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EVALUATION OF GREEK BREAD AND DURUM WHEAT CULTIVARS FOR DROUGHT TOLERANCEUSING POLYETHYLENE GLYCOL

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ABSTRACT

In order to study the effect of drought stress seven bread wheat (*Triticum aestivum* L.) cultivars (Acheloos, Apollonia, Generoso, Doirani, Nestos, Strimonas, and Orpheas) and seven durum wheat (*Triticum durum* L.) cultivars (Sifnos, Anna, Elpida, Thraki, Papadakis, Athos, Mexikali 81) were evaluated at three levels of drought treatment using polyethylene glycol in a randomized complete block design with 10 replications. For this purpose, seedlings of the aforementioned genotypes were cultured in pots with three different concentrations of polyethylene glycol (5, 10% and 15% PEG 8000) whereas irrigation without PEG was used as control. During the experiment, the length of spike with awns, the length of spike, the plants height, the number of tillering per plant, and the concentration of proline in the plants treated were measured. The drought treatment reduced the length of spike and the plant height of the cultivars studied, whereas it increased the length of spike with awns in bread wheat cultivars. It was concluded that there are considerable differences in drought resistance between the genotypes studied. The drought stress, caused by the polyethylene glycol, increased the concentration of proline in the cultivars tested. The highest value of proline was estimated in plants of bread wheat cultivar Strimonas and in plants of durum wheat cultivar Sifnos. So consequently, we can conclude that Strimonas and Sifnos were the most tolerant cultivars of the two species. Orpheas (bread wheat) and Thraki (durum wheat) had the lowest concentration of proline, so Orpheas and Thraki were considered the most sensitive cultivars.

Keywords: *drought stress, tolerance, polyethylene glycol, proline*

INTRODUCTION

Drought is the major abiotic stress factor that reduces the productivity of cultivated plants. This reduction depends on the stage of plant development, the intensity of the stress and the resistance of the genotype. Furthermore, durum and bread wheat, two of the most important crops for global economy are affected by drought, with regard to their productivity and quality (Singh and Chaudhary, 2006). In addition, in order to face the drought stress, the breeding of many cultivated plants nowadays is based on the creation and use of varieties with high yield potential and resistance to biotic and abiotic stresses (Acevedo and Fereres, 1994).Thus, the evaluation of the existing genetic material characterized by tolerance to drought is the only approach that could decisively contribute to the problem. Under water stress conditions, plants react with a number of morphological, physiological and biochemical adaptations in order to maintain the basic metabolic activity. Among the effects of a decrease in water potential are the loss of turgescence, a decrease in cell wall composition, a decrease in the rate of protein synthesis, a decrease in the biosynthesis of chlorophyll, an increase in the biosynthesis of abscisic acid, an increase in the rate of respiration, the accumulation of osmotically active substances, and the final drying of the plant. The phenotype remains the basic criterion for the selection of resistant genetic material and is based on the morphological and physiological characteristics of plants in drought conditions, and on yield (Monneveux *et al*., 2012). Biochemical analysis including mannitol, glycine, betaine, and proline has been proposed as an effective method for selecting drought tolerant genotypes (Mwadzingeni *et al*., 2016). The amino acid proline is associated with various osmotic protection roles, including osmotic adaptation (Zadehbagheri *et al*., 2014), membrane stabilization (Hayat *et al*., 2012) and signaling for the activation of antioxidant enzymes (de Carvalho *et al*., 2013).

Polyethylene glycol (PEG), a chemical that causes osmotic stress, is often used to control and select early-stage drought-resistant seedlings in the laboratory. Several studies have shown that PEG of high molecular weights can be used to modify the osmotic potential of a culture medium and thus induce water deficiency in a controlled manner (Zhu *et al*., 1997), and simulate plant stress in water scarcity in a manner similar to soil drought. Therefore, it is an effective and simple enough method in order to evaluate a large number of genotypes for drought tolerance (Hassanein, 2010). Lazaridou and Xynias, (2017) evaluated *in vitro* sixteen bread and durum wheat cultivars using polyethylene glycol and found considerable differences in drought resistance between the genotypes studied.The objective of this study was to evaluate the resistance to drought stress of fourteen Greek bread and durum wheat cultivars using polyethylene glycol 8000.

