9.38	0.32
Belgravia	1.61	1.61	1.29	1.49	19.43	7.43
Concerto	1.68	1.48	1.52	1.35	9.50	8.47
Sulilly	1.51	1.15	1.18	1.13	21.59	1.73
Salome	1.46	1.22	1.36	1.15	6.92	5.75
Arupo	1.35	1.21	1.09	1.04	19.40	13.80
Emir Swabeth	1.60	1.48	1.29	1.27	19.15	14.62

Table 2. Analysis of variability parameters for grain weight/spike (g)

Year / Parameter	2017		2018	
	Untreated	Treated	Untreated	Treated
Average	1.50	1.28	1.34	1.14
Standard deviation	0.12	0.16	0.16	0.14
Amplitude	0.44	0.66	0.53	0.65
Minimum	1.28	0.92	1.12	0.84
Maximum	1.72	1.58	1.65	1.49
Variation coefficient (%)	8.20	12.51	11.77	12.30

Frequency of genotypes in terms of reduction rate for grains weight on the main spike indicates their grouping predominantly in the range of 5.3-20.3%. It can also be mentioned that there is a fairly pronounced analogy in the two experimental years on the response of genotypes to stress factor, so in 2017 the modal is between 10.34-15.34%, and in 2018 this is slightly shifted to the left to lower values between 5.33-10.33% (Figure 1).

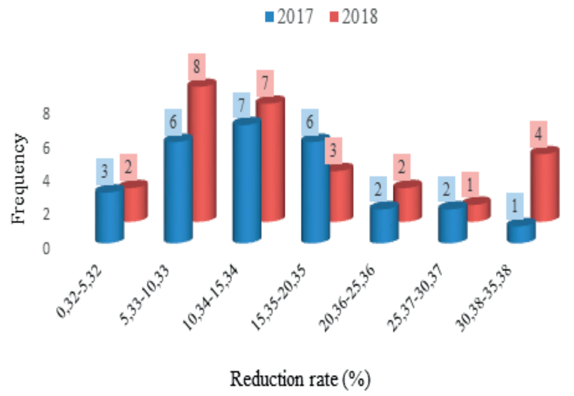

Figure 1. Frequency of genotypes for the reduction rate of grains weight

Drought tolerance can also be seen as a skill of genotypes to maintain yield parameters as stable as possible from year to year and with the highest performance.

In this context, for the breeding process the valuable sources are represented mainly by the genotypes which in both experimental years exhibit reduced fluctuations in the reduction rate of grains weight. Thus, a series of genotypes placed in the first quadrant were identified, which in both experimental years recorded values below the reduction rate average and above the average grains weight.

These can be considered genotypes that have a pronounced stability under the influence of the treatment or action of abiotic stress factors (drought).

Consequently, the genotypes Concerto, Vienna, Chronicle, Marlen and Mauritius (Figure 2) are particularly noteworthy.

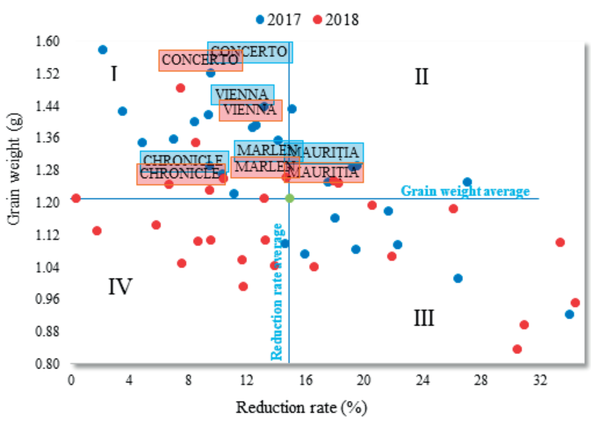

Figure 2. Stability of genotypes for grain weight reduction rate and grain weight

Even though the breeders often do not give up yield in favour of stability, yet under the current conditions where the climatic years are very different, the stability of the crops receives a new dimension in the breeding programs. Given the current increases of annual average temperatures, it is important to identify genotypes capable of fulfilling these requirements and to include them in various breeding schemes.

