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Effects of PEG and NaCl Stress on Two Cultivars of Corn (Zea mays L.) at Germination and Early Seedling Stages

A. Farsiani, and M. E. Ghobadi

***Abstract*—**To study on effect of PEG and NaCl stress on germination and early seedling stages on two cultivar of corn, two separated experiment were laid out at physiology laboratory, faculty of Agriculture, Razi University, Kermanshah, Iran in 2009. This investigation was performed as factorial experiment under Complete Randomized Design (CRD) with three replications. Cultivar factor contains of two varieties (sweet corn SC403 and Flint corn SC704) and five levels of stress (0, -2, -4, -6 and -8 bar). The principal aim of current study was to compare the two varieties of maize in relative to the stress conditions. Results indicated that significant decrease was observed in percentage of germination, germination rate, length of radicle and plumule and radicle and plumule dry matter. On the basis of the results, NaCl as compared with PEG had more effect on germination and early seedling stage and sweet corn had more resistant than flint corn in both stress conditions.

***Keywords*—**Corn, Early Seedling Stage, Germination, PEG and NaCl Stress.

***Abbreviations*—**PEG: Polyethylene glycol, NaCl: sodium chloride.

I. Introduction

CORN (*Zea mays* L.) is a main food and economical crop. It is one of the most important crops throughout the world so, it is urgent to increase maize yields even under the unfavorable conditions [13]. Abiotic stresses, such as drought, salinity, extreme temperatures, chemical toxicity and oxidative stress are serious threats to agriculture and result in the deterioration of the environment. Abiotic stress is the primary cause of crop loss worldwide, reducing average yields for most major crop plants by more than 50% [2]. One of the most important abiotic factors limiting plant germination and early seedling stages is water stress brought about by drought and salinity [1], which are widespread problems around the world [12]. Salinity and drought affect the plants in a similar way [7]. Reduced water potential is a common consequence of both salinity and drought [9]. Water stress acts by decreasing the percentage and rate of germination and seedling growth [3]. Germination of seeds, one of the most critical phases of plant life, is greatly influenced by salinity [11]. NaCl and Polyethylene glycol (PEG) compounds have been used to simulate osmotic stress effects in petri dish (in vitro) for plants to maintain uniform water potential throughout the experimental period [8]. The principal aim of present study was to compare the effects of drought and salt stress induced on germination and early seedling stage of two cultivars of maize.

Authors are with Department of Plant Breeding and Agronomy, Faculty of Agriculture, Razi University, Iran (corresponding author: e-mail: Arashfarsiani@yahoo.com, P.C: 34146-76697; phone +989122813654).

II. Materials and Methods

In two separated experiments, effect of drought and salt stresses induced by different osmotic potential levels [0(control), -2, -4, -6 and -8 bar] of polyethylene glycol 6000 (PEG 6000) and NaCl treatments on Germination and early seedling development of corn were studied. Two cultivar of corn including Flint corn (SC704) and Sweet corn (SC403) were used. This investigation was performed as factorial experiment under Randomized Complete Design (CRD) with three replications. In each experiment and each level of stress, twenty seeds of any cultivar were selected and sterilized in sodium hypochlorite (1%) and then washed in water for two times. The seeds of both cultivars were germinated in petri dishes on 2 layers of filter paper in an incubator maintained at 25 ºC. Daily, germination rate was measured and need of replace the filter papers and add the PEG and NaCl solubles were performed. After 10 days, percentage of germination was measured by ISTA (International Seed Testing Association) standard method. At end of the tenth day, the percentage of germination, germination rate, the length of radicle and plumule of seeds, and dry matter weight of radicle and plumule were also measured. Osmotic potentials of PEG 6000 were calculated as described by Michael and Kaufman [10].

III. Results

A. Drought Stress Experiment

According to results of analysis of variance, percentage of germination and germination rate in different levels of drought stress and different varieties were significant. But interaction between cultivars and stress level in of germination and germination rate not significant. Means results indicated that percentage of germination and germination rate in sweet corn had more than flint corn (Table I). The effect of drought stress levels revealed that there was no significant differences in germination rate in stress level (-2 bar) but in (-4 bar), the significant decrease was observed. But, the variability trend of germination is more severe and in primary levels of stress, decrease amount is significant. Also, the interaction between cultivars and stress levels showed that maximum of percentage of germination (% 90) in flint corn (control) as compared with sweet corn not significant (Table II).