MATERIALS AND METHODS

For the purpose of the study seven bread wheat (*Triticum aestivum* L.) cultivars (Acheloos, Apollonia, Generoso, Doirani, Nestos, Strimonas, and Orpheas) and seven durum wheat (*Triticum durum* L.) cultivars (Sifnos, Anna, Elpida, Thraki, Papadakis, Athos, Mexikali 81) developed at the Cereal Institute of Thessaloniki (Cereal Institute, 1985) were used. The effect of drought stress was measured *in vivo* in a greenhouse (plants in pots) at four different osmotic potential levels (four concentrations of Polyethylene glycol PEG 0%, 5%, 10% and 15%). The stress applied to mature plants before and after flowering. The experimental design was split-plot in randomized complete block design (RCB). Ten replications were used for each treatment, so 560 experimental plots were used (14 varieties x 4 treatments x 10 replications = 560 pots). During the growing period, phenotypic as well as biochemical parameters were evaluated. The length of spike with awns, the length of spike, the plants height and the concentration of proline in the plants, as a response to the drought, were measured. The concentration of proline (mmol/gr dry weight) in the plant tissues was measured using the spectrophotometer according to Bates method (Bates *et al*., 1973). Data were statistically analyzed and the means were compared according to LSD test at p=0.05.

RESULTS AND DISCUSSION

Significant differences were recorded between the examined cultivars in all morphological traits and the concentration of proline. Significant differences were recorded also between the different treatment (0, 5, 10 and 15% PEG) in all morphological traits and the concentration of proline.

Table 1. Height, length of spike with awns, length of spike, and concentration of proline after 4 treatments with PEG (0, 5, 10 and 15%) of seven bread wheat cultivars

PEG	**Height cm**	**Length of spike without awns**	**Length of spike with awns**	**Proline mmol/gr DW**
0%	56.93 a	4.93 a	8.06 b	0.10 c
5%	53.42 b	4.59 b	8.14 b	0.24a
10%	50.62 c	3.70 c	9.67 a	0.21 b
15%	50.68 c	3.49 d	9.70 a	0.22 ab

Means in columns followed by different letters, are significantly different at $p<0.05$ by LSD test.

The length of spike as well as the height of the plants of bread wheat decreased with the increase of the concentration of polyethylene glycol, which caused an increase in water stress in plants (Table 1). The same was reported by Aboughadareh *et al*., (2020) who found that water stress caused a significant reduction, among other agro-morphological characteristics, in the height of the plant, and the length of the spikes of 17 durum wheat genotypes. Reduction in plant height was noticed also by Khamssi and Najaphy (2011) who studied the effect of drought stress in fourteen bread wheat cultivars. Singh *et al*., (2014) came to the same conclusion in terms of spike length when they evaluated 10 bread wheat genotypes from India under drought stress, caused by treatment with polyethylene glycol (PEG). On the contrary the present work showed that the water stress caused by the treatment with polyethylene glycol led to an increase in the spike length with awns, giving the highest length with the highest concentration of polyethylene glycol (15%). This could be because, according to Evans *et al*. (1971), the presence of awns in the spike is related to the yield of cereals under water stress conditions.

Table 2. Height, length of spike with awns, length of spike, and concentration of proline of seven bread wheat cultivars after the treatments with PEG

A/A	Genotype	Height cm	Length of spike without awns	Length of spike with awns	Proline
1	**ACHELOOS**	53.77 ab	4.08 b	10.95a	0.16 c
2	**APOLLONIA**	50.97 c	4.15 b	11.32 a	0.17 c
3	**GENEROZO**	47.94d	4.04 b	4.76 d	0.18 c
4	**DOIRANI**	54.29 ab	3.35 c	8.88 b	0.21 b
5	**NESTOS**	52.30bc	5.41a	6.18 c	0.16 c
6	**STRYMONAS**	56.14a	4.20 b	9.26 b	0.31 a
7	**ORPHEAS**	54.98 ab	4.01 b	10.90 a	0.15 c

Means in columns followed by different letters, are significantly different at $p<0.05$ by LSD test.