Thousand grain weight (TGW) trait is one of the main qualitative parameters of cultivars intended to beer industry. TGW must exceed the admissible minimum of 42 g.

Thus, a higher value of this parameter is directly correlated with higher starch content and superior germination energy. The highest values of TGW, both treated and untreated, are recorded by Belgravia genotype followed by Concerto, and in the normal conditions are also noted the native genotypes Daciana and Romaniţa (Table 3).

Table 3. Genotypes behaviour on thousand grain weight (TGW) and the reduction rate

Cultivars	Untreated		Treated		Reduction rate, %	
	2017	2018	2017	2018	2017	2018
Turdeana	54.04	50.87	45.15	40.97	16.44	19.47
Daciana	58.82	54.82	42.95	40.54	26.98	26.06
Capriana	50.65	46.89	40.99	36.73	19.07	21.67
Jubileu	51.81	52.54	46.22	47.27	10.78	10.02
Romaniţa	55.62	58.96	45.95	42.54	17.39	27.85
Prima	54.08	54.53	49.22	41.06	8.99	24.70
Farmec	50.19	50.18	41.04	43.37	18.23	13.57
Adina	56.16	53.93	54.77	43.05	2.48	20.17
Bogdana	53.61	55.24	46.75	47.22	12.79	14.51
Sidney	57.43	59.45	38.57	46.89	32.83	21.13
Steward	54.47	51.58	44.95	46.64	17.48	9.57
Mauriţia	53.73	55.87	45.65	49.39	15.03	11.59
Marlen	52.21	50.32	49.58	43.65	5.05	13.26
Vienna	58.04	53.37	50.92	46.11	12.26	13.60
Victoriana	56.64	52.61	51.36	42.72	9.32	18.80
Marthe	51.74	49.18	45.78	46.39	11.52	5.67
Alexis	54.93	51.04	45.80	38.83	16.63	23.93
Scarlet	53.89	50.37	47.52	36.89	11.81	26.75
Jubilant	50.39	49.15	47.64	39.77	5.46	19.08
Elisa	53.38	51.38	46.76	47.21	12.41	8.12
Chronicle	53.90	53.16	45.42	52.95	15.74	0.38
Belgravia	59.87	65.91	54.54	62.67	8.91	4.91
Concerto	59.33	62.33	53.99	54.87	9.01	11.98
Sulilly	58.52	51.96	52.64	50.11	10.05	3.56
Salome	51.16	47.04	41.22	42.42	19.43	9.83
Arupo	47.50	45.96	43.19	37.02	9.08	19.46
Emir Swabeth	53.48	49.31	41.95	42.56	21.56	13.70

Most affected genotypes of the effects of induced drought that have a reduction rate over 15% are: Daciana (27%), Turdeana (16%), Capriana (19%), Romaniţa (17%), Farmec (18%), Steward (17.48%), Alexis (17%), Chronicle (16%), Salome (19%) and Emir Swabeth (22%). Some of these genotypes are also found in 2018 with high values of the reduction rate of TGW, namely Daciana, Turdeana, Capriana, Romaniţa, Sidney and Alexis. Therefore, it could be extrapolated that these genotypes have less power to translate assimilates from vegetative parts to grains. This assertion is also based on the fact that under normal conditions, some of these genotypes perform for this trait: Daciana (58.82 g in 2017 and 54.82 g in 2018), Romaniţa (55.62 and 58.96) and Sidney (57.43 and 59.45).

Although most breeders claim that this trait is closely related to genotype, the difference between averages over the two experimental years suggests that besides genotype, also environmental factors have influence on the phenotypic expression of this trait. It can also be noticed that by applying the treatment, the values of variation coefficients increase; that suggests the differential response of genotypes and a more pronounced degree of spreading of values around the average.

The useful portion of the variability that could lead to a plus value is between the average and the maximum values (Table 4).

