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Cytoplasmic membrane stability assessment as an indirect criterion in draught tolerance selection in bread wheat

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ABSTRACT

To assess cytoplasmic membrane stability as an indirect criterion in draught tolerance selection in bread wheat, two separate experiments were carried out in Ardabil IAU Agricultural Research Station and Biotechnology and Tissue Culture Laboratory, in 2012. The research included 10 genotypes which were studied in randomized complete block design in 3 replications. Greenhouse experiment was conducted as a randomized complete block design in 3 replications in two phases of vegetation and reproduction Ardabil IAU Agricultural Research Station. The 3 stresses in this research induced osmotic stress by polyethylene glycol, osmotic atmospheric stress and heat stress by warm water on flag leaves of plants during vegetation and reproduction (before and after flowering). Stresses were applied to the plants and the damage to cytoplasmic membrane was measured. Results from analysis of variance on damage indices during phases of vegetation and reproduction under heat, osmotic atmospheric and osmotic stress by polyethylene glycol suggested that there is a little genetic diversity between genotypes (genotype differences was insignificant in some cases and in some other cases, differences was significant at 5%). Mean comparison results on membrane damage indices indicated that based on stress type and growth stage, genotypes order changes on membrane stability. However, it could generally be said that genotypes No. 3, 6, 9 and 4 have more stable membranes (it should also be mentioned that genotypes No. 3, 4 and 9 are among the most draught stress tolerant cultivars).

Key words: cytoplasmic membrane stability, draught stress resistance, bread wheat, draught stress tolerance

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INTRODUCTION

Most draught stress resistance breeding programs nowadays are based on experimental self-functioning selections, which are not that successful due to low heritability and high genotype × environment interaction effect [1]. Hence, indirect selection based on physiological traits is proposed as a complementary for yield selection [2]. Selecting proper parents for draught stress resistance modification programs, with this aim produce new genotype which possess a combination of their parents' characteristics, has always been one of the most significant tools used by plant breeding experts. From plant breeding point of view, any secondary physiologic trait should have a strong genetic diversity by yield and a higher heritability to comparing yield [1]. In addition, assessing these traits must be quick, easy and cheap [3, 4]. Therefore, identifying results by combining the best genes for higher yield using omission of weak phenotypes based on morphological characteristics in the primary generations, selecting better physiological phenotypes using quick techniques in intermediate generations and selection for yield in advanced generations have been more efficient [5]. Cytoplasmic membrane has been among the first targets for many stresses and keeping its integrity and stability under draught stress is considered as one of the main components in plant

resistance to draught [6]. Measuring the solutions leakage from plant membranes is an old method for measuring membrane penetrability against environmental stresses [7]. This method is suitable since this kind of measurement is easy, cheap and it doesn't damage the whole bush to analyze great number of samples. This technique is applied to measure the damage due to the various abiotic stresses such as cold, heat, air pollution, heavy metals, salinity and acidic condition. It has been proved that ionic leakage is related to many physiological and biological parameters such as antioxidant enzymes [8], water consumption efficiency [9], stomatal resistance, osmotic potential, leaf twisting index and leaf relative water content [10], and draught stress resistance screening has been used in wheat selection [11]. The objective to this research is to determine the efficiency of various cytoplasmic membrane stability assessment methods in bread wheat draught stress resistance assessment.

MATERIALS AND METHODS

To assess cytoplasmic membrane stability as an indirect criterion in draught tolerance selection in bread wheat, two separate experiments were carried out in Ardabil IAU Agricultural Research Station and Biotechnology and Tissue Culture Laboratory, in 2012. The research included 10 genotypes which were studied in randomized complete block design in 3 replications. Greenhouse experiment was conducted as a randomized complete block design in 3 replications in two phases of growth and reproduction Ardabil IAU Agricultural Research Station. The 3 stresses in this research induced osmotic stress by polyethylene glycol, osmotic atmospheric stress and heat stress by warm water on flag leaves of plants during vegetation and reproduction (before and after flowering).

RESULTS AND DISCUSSION

Analysis of variance results from assessment of RI, MII and ID indices in two phases of vegetation and reproduction and under three stresses of heat, osmotic atmospheric and osmotic stress by polyethylene glycol suggested that under heat stress there was no significant difference between genotypes on RI and MII during vegetation stage, while there was a significant difference between genotypes on both indices at 5% (Table 1). Data mean comparison under heat stress by Duncan methods at 5% suggested that genotype No. 1 at reproduction stage had the lowest IR and MII and there was no difference between other genotypes and located in one class while during vegetation stage, genotypes No. 6 and 3 had the lowest damage to membrane and genotypes No. 4 and 7 were in the next stage (Table 2). Under osmotic atmosphere stress, there was a significant difference between genotypes on IR and MII rate during vegetation stage at 5%, while there was no significant difference between genotypes on the two indices during reproduction. Genotypes mean comparison indicated that genotypes No. 4, 9, 6 and 3 in reproduction phase in and genotypes No. 7, 9, 4, 2 and 1during vegetation phase had the lowest IR and MII and as a result, they had higher membrane stability. Under osmotic stress condition resulted by PEG, except genotype No. 1 which had the letter "a" only, all genotypes had the common letter of "B" and there was no significant difference between genotypes on three indices of IR, MII and ID, while mean comparison during the reproduction stage suggested that genotypes 9, 3, 4 and 1 had the lowest rate of IR and MII. Considering the results, it could be observed that based on stress type and growth stage genotypes order could change on membrane stability. However, it could be claimed that genotypes No. 4, 9, 6 and 3 had a more stable membrane.