The drought stress, caused by the polyethylene glycol, increased the concentration of proline in the cultivars tested compared to the control. Increased concentration of proline was also recorded by Alvarez *et al*., (2008), in corn under water stress conditions. Similar results were recorded in wheat by Saeedipour (2013). The same conclusion was reached by Singh *et al*., (2014) who recorded an increase in proline content after treatment with PEG in 10 wheat genotypes from India. In the present study the highest value of proline was recorded in the plants of Strimonas (0.31 mmol/gr DW), whereas the lowest concentration of proline (0.15 mmol/gr DW) had the plants of Orpheas (Table 2). Lazaridou and Xynias, (2017) evaluated *in vitro*, using polyethylene glycol, Greek varieties of bread wheat, and found that the cultivars Acheron, Acheloos and Apollonia were the most tolerant ones. The results of the present study do not agree with the above researchers because Strimonas had the highest value of proline, so it was considered the most resistant variety.

Table 3. Height, length of spike with awns, length of spike, and concentration of proline after 4 treatments with PEG (0, 5, 10 and 15%) of seven durum wheat cultivars

PEG	Height cm	Length of spike without awns	Length of spike with awns	Proline mmol/gr DW
0%	61.24a	4.00a	12.06 a	0.11d
5%	55.26b	3.50b	11.82 a	0.18c
10%	53.78b	2.79c	11.75 b	0.25b
15%	51.57c	2.54d	11.44 c	0.29a

Means in columns followed by different letters, are significantly different at $p<0.05$ by LSD test.

The length of spike with awns, the length of spike without awns, as well as the height of the plants of durum wheat decreased with the increase of the concentration of polyethylene glycol (Table 3). Regarding the proline concentration, in the present study it was found that drought stress led to an increase in the concentration of proline in the treated plants, compared to the control and the highest value was measured in the plants treated with 15% PEG.

Table 4. Height, length of spike with awns, length of spike, and concentration of proline of seven durum wheat cultivars after the treatments with PEG

A/A	GENOTYPE	Height cm	Length of spike without awns	Length of spike with awns	Proline
1	**ANNA**	54.65bc	3.38a	11.98a	0.27b
2	**SIFNOS**	57.27ab	3.51a	11.99a	0.31a
3	**ATHOS**	52.27c	2.76c	11.68b	0.24c
4	**MEXIKALI 81**	55.04 b	3.39a	10.86c	0.17d
5	**PAPADAKIS**	55.68 b	3.37a	11.67b	0.23 c
6	**ELPIDA**	58.68 a	3.12b	12.06a	0.17d
7	**TRHAKI**	54.65bc	2.91b	12.12 a	0.08e

Means in columns followed by different letters, are significantly different at $p<0.05$ by LSD test.

Significant differences were observed between the durum wheat genotypes regarding the plant height, the length of spike, the length of spike with awns and the concentration of proline (Table 4). Similar results were recorded by Mirbahar *et al*., (2009) who studied the effect of different water stresses at different stages of development of 25 wheat varieties.

In the present study the highest value of proline had the plants of Sifnos (0.31 mmol/gr DW) whereas the lowest concentration of proline (0.08 mmol/gr DW) had the plants of Thraki (Table 4). Lazaridou and Xynias (2017) evaluated *in vitro,* Greek durum wheat varieties for drought tolerance and found that Thrace and Anna were the most tolerant varieties to drought, while Papadakis and Mexikali 81 were the most sensitive ones. In the present study the highest value of proline had Sifnos followed by variety Anna. In addition, Thraki according to the concentration of proline was the most sensitive variety.

CONCLUSION

There are considerable differences in drought resistance between the genotypes studied. The presence of PEG, or otherwise the drought stressing conditions reduced the height of plants, the length of spike and increased the concentration of proline in bread and durum wheat cultivars. Among the genotypes studied Strimonas and Sifnos were the most tolerant cultivars of the two species. Orpheas (bread wheat) and Thraki (durum wheat) were considered the most sensitive cultivars. However, further research, is needed to confirm the results of the present study.

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