SENSITIVITY QUICK SCREENING OF WHEAT GENOTYPES TO WATER STRESS

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ABSTRACT

Wheat production in Libya is limited by water scarcity and high soil salinity, so the selection of tolerant genotypes is an important step in achieving high yields. Water takes up the position of the main environmental factor that causes osmotic stress and affects growth, crop development and especially yields. The aim of these studies was to determine the most reliable parameter (germination parameters and length, fresh and dry weight of vegetative parameters) for the separation of the genotypes sensitive to water deficit and the selection of the most tolerant one. Based on the percentage of seed germination in drought conditions, genotypes were classified into three categories: poor (<80%) V5, V2, V7 and V3, medium (80-90%) V1, V4, V8 and V12, and good germination (>90%) V6, V9, V10 and V11. The most reliable parameters for the separation of the sensitivity were: germination percentage and index of germination, shoot and root length, fresh weight of root and shoot, and dray shoot weight. Based on the overall analysis, the most tolerant varieties for water deficit are V6 (Bhoth 306, Libyan) and V11 (NS Vlajna, Serbian), while the most sensitive are V9 (Marshosh, Libyan) and V10 (Zemunska rosa, Serbian).

KEYWORDS:
Wheat, water stress, germination, growth, PEG polyethylene glycol

INTRODUCTION

Agricultural production in Libya is predominantly extensive and limited by water scarcity and high soil salinity. Wheat is grown on an area of 179,558 ha [1]. It is a Mediterranean belt in the province of Tripolitania. Although the production of this field crop is in the second place in the world, Libya, due to unfavourable agro-ecological conditions and edaphic factors, imports certain quantities of wheat. Wheat belongs to the genus *Triticum*, which has 22 species and more than 1,000 recognized varieties. During the development of wheat, there is a relatively high need for water (ideally 650-750 mm of precipitation) [2]. Therefore, water is considered to be one of the main environmental factors that cause osmotic stress and the occurrence of irreversible damage to plants [3]. Water deficiency affects the overall growth of plants: growth, development and especially the yield that can be reduced by up to 50% [4]. Lack of water reduces grain quality, increases the protein content and decreases oil content [5]. By naturally activating certain mechanisms (ionic homeostasis, an antioxidant enzyme, cell detoxification, etc.) crops can mitigate or neutralize the negative effects of stress [6-8] with the help of science and genetic engineering. Producers are therefore very interested in growing drought-tolerant genotypes because frequent and severe droughts appear in many wheat cultivation areas in the world, especially during periods of sowing and flowering of plants [9]. The aim of these studies was to determine which parameter would be a reliable indicator of varieties' tolerance for cultivation in arid regions (Libya) and relatively favourable climatic conditions in Serbia. Based on the obtained results, tolerant genotypes could be distinguished.

MATERIALS AND METHODS

Germination of nine Libyan and three Serbian varieties of wheat was examined. Libyan varieties are Abkhir (V1), Ashtar (V2), Slambo (V3), Acsad 901 (V4), Khrise (V5), Bhoth 306 (V6), Abu Al-Jud (V7), Bhoth 208 (V8) and Marshosh (V9), and Serbian Zemunska rosa (V10), NS Vlajna (V11) and NS Rani otkos (V12). Growth response under osmotic stress induced by polyethylene glycol (PEG) was investigated. The following parameters were measured: mean germination time (MGT), coefficient of variation of germination time (CVT), mean daily germination (MDG), germination percentage, germination index (GI), coefficient of the velocity of germination (CVG), coleoptile (CL) and root (RL) length, fresh and dry mass of shoot (FSW, DSW) and root (FRW, DRW) and root/shoot ratio (RSR = FRW/FSW, RSR = RDW/ SDW, RSR = RL/SL) under stress conditions and were compared with control. To test germination, 10 seeds of each variety were placed in Petri dishes in different concentrations of PEG solution: 5, 10 and 15% (5 ml per Petri dish). The experiment was set up in three replicates. Seeds were incubated at 20 ± 2 °C and 12 hours light-dark period (10 days). Germination was measured every day (10 days). The seed was considered as 'germinated' visually (radicle 1 mm). After 14 days, the values of the tested traits were measured in the fresh state, then the plants were deposited in the dryer and after three days the weights of dry samples were measured and the average value per plant was calculated. The obtained results were processed by variance analysis (one-way analysis of variance-ANOVA), significant difference test at 5% probability (LSD test) and t-test (Statistics 7).