Table 1- Analysis of variance for Cytoplasmic Membrane Stability Indices

Sov	df	Osmotic Stress by Polyethylene Glycol						Osmotic Atmospheric Stress				Heat Stress			
		Vegetation Phase			Reproduction Phase			Vegetation Phase		Reproduction Phase		Vegetation Phase		Reproduction Phase	
		ID	MII	RI	ID	MII	RI	MII	RI	MII	RI	MII	RI	MII	RI
Rep	2	335.14^{ns}	306.68^{ns}	323^{ns}	97.05^{ns}	240.74^{ns}	111.63^{ns}	1006.20**	1283.62**	96.32*	63.89^{ns}	141.19^{ns}	217.44^{ns}	1320.23**	2878.86**
Genotype	9	701.92*	479.35*	585.52*	95.65^{ns}	144.08^{ns}	179.91^{ns}	206.72^{ns}	241.51^{ns}	51.32*	97.90*	143.48*	224.70*	275.05^{ns}	453.75^{ns}
E	18	235.90	188.25	213.93	62.25	88.71	196.46	103.26	127.37	20	28.07	54.18	77.29	149.75	368.27
CV		25.22	19.43	22.52	25.96	25.36	27.96	13.43	15.40	21.51	31.65	8.29	10.18	14.97	26.15

*ns, * and ** are insignificant, significant at 5% and 1%, respectively*

Table 2- Cytoplasmic Membrane Stability Indices Mean Comparison Assessed under Osmotic Stress by PEG

Osmotic Stress by Polyethylene Glycol						Osmotic Atmospheric Stress				Heat Stress				Genotype
Vegetation Phase			Reproduction Phase			Vegetation Phase		Reproduction Phase		Vegetation Phase		Reproduction Phase		
ID	MII	RI	ID	MII	RI	MII	RI	MII	RI	MII	RI	MII	RI	
51.73abc	60.54abc	56.94abc	24 a	45.82a	26.36a	85.64a	84.41 a	20.54abc	14.50bc	71.43b	64.37b	86.99ab	82.44ab	1
72.27ab	78.23 ab	75.81ab	13.51ab	26.82b	14.68a	77.56a	74.49 a	19.49bc	17.24ab	87.61a	84.94a	98.77a	98.56 a	2
45.77bc	56.03 bc	51.65bc	13.89ab	30.24ab	12.09a	73.67ab	72.01ab	21.39abc	18.33ab	96.94a	96.31a	67.13b	51.70 b	3
49.60abc	66.11abc	55.98abc	16.42ab	47.86a	18.70a	56.78b	53.25b	15.61 c	5.22 c	89.64a	86.66a	67.25b	61.19ab	4
73.41ab	81.44 ab	76.57ab	18.61ab	35.27ab	18.46a	84.32a	82.12a	24.40ab	20.93ab	92.11a	90.33a	86.57ab	82.87ab	5
56.42abc	63.70abc	57.60abc	7.98b	29.66ab	11.03a	73.86ab	71.44ab	28.44a	25.50 a	89.76a	88 a	67.87b	49.83 b	6
78.25 a	87.16 a	81.09 a	22.97ab	38 ab	29.93a	78.40a	75.64a	18.09bc	14.51bc	93.50a	92.47a	75.36ab	63.45ab	7
77.76 a	83.91 a	80.54 a	20.43ab	42.35ab	27.38a	77.21a	74.98a	20.40abc	17.59ab	85.25a	82.75a	85.95ab	81.60ab	8
34.39 c	51.17 c	41.02 c	10.41ab	37.88ab	10.21a	68.83ab	64.54ab	15.10c	11.64bc	92.45a	90.90a	90.68ab	88.18ab	9
69.34ab	77.81ab	72.14ab	23.43ab	37.49ab	28.68a	80.34a	77.88a	24.49ab	21.95ab	89.51a	86.47a	94.64a	76.67ab	10

CONCLUSION

Results from analysis of variance on damage indices during phases of vegetation and reproduction under heat, osmotic atmospheric and osmotic stress by polyethylene glycol suggested that there is a medium genetic diversity between genotypes (genotype differences was insignificant in some cases and in some other cases, differences was significant at 5%). Mean comparison results on membrane damage indices indicated that based on stress type and growth stage, genotypes order changes on membrane stability. However, it could generally be said that genotypes No. 3, 6, 9 and 4 have more stable membranes (it should also be mentioned that genotypes No. 3, 4 and 9 are among the most draught stress tolerant cultivars).

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