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Effect of Osmotic Stress on Germination and Seedling Growth of *Agropyron trichophorum* Genotypes

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ABSTRACT

Drought stress is one of the most important environmental stresses which limit crop growth and production in different places of the world. In this regard, in order to evaluate effects of drought stress, induced by polyethylene glycol, on germination and seedling growth of *Agropyron trichophorum* an experiment was conducted in Payame noor University, Kermanshah, Iran in 2010. The experimental design was a completely randomized design arranged in factorial with three replications. Different *Agropyron trichophorum* genotypes (13 genotypes) were considered as first factor and also different osmotic potentials (0, -0.4, -0.6 and -0.8 MPa) imposed by polyethylene glycol were applied as second factor in this study. The results demonstrated that effect of osmotic stress was significant on germination percentage, germination promptness index, radical number, radical length and plumule length. Germination percentage decreased with increasing stress level so that germination percentage decreased from 92% in control treatment to 54% in high stress treatment (-0.8 MPa). The highest and lowest germination percentage was related to number 9 and number 13 genotypes, respectively. Number 4 genotype was the best genotype regarding radical number and plumule length compared with other genotypes. In addition, number 9 and number 5 genotypes had the highest and lowest germination stress index, respectively. The strongest correlation was found between germination percentage and germination promptness Index. Moreover, germination stress index showed positive correlation with most of germination attributes. Based on obtained results we concluded that germination and growth parameters significantly decreased with increasing osmotic stress level.
Keywords: Polyethylene glycol 6000, Germination stress index, *Agropyron trichophorum.*

INTRODUCTION

Agropyron trichophorum is one of the most important pasture plants in Iran. Different species of this plant are growing in most of pastures. It is a perennial herbaceous plant with 19 different species distributed in Iran (Bor 1970). Under conditions of drought stress and low and irregular precipitation, achievement to desirable vegetative covers is considered as suitable features of crops. Under such conditions, seedling emergence potential is one of the most important traits related to seedling establishment (Saeidi et al., 2007). Evaluation of drought tolerance at germination stage in different pasture crops has specific importance in pasture management. To study drought tolerance at germination stage polyethylene glycol is used because of its osmotic potential when it is solved into the water (Mohammadi, 2000; Jamshid Moghaddam, M., and Pourdad, S. S, 2006). Under warm and arid conditions, it is necessary to plant seeds deeply to decrease drought injuries. In those cases that seeds are sown before precipitation into dry soils, planting depth should be considered more than usual because if seeds are sown close to soil surface, a light precipitation led to germination while there is no enough moisture for later growth. In these cases, coleoptile length plays an important and key role in seedling emergence (Fick and Qualset, 1976). According to previous studies, it is obvious that germination percentage and promptness index decreases with increasing drought stress level induced by polyethylene glycol (De and Kar, 1995). Decrease in germination on account of polyethylene glycol application might be due to decrease in water contact with seeds and low hydrolic conductivity of water around the seeds (Emmerich and Hardegree, 1991). It has been reported that germination promptness index is more sensitive to drought or osmotic stress than germination percentage (Abdul-baki and Anderson, 1970). Plumule to radical ratio is used for comparison of genotypes in response to drought stress (Asgari and Tagvayi, 1988). For example, different wheat and triticale genotypes were classified based on germination stress index (GSI) and response of them to sensitivity, resistance and tolerance to drought stress was evaluated (Sapra et al., 1991). This experiment was aimed to study germination response of 13 *Agropyron trichophorum* genotypes to osmotic stress.