RESULTS AND DISCUSSION

During ontogenesis, the relatively greatest needs of plants for water are in the germination phase. In this phenophase water enables seed swelling, activation of hydrolytic enzymes and decomposition of reserve nutrients that provide the initial growth of the embryo/germ. The deficit of soil water might reduce the potential length of the coleoptile and the development of seedling by inhibiting cell growth [10]. At this stage of plant development, a well-formed seedling will ensure that seedlings later adapt more easily to poor environmental conditions (i.e. mechanical soil composition). In these studies, it was hypothesized that the seeds of the tested Libyan varieties will exhibit high germination under water stress conditions and form good coleoptile and root. Analysis of the results showed that the best answer on water deficit resistance can be obtained on the base of germination percentage (Table 1, Figure 1). All examined varieties (V1-V9 Libyan, V10-V12 Serbian) based on the percentage of seed germination (average) in drought conditions were classified into three categories: weak (<80%) V5, V2, V7 and V3, medium (80-90%) V1, V4, V8 and V12, and good germination (>90%) V6, V9, V10 and V11. Based on that, it can be concluded that genotypes from Libya have low to medium seed germination (except V6 and V9 - good germination), and Serbian good germination (except B12 - medium germination). The t-test showed that there are statistically significant differences in the germination of varieties V1, V2, V3, V5, V7 and V8 in relation to varieties V9, V10 and V11, as well as varieties V2, V3 and V5 in relation to V6.

The effect of a more pronounced water deficit on the germination process is observed after the application of PEG in concentrations of 10 and 15% (Figure 1). A PEG concentration of 10% inhibited the germination of varieties V4, V8, V9 (Libyan) and Serbian V10 ≤10%; V1, V2, V5 and V7 (Libyan) <20% and 30.93% of Serbian V12 (Figure 1). The greatest germination inhibition is found after the application of 15% PEG of Libyan varieties 4.12-50% (Figure 1). However, the analysis showed that the changes were statistically significant compared to the control in the varieties: V4, V7 and V8 (Libyan) after the application of 15% PEG and in V12 (Serbian) after the application of 10% PEG (Table 1). Based on the percentage of germination, it can be concluded that the Libyan varieties V1, V2, V3, V5, V6 and V9, and Serbian V10 and V11 are tolerant to

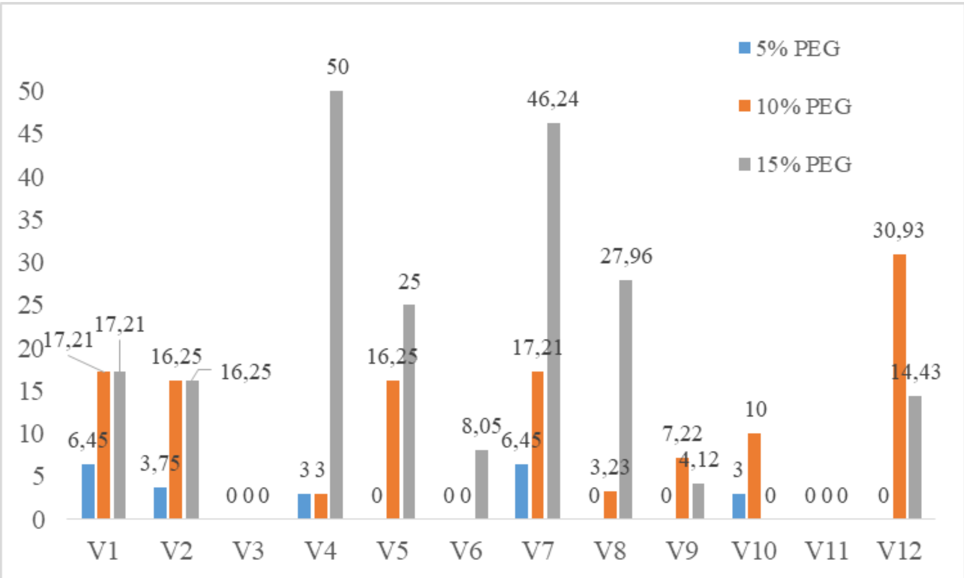

FIGURE 1
Germination decrease of different wheat genotypes (V1-V12) in PEG solution