On the basis of ANOVA results, the effects of variety and stress levels on length of radicle and plumule were significant but interaction between cultivars and stress level in length of plumule had significant difference and on length of radicle not significant. Mean comparison results revealed that the length of radicle and plumule in flint corn was more than sweet corn. It can represent that flint corn was more resistant than sweet corn in stress conditions for this traits (Table I and II).

On the basis of results, the effect of variety and stress levels and their interaction on radicle dry matter were significant but plumule dry matter only on stress levels shown significant difference and with cultivar and their interaction not significant. Results showed that rate of radicle dry matter in sweet corn more than flint corn but plumule dry matter on two cultivars not significant (Table I and II).

TABLE I
COMPARISON OF MEANS SIMPLE EFFECT OF CULTIVAR AND STRESS LEVELS ON GERMINATION AND GROWTH SWEET CORN (SC403) AND FLINT CORN (SC704)

Treatments	Germination (%)	Germination rate	Length of radicle (g)	Length of plumule (g)	Radicle DM (cm)	Plumule DM (cm)
Cultivar						
SC403	50.33 a	6.22 a	2.6 b	0.9 b	0.02 a	0.026 a
SC704	44.00 b	5.30 b	3.5 a	1.1 a	0.01 b	0.026 b
Stress levels (bar)						
0	89.16 a	10.34 a	5.7 a	3 a	0.03 a	0.07 a
-2	75.83 b	10.04 a	5.6 a	1.3 b	0.03 a	0.04 a
-4	47.50 c	6.10 b	2.8 b	0.5 c	0.02 b	0.01 c
-6	23.33 d	2.30c	1.3 c	0.1 d	0.005 c	0.0006 d
-8	0 e	0 d	0 d	0 d	0 d	0d

Values of each column (between two horizon lines) followed by the same letter indicate no significant differences ($p \leq 0.05$) according to DMRT

TABLE II
COMPARISON OF REACTION OF CULTIVAR AND STRESS LEVELS ON GERMINATION AND GROWTH SWEET CORN (SC403) AND FLINT CORN (SC704)

Treatments		Germination (%)	Germination rate	Length of radicle (g)	Length of plumule (g)	Radicle DM (cm)	Plumule DM (cm)
SC403	0	88.33 a	10.65 a	5.11 b	2.82 b	0.048 a	0.07 a
	-2	80 ab	9.92 a	4.65 b	0.88 d	0.039 b	0.04 b
	-4	50 c	7.41 b	2.39 cd	0.79 d	0.025 cd	0.007 cd
	-6	33.33 d	3.15 cd	1.09 e	0.16 ef	0.006 e	0.0006 d
	-8	0 f	0 f	0 f	0 f	0 e	0 d
SC704	0	90 a	10.03 a	6.46 a	3.37 a	0.031 c	0.07 a
	-2	71.67 b	10.16 a	6.55 a	1.91 e	0.030 cd	0.04 b
	-4	45 c	4.88 c	3.35 c	0.4 e	0.024 d	0.01 c
	-6	13.33 e	1.49 de	1.50 de	0.14 ef	0.004 e	0.0006 d
	-8	0 f	0 e	0 f	0 f	0 e	0 d

Values of each column followed by the same letter indicate no significant differences ($p \leq 0.05$) according to DMRT

TABLE III
COMPARISON OF MEANS SIMPLE EFFECT OF CULTIVAR AND STRESS LEVELS ON GERMINATION AND GROWTH SWEET CORN (SC403) AND FLINT CORN (SC 704)

Treatments	Germination (%)	Germination rate	Length of radicle (g)	Length of plumule (g)	Radicle DM (cm)	Plumule DM (cm)
Cultivar						
SC403	44.66 a	6.29 a	2.41 b	1.68 a	0.026 a	0.037 a
SC704	34.33 b	4.91 b	2.6 a	1.39 b	0.009 b	0.019 b
Stress levels(bar)						
0	89.16 a	12.12 a	5.72 a	2.78 a	0.038 a	0.053 a
-2	60.83 b	8.37 b	3.87b	2.38 b	0.033 a	0.031 b
-4	27.5 c	4.24 c	2.05 c	1.63 c	0.006 b	0.026 bc
-6	12.5 d	2.07 d	0.6 d	0.52 d	0.005 b	0.019 c
-8	7.5 d	1.21 d	0.29 d	0.36 d	0.002 b	0.011 d