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MATERIALS AND METHODS

Current study was carried out at Crop Physiology Laboratory in Payame nor University, Kermanshah, Iran during 2010. Experimental design was a completely randomized design arranged in factorial with three replications. Thirteen *Agropyron trichophorum* genotypes (Table 1) and different osmotic potentials (0, -0.4, -0.6 and -0.8 MPa), imposed by polyethylene glycol, were considered as first and second factors, respectively. Polyethylene glycol was applied according to Michel and Kaufmann (1972) equation. Distilled water was used as control treatment (0 MPa). First of all, seeds were disinfected by 96% ethanol for 10 s and 15% sodium hypochloride for 40 s. Then seeds were rinsed several times with sterilized water. Twenty sterilized seeds were put on the filter paper placed in 9 cm petri dishes and then 10 ml polyethylene glycol with certain concentrations was added into petri dishes. Petri dishes were put into germinator at 20±0.5°C temperature and 16/8 h day/night photoperiod. After ten days, germination percentage, radical and plumule length were measured. Germination stress index and promptness index were calculated according to Bouslama and Schapaugh (1984) equations as follow:

$PI = nd_2\ (1.0) + nd_4\ (0.8) + nd_6\ (0.6) + nd_8\ (0.4) + nd_{10}\ (0.2)$

GSI= [PI, under stress condition / PI, under non-stress condition]

Where nd_2, nd_4, nd_6, nd_8 and nd_{10} germinated seed on second, fourth, sixth, eighth and tenth days

Germination percentage = germinated seeds/ total seed number × 100

All date were analyzed using SPPS software. Information on *Agropyron trichophorum* genotypes are given in table 1.