TABLE 1
Statistical analysis of germination parameters in different wheat varieties (ANOVA, LSD)

	GP (%)	MDG (day)	MGT (day)	CVT (%)	GI	CVG
			V1			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	NS	NS	NS	NS	NS	NS
mean	83.33	3.05	0.33	38.33	3.11	33.08
SD	14.35	0.30	0.03	7.51	0.62	3.29
			V2			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	NS	NS	NS	NS	NS	NS
mean	72.50	2.95	0.35	45.47	2.57	34.72
SD	14.85	0.47	0.06	9.67	0.66	5.81
			V3			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	0.03*↓	NS	NS	0.03*↓
C vs 15%	NS	0.033*↑	0.03*↓	NS	NS	0.03*↓
mean	78.33	2.89	0.36	42.52	2.85	35.78
SD	16.97	0.51	0.07	7.33	0.67	7.28
			V4			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	0.011*↓	NS	NS	NS	0.004**↓	NS
mean	85.83	2.63	0.38	36.42	3.79	38.59
SD	26.78	0.33	0.05	13.76	0.84	4.96
			V5			
C vs 5%	NS	NS	NS	0.013*↑	NS	0.034*↑
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	NS	NS	NS	NS	NS	NS
mean	71.67	2.81	0.37	50.80	2.52	36.74
SD	18.01	0.51	0.07	18.07	0.73	6.81
			V6			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	NS	NS	NS	NS	NS	NS
mean	90.83	2.72	0.37	39.70	3.59	37.06
SD	11.64	0.26	0.03	12.19	0.61	3.54
			V7			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	0.022*↓	NS	NS	NS	0.009**↓	NS
mean	76.67	2.97	0.34	41.18	2.7	34.53
SD	23.48	0.48	0.06	21.23	0.91	6.33
			V8			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	0.011*↓	NS	NS	NS	0.042*↓	NS
mean	85.83	2.68	0.37	41.99	3.42	37.58
SD	14.43	0.23	0.03	14.40	0.61	3.20
			V9			
C vs 5%	NS	NS	NS	0.03*↑	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	NS	0.028*↑	0.008**↓	0.019*↑	0.011*↓	0.008**↓
mean	95.00	2.71	0.38	37.02	3.70	38.13
SD	7.98	0.52	0.07	14.59	0.78	7.02
			V10			
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	NS	NS	NS	0.03*↑	NS	NS
mean	96.67	2.64	0.39	31.24	3.98	2.50
SD	8.88	0.44	0.06	14.23	0.68	1.17

V11						
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	NS	NS	NS	NS	NS	NS
C vs 15%	NS	0.037*↑	0.04*↓	NS	NS	0.037*↓
mean	95.83	2.88	0.35	36.34	3.49	35.03
SD	6.68	0.25	0.03	11.00	0.43	3.20
V12						
C vs 5%	NS	NS	NS	NS	NS	NS
C vs 10%	0.003**↓	NS	NS	NS	NS	NS
C vs 15%	NS	NS	NS	NS	NS	NS
mean	86.67	3.80	0.32	33.55	2.87	32.08
SD	15.57	0.43	0.05	11.87	0.52	4.64