Table 4. Analysis of variability parameters for TGW (g)

Parameter \ Year	2017		2018	
	Untreated	Treated	Untreated	Treated
Average	48.45	46.69	52.89	44.81
Standard deviation	3.98	4.35	4.61	5.85
Amplitude	14.16	16.19	19.95	25.94
Minimum	41.20	38.57	45.96	36.73
Maximum	55.36	54.77	65.91	62.67
Variation coefficient (%)	8.20	9.31	8.71	13.05

Most genotypes record a TGW reduction rate below 20%. However, in 2018, seven genotypes register values above 20% compared to 2017 when only three of them exceed this limit. Differentiated expression of genotypes from year to year in the TGW reduction rate suggests that climatic conditions also play an important role in the differentiated rhythm of carbohydrate assimilation genotypes (Figure 3).

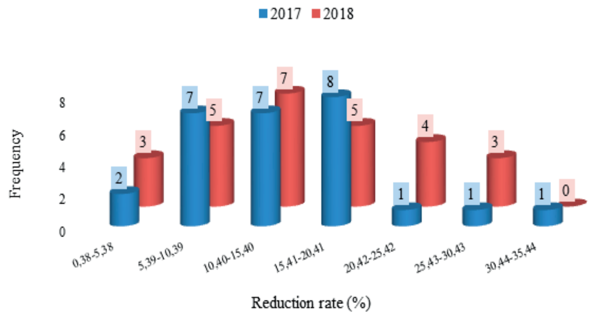

Figure 3. Frequency of reduction rate for TGW

From the perspective of TGW, the genotypes Belgravia, Concerto, Sulilly, Jubilee, Marthe, Elisa, Vienna and Bogdana can be considered genotypes with a pronounced stability under the influence of treatment, as in both experimental years they record values above the TGW average and below the reduction rate. Therefore, it can be argued that in these genotypes the rate of reduction is not influenced largely by the environmental conditions and therefore on these genotypes the transfer of assimilates to the grain is not disturbed by the environmental conditions (Figure 4).

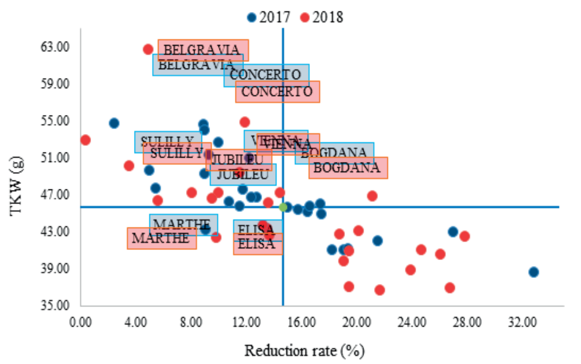

Figure 4. Stability of genotypes for TGW reduction rate and TGW

CONCLUSIONS

Concerto and Vienna varieties respond highly favourable to the influence of stress factor on the stability of grain weight on the main spike and of TGW, as well as the rate of reduction of these analysed traits, both under the conditions of a favourable 2017 year, but also under the less favourable 2018 year. Therefore, these two varieties can be considered as valuable genetic sources for the stability of both parameters under heat stress conditions during the post-anthesis period.

Generally speaking, under the stress conditions a significant percentage of genotypes respond favourably both in terms of grains weight and TGW. Thus, 18.52% is represented by the genotypes Concerto, Vienna, Chronicle, Marlen and Maurice, which under stress conditions record values of grain weight over the average of the two experimental years (1.21 g), but also with a reduction rate of grain weight below 14.83%. On the other hand, regarding TGW, a percentage of 22.22% is represented by the genotypes Belgravia, Concerto, Vienna, Sulilly, Jubileu, Bogdana, Marthe and Elisa, which record values above the average of 45.75 g and a reduction rate below the average of 14.63%.

Enlarging the identification area of valuable genotypes in terms of yield loss limitation under conditions of simulated atmospheric draught, constitutes an important prerequisite in order to create new varieties tolerant to this limitative factor which appears in the critical phenophase of grain filling. Also, the most valuable lines from the comparative cultures will be tested in this respect, too.

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