RESULTS AND DISCUSSION

Obtained results from analysis of variance are shown in table 2. Results showed that there was significant difference among genotypes in respect to germination attributes except for radical number. In addition, different osmotic stress levels had significant effect on all measured parameters (Table 2). Geravandi et al., (2010) have reported that there are significant variations among wheat genotypes regarding germination attribute. Saeidi and co-workers (2007) have shown significant differences among different drought stress levels (0, -0.4, -1.2 and -1.6 MPa) when radical and plumule length of wheat was evaluated. In addition, interaction between genotypes and stress level was significant (Table 2). Interaction between osmotic stress and genotype on germination percentage is shown in figure 1. Germination percentage was registered 85% and 100% in number 8 and number 9 genotypes, respectively. Decrease in osmotic potential up to -0.4 MPa decreased germination percentage by 65% in number 5 genotype and by 91% in number 9 genotype. -0.6 MPa osmotic stress decreased germination percentage to 32% in number 13 genotype and 87% in number 2 genotype. Under -0.8 MPa osmotic stress, there were significant variations among genotypes. Germination percentage in control treatment was registered by 91% while under -0.8 MPa osmotic stress germination percentage decreased to 50%. Our results demonstrated that germination promptness index dramatically decreased due to -0.4 MPa osmotic stress, however this reduction was not observed in number 2, 9 and 11 genotypes. On the other hand, germination percentage was not affected by -0.4 MPa osmotic stress except for number 5 and number 13 genotypes. Germination promptness index was more sensitive to osmotic stress than germination percentage so that germination promptness index decreased by 40%, 70% and 75% due to -0.4, -0.6 and -0.8 MPa osmotic stress, respectively compared to control, while germination percentage decreased by 14%, 40% and 50% under similar stress conditions. These results are in agreement with findings of Geravandi et al., (2010) and Abdul-baki and Anderson (1970). The lowest germination percentage and germination promptness index were observed in number 13 genotypes under -0.8MPa osmotic stress. There were considerable variations in respect to plumule length and -0.4 MPa osmotic stress (Figure 3).The highest and lowest plumule length was related to number 6 and number 1 genotypes grown under control conditions, respectively. By contrast, under conditions of -0.4MPa osmotic stress, the highest plumule length were related to number 8 and number 12 genotypes and the lowest plumule length were related to number 5, 13 and 9 genotypes. Under conditions of -0.6MPa the highest and lowest plumule length was observed in 7, 8, 9 and 1, 2, 5, 10, and 12 genotypes, respectively. Furthermore, under conditions of -0.8MPa the highest and lowest plumule length was observed in 3, 6, 9 and 1, 7, 10 and 13 genotypes, respectively. In general, number 4, 8 and 9 genotypes had the highest plumule length under each osmotic stress level. In case of radical length, there were considerable variations among genotypes grown under -0.4MPa osmotic stress (Figure 4). It is interesting to remark that there was significant increase in radical length in number 1, 3, 4 and 6 genotypes due to -0.4MPa osmotic stress while in other genotypes significant decrease in radical length was observed. With increasing osmotic stress to -0.6MPa considerable variation was observed among genotypes. The highest radical length was obtained form number 2, 4, 6, 9 genotypes and the lowest radical length was related to number 1, 8, 10, 12 genotypes. Under conditions -0.8MPa osmotic stress, the highest radical length was related to number 4 and 9 genotypes while number 13, 10. 6 and 2 genotypes produced the shortest radicals. Radical length in 12, 8 and 1 genotypes treated with -0.8MPa was more than -0.6MPa. Generally, number 9, 7 and 4 genotypes had the longest radicals in all osmotic stress levels. It seems that in studied genotypes, plumule growth is more sensitive to drought stress than radical growth. This finding is in agreement with Saeidi and co-workers (2007). Different genotypes allocate more assimilate to the roots to increase drought tolerance (Aguirrezabal et al., 1994). In current study, the genotypes showed considerable variation in respect to radical length to plumule length ratio (Figure 5). With increasing osmotic stress to -0.4MPa, number 5 genotype produced the highest radical length to plumule length ratio. On the contrary, number 7 and 8 produced the lowest ratio. Under -0.6MPa osmotic stress, the highest ratio was observed in number 5, 2, 6 and 10 genotypes while under -0.8MPa osmotic stress, this variation increased so that number 7, 1 and 2 genotypes showed the highest radical length to plumule length ratio. It is worth mentioning that number 6 and 5 genotypes had the lowest ratio. In case of germination stress index, there was significant variation among genotypes grown under -0.4MPa osmotic stress (Figure 6). The highest and lowest germination stress index was related to 2 and 9 genotypes and 5 and 13 genotypes, respectively. Under -0.6MPa osmotic stress, variation among genotypes increased but germination stress index decreased. Number 2 and 7 genotypes showed the highest germination stress index while number 13 genotype showed the lowest germination stress index. With increasing osmotic stress level to -0.8MPa variation increased among the genotypes and germination stress index was decreased compared with -0.4 and -0.6MPa osmotic stress. The highest and lowest germination stress index was related to number 9 and number 13 genotypes, respectively. Generally, comparison of means indicated that there is considerable variation among genotypes. Number 9, 7 and 2 genotypes were better than other genotypes. Results of correlation coefficient analysis are given in Table 4. There was significant and positive correlation between germination stress index and germination percentage, promptness index, radical length, plumule length and number of radical. Similar results have been reported by Zarei et al., (2007). In this study, we found significant and positive correlation between radical length and plumule length. This correlation was previously obtained by Salehi et al (2008). According to table 3, number 4, 8 and 9 genotypes had the longest radical length and highest germination stress index. Therefore genotype selection base don plumule length can be effective to reach desirable seedling establishment. Germination stress index was used for genotype screening previously by Farshadfar and mohammadi, (2003) and Sapra et al (1991). In addition, there was significant and positive correlation between germination promptness index and radical length (Table 4). In this study number 7 and number 9 genotypes had desirable germination promptness index, germination stress index and the longest plumule length. Relations between plumule length and germination stress index has been reported by Nourmand et al., (2001).