Values of each column (between two horizon lines) followed by the same letter indicate no significant differences ($p \leq 0.05$) according to DMRT

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TABLE IV
COMPARISON OF REACTION OF CULTIVAR AND STRESS LEVELS ON GERMINATION AND GROWTH SWEET CORN (SC403) AND FLINT CORN (SC704)

Treatments		Germination (%)	Germination rate	Length of radicle (g)	Length of plumule (g)	Radicle DM (cm)	Plumule DM (cm)
SC403	0	90 a	11.38 a	4.87 b	2.46 b	0.05 a	0.06 a
	-2	60 b	8.29 b	3.68 c	2.52 b	0.04 b	0.019 cd
	-4	33.33 c	5.23 c	1.73 de	1.64 c	0.005 de	0.044 b
	-6	25 cd	4.14 cd	1.2 ef	1.05 d	0.01 d	0.039 b
	-8	15 d	2.42 d	0.5 fg	0.72 d	0.005 de	0.022 c
SC704	0	88.33 a	12.87 a	6.56 a	3.11 a	0.02 c	0.044 b
	-2	61.67 b	8.44 b	4.06 bc	2.23 b	0.01 d	0.043 b
	-4	21.67 cd	3.26 cd	2.37 d	1.63 c	0.006 de	0.008 de
	-6	0 e	0 e	0 g	0 e	0 e	0 e
	-8	0 e	0 e	0 g	0 e	0 e	0 e

Values of each column followed by the same letter indicate no significant differences ($p \leq 0.05$) according to DMRT

IV. SALT STRESS EXPERIMENT

Percentage of germination and germination rate in different levels of salt stress and different varieties were significant but interaction between them not significant. Means results indicated that percentage of germination and germination rate in sweet corn was more than flint corn (Table III). In addition to, interaction means showed that maximum of percentage of germination (%90) in sweet corn (control) which not significant in flint corn (Table IV). According to results, the effect of stress levels causes significant difference in length of radicle and plumule but effect of variety only in length of plumule was significant. Results shown that length of radicle in flint corn (SC704) was more than sweet corn (SC403) but length of plumule in sweet corn was more than flint corn (Table III and IV). The effect of variety and stress levels cause significant difference in radicle and plumule dry matter. But interaction variety and stress level only in radicle dry matter was significant. In this regards, radicle dry matter and plumule dry matter in sweet corn were more than flint corn (Table III and IV).

V. DISCUSSION

Water stress due to drought and salinity is probably the most significant abiotic factor limiting plant and also crop growth and development [5]. Salinity and drought stresses are physiologically related, because both induce osmotic stress and most of the metabolic responses of the affected plants are similar to some extent [4]. Water deficit affects the germination of seed and the growth of seedlings negatively [14]. In present study, all considered traits except length of radicle and plumule in sweet corn had significant differences relative to flint corn. Because of germination is one of the most important traits in early stage of growth in most plants, it seems that sweet corn in drought and salt stress conditions had more resistant than flint corn and had more yield potential (Figs. 1 and 2).

There was no report about physiological and agronomical aspects sweet corn in Iran. In attention to growth period of cv. SC403 was shorter than cv. SC704, it seems that cv. SC403 can be proper substitution crop for flint corn in area where drought and soil salinity was prominent. In according to results of the present study, it suggested that more experiments were carried out on the similar cultivars of sweet corn and even in flint corn. Results of the current study were in agreement with other experiments in different plants including Kalefetoglu *et al.* (2009) in chickpea, Almansouri *et al*. (2001*)* in wheat and Soltani *et al,* (2006) in wheat.