V1-V12 wheat varieties; 5, 10 and 15% PEG; NS-nonsignificant difference, $p<0.05$*, $p<0.01$**; SD-standard deviation; C-control; GP-germination percentage; MGT-mean germination time; CVT-coefficient of variation of germination time: MDG-mean daily germination; GI-germination index; CVG-coefficient velocity of germination

water deficit (Table 1). Based on the obtained results, the germination percentage parameter proved to be reliable for measuring the susceptibility of wheat cultivars to water deficit. Other researchers have stated similar conclusions and high reliability of this parameter. Mahpara et al. [11], based on the germination of seeds of wheat cultivars grown in Turkey, classified cultivars into three categories: sensitive, particularly sensitive and tolerant to water deficit. Asilan et al. [12] and Salehi [13] stated similarly. The researchers examined the effect of water deficit on the alfalfa seed and bean crops germination process. They concluded that water deficit markedly reduced the germination percentage. However, Khan [14] concludes that varieties that have a similar germination percentage are water deficit tolerant even when drought intensifies. In contrast, Kiani et al. [15] point out that germination decreases in drought conditions because of changed metabolic and physiological processes in the seed, i.e. the hydraulic conductivity of seeds decreases.

The analysis of parameters (GP, MDG, MGT, CVT, GI, CVG) did not provide a certain regularity in the sensitivity of the examined varieties. Therefore, the classification of sensitivity was observed on the basis of individual parameters or some interrelated parameters (MDG vs MGT). Under stress conditions, MGT (germination as a function of time) is prolonged, which affects the reduction of MDG (daily germination) [16], which was confirmed by statistical analysis for Serbian variety V11, and Libyan V3 and V9, after the application of 15% PEG (Table 1). Researchers point out the association of these parameters with the final percentage of germinated seeds [17]. They state that the percentage of germination of berry plant seeds, in conditions of severe drought, decreases and thus prolongs the time required for germination (MGT) with a decrease in daily germination (MDG). The correlation of the germination percentage (GP) parameter with the MDG and MGT parameters was not obtained during the experiment (Table 1) since the changes in germination in varieties V3, V9 and V11 were not statistically significant compared to the control. This can be partly explained by the fact that a number of factors during seed maturation before harvest can affect the quality and characteristics of seeds (dormancy, germination, etc.) [18], which is addressed in a well-conducted breeding program [19]. Also, some authors consider that storage conditions (especially in wheat, barley, cabbage and onion) may affect the inverse relationship between MDG and the final percentage of germination [20]. Often the definition and calculation of MGT (used to compare specific pairs or groups of means to evaluate seed vigour) can influence the conclusion and calculation of the germination rate [21]. In practice, this means that the seeds of one individual or population may have the same percentage of germination but different germination rates caused by different stages of dormancy break [22]. Although in our research the analysis of MGT showed certain differences between genotypes (t-test: V1 and V12 vs V4, V6, V8, V9 and V10), no regularity was found. The explanation for the lack of regularity lies in the fact that the shift (rise) of MGT can be caused by stress but also by seed biology (e.g. age) [23] and naturally aged seeds [24]. On the other hand, the CVT parameter (variations during germination) shows that there are statistically significant differences (t-test) between varieties: V5 vs V1, V4, V11, and V12; V2 and V3 vs V10 and V12. In contrast, ANOVA analysis showed that changes compared to the control were recorded even after the application of lower (5% in V5, V9 and V10) and higher (15% in V9 and V10) PEG concentrations (Table 1). In general, changes in CVT parameters are associated with stress conditions but also with seed biology (physiological processes, different dormancy, maturation conditions, etc.) [25]. The authors emphasize that variation in seed germination is due to a complex of environmental and genetic factors during seed formation.

A frequently used parameter for measuring the level of sensitivity of varieties (i.e. defining the vigour of seeds) is the germination index (GI). Based on this parameter, the studied genotypes were ranked, from V5 (GI = 2.36), V2, V7, V12, V3, V1, V8, V11, V9, V4, V6 to V10 (GI = 3.82). However, statistically, significant differences were obtained in the variant with the use of 15% PEG (GI lower than in the control) in the Libyan varieties: V4, V7, V8 and V9 (Table 1). These results confirm their sensitivity to water stress. Similar conclusions (reduction of GI) are reached by Qadir [26]. He states that water stress (160 g/l PEG) causes a decrease in GI in wheat varieties. Based on the CVG parameter, the author also defines the sensitivity of wheat varieties from Iraq in water deficit conditions. The CVG parameter decreased significantly with increasing PEG concentration (0, 80 and 160 g/l), which is in accordance with our results (Table 1). In varieties V3 (Libyan), V9 (Libyan) and V11 (Serbian) there is a decrease in CVG under conditions of 15% PEG application. The growth of CVG parameters after the use of 5% PEG in variety V5 is explained by the fact that a small amount can stimulate the germination process.