Table 1: Studied *Agropyron trichophorum*

Number	Code	Origin	Pedigree
1	4007	Isfahan	Feridan
2	7-6	Kohkiloieh	Eghlid pasahlaki
3	14-13	Isfahan-plot93	T24
4	10-6	Naghan chahartagh	chaharmahal
5	7-5	Eghlid-dejkord	fars
6	8-4	Yasoj-mimand	kohkiloieh
7	2-13	Semirom-ghaleaarezon	Isfahan
8	10-7	Naghan-sabzekouh	chaharmahal
9	13-13	Yasoj-patapeh	kohkiloieh
10	1-13	Semirom-ghaleaarezon	Isfahan
11	14-13	T24	Isfahan-plot13
12	10-8	Birjand-bidghataer	chaharmahal
13	**291**	**Gonbad-maravehtapeh**	**Golestan**

Table 2: Analysis of variance on germination parameters affected by genotype and osmotic stress

	d.f	Radical length to plumule length ratio	Plumule length	Radical length	Radical number	Promptness index	Germination percentage
Genotypes	12	**	**	**	ns	**	**
Osmotic stress	3	**	**	**	**	**	**
Genotype × Stress	36	**	**	**	**	**	**
Error	104	27.35	11.70	7.96	0.03	0.04	**121.15**
C.V		27.35	20.12	11.54	22.54	14.89	**15.28**

**** and ns significant at 1% probability level and no significant, respectively**

Table 3: Comparison of means among different *Agropyron trichophorum* genotypes

Genotypes	Radical length to plumule length ratio	Plumule length	Radical length	Radical number	Promptness index	Germination percentage	Germination stress index #
1	3.27bc	22.43d	25.23cd	1.18ab	1.36cde	1.36cde	**73**
2	4.06ab	23.56d	24.64cde	1.10b	1.65ab	1.65ab	**79**
3	1.77ef	30.80ab	26.75bc	1.22ab	1.50bcd	1.50bcd	**70**
4	1.93def	29.20bc	29.31a	1.30a	1.53bc	1.53bc	**73**
5	4.76a	20.95d	22.61e	1.22ab	1.17fg	1.17fg	**55**
6	2.77cde	32.45a	29.58a	1.24ab	1.48bcd	1.48bcd	**79**
7	2.91cd	33.47a	24.81cde	1.15ab	1.65ab	1.65ab	**84**
8	1.03f	33.37a	22.41e	1.22ab	1.19efg	a.19efg	**60**
9	1.33f	30.86ab	28.24ab	1.24ab	1.78a	1.78a	**86**
10	3.13bc	27.05c	18.92f	1.17ab	1.43cd	1.43cd	**65**
11	1.60f	29.08bc	23.51de	1.22ab	1.64ab	1.64ab	**77**
12	1.88def	28.00bc	22.83de	1.16ab	1.32def	1.32def	**61**
13	1.60f	23.33d	18.99f	1.17ab	1.02g	1.02g	**43**

 # has not been statistically analyzed.
Values within the each column and followed by the same letter are not significantly different

Table 4: Correlation between germination parameters

	Germination percentage	Promptness index	Radical length	Plumule length	Radical length to plumule length ratio	Radical number	Germination stress index
Germination percentage	1						
Promptness index	0.98**	1					
Radical length	0.74**	0.74**	1				
Plumule length	0.66**	0.69**	0.80**	1			
Radical length to plumule length ratio	-0.31**	-0.31**	-0.42**	-0.55**	1		
Radical number	0.52**	-0.53**	0.59**	0.59**	0.30**	1	
Germination stress index	0.95**	0.97**	0.66**	0.60**	-0.15**	0.48**	1