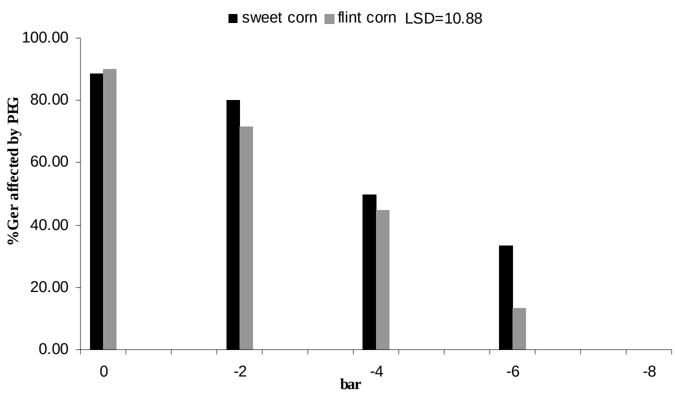

Fig. 1 Percentage of germination affected by PEG

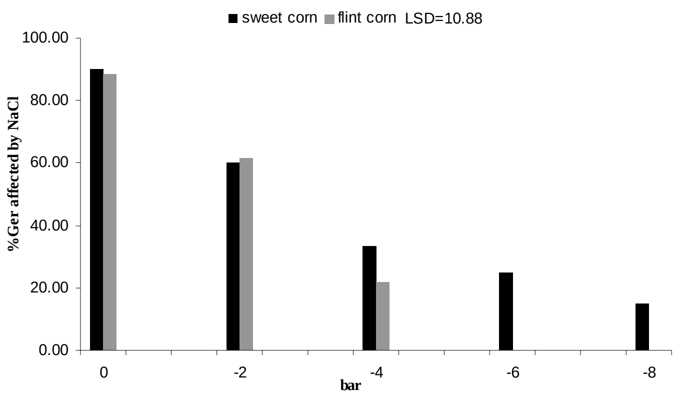

Fig. 2 Percentage of germination affected by NaCl

REFERENCES

[1] M. Almansouri, J. M. Kinet and S. Lutts, "Effect of salt and osmotic stresses on germination in durum wheat (Triticum durum Desf.)", Plant Soil, 2001, vol. 231, pp. 243-254.

[2] J. S. Boyer, "Plant productivity and environment" Science, 1982, vol. 218, pp. 443-448.

[3] M. E. A. Delachiave and S. Z. De Pinho, "Germination of Senna occidentalis link: seed at different osmotic potential levels", Braz. Arch. Techn, 2003, vol. 46, pp.163-166.

[4] S. Djibril, O. K. Mohamed, D. Diaga, D. Diégane, B. F. Abaye, S. Maurice and B. Alain, "Growth and development of date palm (Phoenix dactylifera L.) seedlings under drought and salinity stresses". Afr J. Biotechnol, 2005, vol.4, no. 9, pp. 968-972.

[5] T. Hartmann, M. College and P. Lumsden, "Responses of different varieties of Lolium perenne to salinity". Annual Conference of the Society for Experimental Biology, Lancashire, 2005.

[6] T. Kalefetogllu Macar, O. Turan and Y. Ekmekci, "Effect of water deficit induced by PEG and NaCl on Chickpea (Cicer arieitinum L.) cultivar and lines at early seedling stage". G. U. Journal of Science, 2009, vol. 22, no.1, pp. 5-14.

[7] N. Katerji, J. W. Van Hoorn, A. Hamdy and M. Mastrorilli, "Comparison of corn yield response to plant water stress caused by salinity and by drought", Agr. Water Manage, 2004, vol. 65, pp. 95-101.

[8] M. Kulkarni and U. Deshpande, "In vitro screening of tomato genotypes for drought resistance using polyethylene glycol", Afr. J Biotechnology, 2007, vol. 6, no 6, pp. 691-696.

[9] J. Legocka and A. Kluk, "Effect of salt and osmotic stress on changes in polyamine content and arginine decarboxylase activity in Lupinus luteus seedlings". Plant Physiol, 2005, vol. 162, pp. 662-668.

[10] B. E. Michael and M. R. Kaufman, "The osmotic potential of polyethyleneglycol-6000" Plant Physiol, 1973, vol 51, pp. 914-916.

[11] N. Misra and U. N. Dwivedi, "Genotypic differences in salinity tolerance of green gram cultivars". Plant Sci, 2004, vol. 166, pp. 1135-1142.

[12] A. Soltani, M. Gholipoor and E. Zeinali, "Seed reserve utilization and seedling growth of wheat as affected by drought and salinity". Environ. Exp. Bot, 2006, vol. 55, pp. 195-200.

[13] G. E. Ti – da, S. O. I. Fang- Gong- Sui., B. A. I. L. I. Ping, L.U. Ying-yan and Zh. Guang-sheng, "Effect of water stress on the protective enzymes and lipid per oxidation in roots and leaves of summer maize" Agric. Sci, China, 2006, vol. 5, pp. 291-228.

[14] L.Van den Berg and Y. J. Zeng, "Response of South African indigenous grass species to drought stress induced by polyethylene glycol (PEG) 6000" Afr. J. Bot, 2006, vol. 72, pp. 284-286.