Based on the overall analysis of measured germination parameters (processed by ANOVA), it can be concluded that Libyan genotypes V1, V2, V5, V6 and V9, and Serbian V10 and V12 are tolerant to water deficit (Table 1). The most reliable parameters are germination percentage and germination index.

The germination phase is the most important for the further development of the individual plant. Water needs are greatest in the seed germination phase and any delay in this process is significantly reflected in many aspects of plant growth (e.g. limits the root and shoot) [27]. During plant development, water needs grow depending on the plant species and production conditions [28, 29]. Water deficit mostly affects seed germination, but significantly reduces shoot and root length in stress conditions (water deficit), root emerge before other parts of plants [30]. Application of 5% PEG did not affect shoot and root growth, in contrast to statistically very significant differences in the length of the measured parameters compared to the control after the application of 10 and 15% PEG (Table 2). Therefore, both parameters can be used when defining the sensitivity of wheat varieties under water stress conditions, which is in line with the conclusions of other authors [31-35]. Some researchers state that one should be careful when making conclusions based on shoot length because its maximum value may be affected more by the duration of the germination process than by the lack of moisture [36].

A comparison of varieties based on the shoot and root length (t-test) showed more differences between different shoot length genotypes than root (Table 3). However, the classification of the examined varieties was done on the basis of RSR parameters (tolerant to sensitive): V11, V6, V4, V12, V1, V5, V7, V3, V10, V8, V2 and V9 (Table 2). Based on the derived classification, it can be stated that the most sensitive varieties are: Serbian V10 and Libyan V9, and the most tolerant to drought conditions are: Serbian V11 and V12, and Libyan V6.

Changes in fresh root and shoot mass after application of different PEG concentrations proved to be reliable parameters for separating the sensitivity/tolerance of the tested genotypes (Table 4). Based on the analysis, it can be concluded that the highest tested concentrations of PEG influenced on statistically significant reduction in fresh weight. Also, it can be stated that changes in fresh root mass in genotype V10 (Serbian) were not significant compared to the values measured in the control (Table 4). Mohammadi and Mojadamm [16] conclude that the weight of shoot parameter is a more reliable parameter because changes occur as a result of reduced transport of nutrients from storage tissue. Also, good root growth in drought conditions is related to the fact that longer root length in water deficit conditions occurs due to the tendency to grow in the direction of soil volume for water [37, 38]. In contrast, photosynthesis related characteristics in drought conditions decline [39]. Comparison of genotypes (t-test) based on changes in shoot and root mass in water deficit conditions showed that the examined genotypes differ more on the base of fresh root weight (Table 3).

TABLE 2
Statistical analysis (LSD) of shoot and root length after growth in different PEG concentrations

	Coleoptile length (CL)			Root length (RL)			RSR
	5%	10%	15%	5%	10%	15%	
V1	NS	0.027*	0.008**	NS	0.0002**	0.0002**	1.32
V2	NS	0.007**	0.0007**	NS	0.006**	0.0001**	1.49
V3	NS	0.002**	0.0000**	NS	0.034*	0.0008**	1.37
V4	NS	0.025*	0.0001**	NS	NS	0.0001**	1.26
V5	NS	0.001**	0.0000**	NS	NS	0.0004**	1.32
V6	NS	0.015*	0.0001**	NS	NS	0.0008**	1.24
V7	NS	0.0005**	0.0000**	NS	0.0000**	0.0000**	1.33
V8	NS	NS	0.0005**	NS	0.0098**	0.0004**	1.43
V9	NS	0.005**	0.0000**	NS	NS	0.0000**	1.61
V10	NS	0.001**	0.0000**	NS	NS	0.034*	1.38
V11	NS	0.005**	0.0000**	NS	NS	NS	1.08
V12	NS	0.011*	0.0000**	NS	0.0000**	0.0000**	1.31