**** Significant at 1% probability level.**

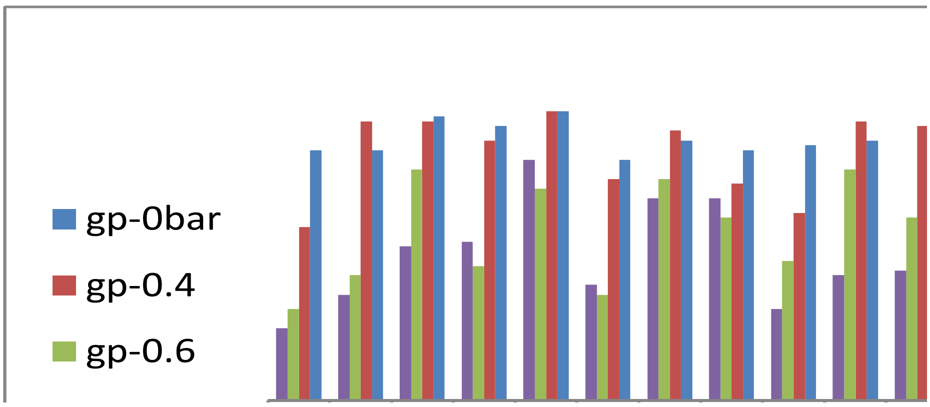

Fig.1. Mean comparison of interaction effects among osmotic potential levels and genotypes for germination percentage

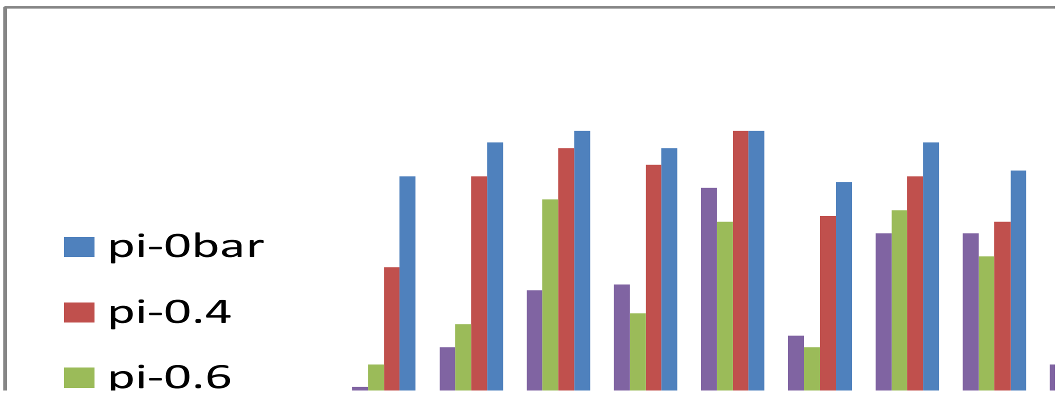

Fig.2. Mean comparison of interaction effects among osmotic potential levels and genotypes for germination Rate

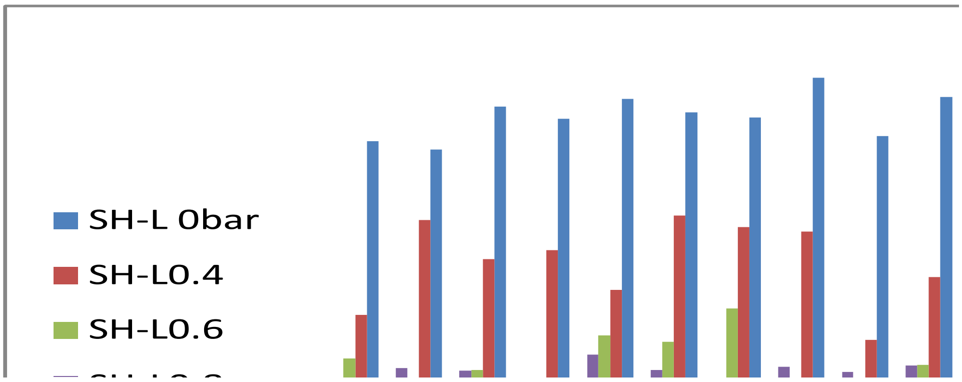

Fig.3. Mean comparison of interaction effects among osmotic potential levels and genotypes for shoot Length