V1-V12 wheat varieties, 5, 10 and 15% PEG, NS-nonsignificant difference, p<0.05*, p<0.01**, RSR=RL/SL

TABLE 3
Differences between genotypes (t-test) based on vegetative parameters after germination and growth in different PEG concentrations

Shoot length		Root length		Fresh shoot weight		Fresh root weight		Dray shoot weight		Dray root weight	
varieties	p	varieties	p	varieties	p	varieties	p	varieties	p	varieties	p
V1vsV6	*	V10vsV1	*	V2vsV6	*	V1vsV6	*	V1vsV6	*	V1vsV6	**
V2vsV6	*	V10vsV2	*	V3vsV6	*	V1vsV8	*	V2vsV6	**	V1vsV8	**
V2vsV10	*	V10vsV3	*	V5vsV6	*	V1vsV10	*	V2vsV8	*	V1vsV10	**
V2vsV11	*	V12vsV10	*	V6vsV12	*	V2vsV5	*	V2vsV10	**	V2vsV5	*
V3vsV6	*	V12vsV11	*			V2vsV10	**	V2vsV11	*	V2vsV6	**
V3vsV10	*	V12vsV6	*			V3vsV5	*	V3vsV6	**	V2vsV8	**
V3vsV11	*					V3vsV10	**	V3vsV8	*	V2vsV10	**
V6vsV7	*					V4vsV5	*	V3vsV10	**	V2vsV12	*
V6vsV12	*					V4vsV10	**	V3vsV11	*	V3vsV6	**
						V5vsV6	**	V4vsV6	*	V3vsV8	**
						V5vsV7	*	V5vsV6	**	V3vsV10	**
						V5vsV8	**	V5vsV8	*	V4vsV5	**
						V5vsV9	**	V5vsV10	**	V4vsV6	*
						V5vs10	**	V5vsV11	*	V4vs V8	*
						V5vs11	**	V6vsV7	*	V4vsV10	*
						V6vsV10	**	V6vsV9	*	V4vsV12	**
						V8vsV11	*	V6vsV11	*	V5vsV6	**
						V10vsV11	**	V6vsV12	**	V5vsV7	*
						V10vsV12	**	V8vsV12	*	V5vsV8	**
								V10vsV12	*	V5vs V9	**
										V5vsV10	**
										V5vsV11	*
										V6vsV7	*
										V6vsV9	*
										V6vsV11	**
										V6v V12	**
										V7vsV8	*
										V7vsV10	*
										V7vsV12	*
										V8vsV9	*
										V8vsV11	**
										V8vsV12	**
										V9vsV10	*
										V9vsV12	**
										V10vsV11	**
										V11vsV12	*

V1-V12 wheat, varieties, $p<0.05$*, $p<0.01$**

The tested genotypes were classified based on RCR parameters (Table 4): (1) V5 and V6; (2) V1, V4, V7, V8, V9 and V11; and (3) V2, V3, V12 and V10. Based on this, resistant V5 and V6 (Libyan) and sensitive varieties V2 and V3 (Libyan) and V10 (Serbian) are singled out.

Separation of varieties based on dry shoot and root weight parameters showed that the dray shoot weight parameter was more reliable (Table 5). Similar results are reported by Belachew et al. [40] who point out that the reductions in fresh and dry mass can be 2-3x higher than the control due to water deficit conditions. By comparing the varieties based on these parameters (t-test), it was concluded that the dray root weight parameter showed greater variations between genotypes in drought conditions (Table 3). Separation of the examined genotypes was performed on the basis of RSR parameters (Table 5): (1) V5, V6, V11 and V12; (2) V1, V2, V3, V4 and V7; and (3) V8, V9 and V10. Based on the classification, it is concluded that the most drought tolerant varieties are: Libyan V5 and V6, and Serbian V11 and V12.