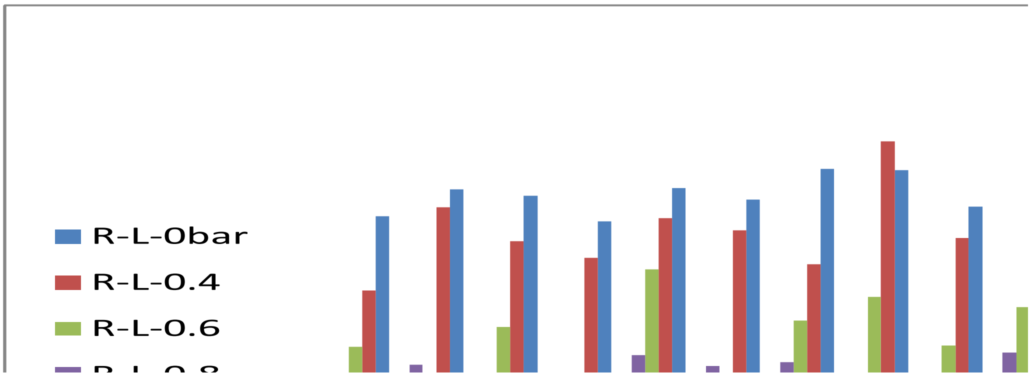

Fig.4. Mean comparison of interaction effects among osmotic potential levels and genotypes for Root Length

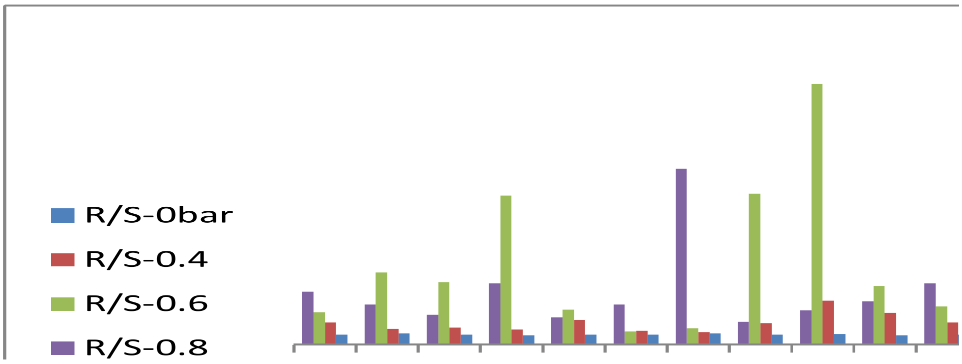

Fig.5. Mean comparison of interaction effects among osmotic potential levels and ratio for Root Length to soot length

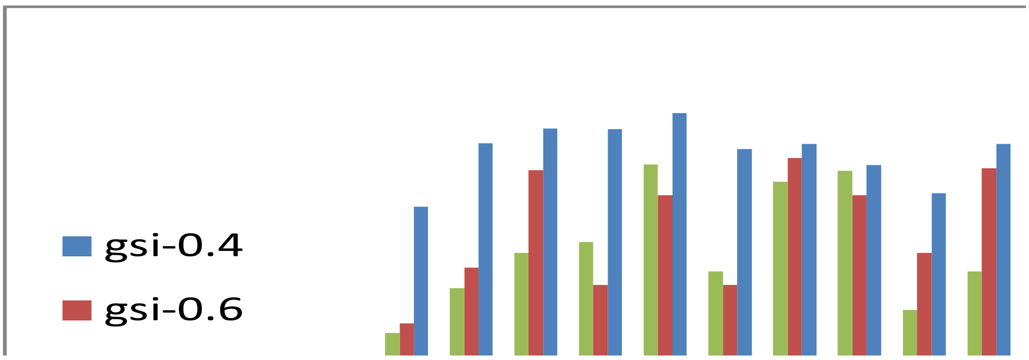

Fig.6. Mean comparison of interaction effects among osmotic potential levels and genotypes for germination stress index

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