Based on the measured vegetative parameters (length, fresh and dry mass) and statistical processing, it can be stated that varieties V6 (Libyan) and V11 (Serbian) are the most tolerant while V9 (Libyan) and V10 (Serbian) are the most sensitive to water stress, i.e. drought.

CONCLUSION

Successful production of field crops depends on modern scientific knowledge that is the result of studying the tolerance of genotypes to changing environmental factors. Water regime is, in addition to thermal conditions, the most important agro-ecological factor of plant production. Therefore, current scientific knowledge and rapid screening of seed tolerance are a reliable way to select drought-tolerant varieties. Based on the results of these studies, it can be concluded that the most reliable parameters for defining resistance/tolerance to drought are the following factors: germination percentage and index of germination, shoot and root length, fresh weight of root and shoot, and dray shoot weight. The obtained

TABLE 4
Statistical analysis (LSD) of fresh shoot and root weight after growth in different PEG concentrations

	Fresh shoot weight (FSW)			Fresh root weight (FRW)			RSR
	5%	10%	15%	5%	10%	15%	
V1	0.047*	0.005**	0.001**	0.0008**	0.0000**	0.0000**	0.2
V2	0.034*	0.002**	0.0001**	0.03*	0.0011**	0.0002**	0.25
V3	NS	0.0000**	0.0000**	NS	0.001**	0.0003**	0.25
V4	0.018*	0.0025**	0.0000**	0.036*	0.005**	0.0002**	0.2
V5	NS	0.004**	0.0001**	NS	0.027*	0.001**	0.12
V6	NS	0.0013**	0.0000**	0.008**	0.004**	0.0004**	0.15
V7	0.0029**	0.0000**	0.0000**	NS	0.0002**	0.0001**	0.2
V8	NS	0.016*	0.0002**	NS	NS	0.001**	0.2
V9	0.04*	0.0000**	0.0000**	NS	0.016*	0.001**	0.2
V10	NS	0.0004**	0.0000**	NS	NS	NS	0.3
V11	NS	0.002**	0.0000**	NS	NS	0.012**	0.2
V12	NS	0.0000**	0.0000**	0.026*	0.0003**	0.0000**	0.25

V1-V12 wheat varieties, 5, 10 and 15% PEG, NS-nonsignificant difference, p<0.05*, p<0.01**, RSR= FRW/FSW

TABLE 5
Statistical analysis (LSD) of dry shoot and root weight after growth in different PEG concentrations

	Dry shoot weight (DSW)			Dry root weight (DRW)			RSR
	5%	10%	15%	5%	10%	15%	
V1	NS	0.048*	0.008**	NS	0.04*	0.014*	0.5
V2	NS	0.008**	0.001**	NS	NS	NS	0.5
V3	NS	0.007**	0.0003**	NS	NS	0.005**	0.5
V4	NS	NS	0.0001**	NS	NS	0.01*	0.54
V5	NS	0.03*	0.0001**	NS	NS	0.005**	0.4
V6	NS	NS	0.02*	NS	NS	0.01*	0.44
V7	NS	0.0003**	0.0000**	NS	0.002**	0.0000**	0.54 2
V8	NS	NS	0.0003**	NS	NS	0.046*	0.64
V9	NS	0.001**	0.0000**	NS	NS	0.005**	0.64
V10	NS	0.0002**	0.0000**	NS	NS	NS	0.61
V11	NS	0.03*	0.0005**	NS	NS	NS	0.42
V12	NS	0.002**	0.0001**	NS	0.01*	0.01*	0.41

V1-V12 wheat varieties, 5, 10 and 15% PEG, NS-nonsignificant difference, p<0.05*, p<0.01**, RSR=RDW/RSW

results showed that the most tolerant to drought were Libyan varieties V1, V2, V5, V6 and V9, and varieties V10-V12 originating from Serbia. Based on indicators of vegetative parameters, the most tolerant genotypes were Bhoth 306 (V6) from Libya and NS Vlajna (V11) from Serbia, while the most sensitive varieties were Libyan Marshosh (V9) and Serbian Zemunska rosa (V10).

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