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Full Length Research Paper

The effects of NaCl priming on salt tolerance in sunflower germination and seedling grown under salinity conditions

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This experiment was conducted to evaluate the effects of NaCl priming with KNO_3 on the germination traits and seedling growth of four *Helianthus annuus* L. cultivars under salinity conditions. Seeds of four spring sunflower (Armawireski, Airfloure, Alestar and Ismailli) were primed with KNO_3 (-1.0 M Pa) for 24 h in continuous 30°C. Primed (P) and un-primed (NP) seeds were cultured in medium grade perlite and placed in greenhouse for 40 days. Experiments were conducted using various osmotic pressures induced by NaCl (5, 10, 15, 20 and 25 dS m^{-1}) in salinity experiment. Results showed that germination percentage of primed seeds was greater than that of un-primed seeds. Radicle length, seedling height and dry weight and leaf number of plants derived from primed seeds were higher compared with un-primed seeds. Na content of plants derived from primed seeds was higher than that of un-primed ones. In contrast, K content of priming resulted plantlets was comparatively higher compared with un-primed counterparts. It seems that salinity tolerance in priming resulted plantlets was due to higher potential of these plants for osmosis regulation. Decreasing osmotic potential progressively decreased both root and shoot length.

Key words: Sunflower, NaCl priming, KNO_3, seed germination, salinity.

INTRODUCTION

Salinity can affect germination and seedling growth either by creating an osmotic pressure that prevents water uptake or by toxic effects of sodium and chloride ions (Hopper et al., 1979). Salinity is also considered as a major abiotic stress and significant factor affecting crop production all over the world and especially in arid and semi-arid region (Davidson and Chevalier, 1987; Khajeh-Hosseini et al., 2003). Seed germination was negatively affected by drought (Damirkaya et al., 2006) and salinity stresses (Zhu, 2002). Seed size is an important seed quality characteristic affected by variety, environment and management practices (Jumsoon et al., 1996). The influence of seed size on crop establishment has been studied extensively. Generally, decreasing seed size reduced seedling establishment (Damirkaya et al., 2006; Mauromicale and Cavallaro 1997). In field condition poor germination and decrease of seedling growth results in poor establishment and occasionally crop failure (Afkari, 2009). Biotic and abiotic stresses are of main problems of agricultural systems. About 7% of arable lands of the world are under salinity pressure (Jumsoon et al., 1996). High levels of soil salinity negatively affect productivity of most field crops (Munns, 1993). Saline soils remarkably reduce oil production potential and oil yield of sunflower (Szabolcs, 1994). Soil salinity reduces water availability of plant roots via negative (low) osmosis potential, as well as decrease of germination dynamics of plant seeds by ionic toxicity of Na^+ and Cl^- (Munnset al., 1988). Seed priming is an efficient method for increasing of seed vigor and improvement of germination and seedling growth (Ascherman-Koch et al., 1992; Jumsoon et al., 1996). There are several reports that under diverse environmental stresses such as salinity, water deficiency and high and low temperatures osmo-priming leads to cellular, sub-cellular and molecular changes in seeds and subsequently promotes seed vigor during germination and emergence in different plant species (Godfery et al., 2004; McDonald, 2000; Numjun et al., 1997). There is evidence that seed osmo-priming increased salinity tolerance of sunflower (*Helianthus annus* L.), bean (*Phaseolus vulgaris* L.) and

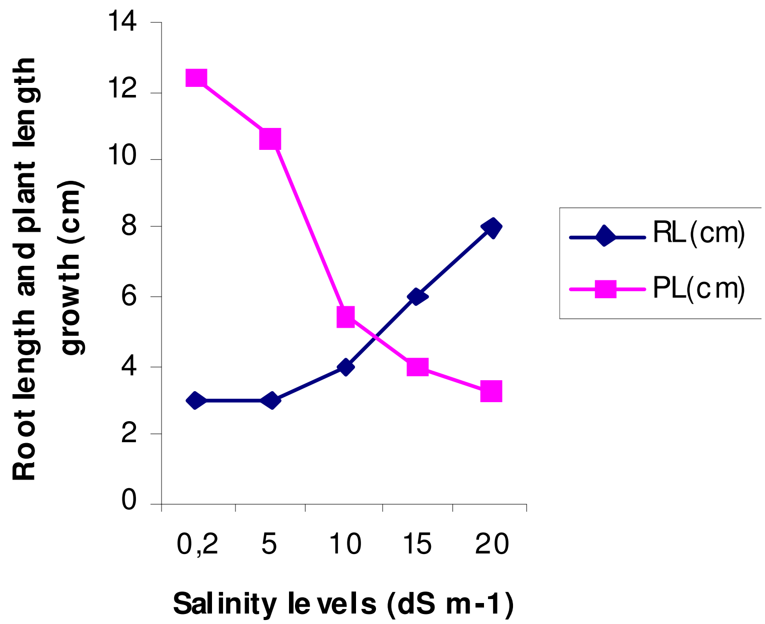

Figure 1. The effect of NaCl priming on root length and plant length of Sunflower cultivars under salinity conditions.

tomato (*Lycopersicon esculentum* Mill (Damirkaya et al., 2006; Jumsoon et al., 1996; Khadri et al., 2007).

The aim of this research was to evaluate the effects of NaCl priming on the germination dynamics and subsequent seedling growth of four *Helianthus annuus* L. cultivars (Armawireski, Airfloure, Alestar and Ismailli) under salinity condition for the first time. NaCl priming could be used as useful method for improving salt tolerance of seeds. Previous studies on tomato (Cuartero et al., 2006; Jumsoon et al., 1996) and melon (Sivriteps et al., 2003) showed that seed priming improves seed germination, seedling emergence and growth under saline conditions. However, physiological changes induced by NaCl priming have rarely been studied in plants. Cayuela et al. (1996) concluded that higher salt tolerance of plants obtained from primed (P) seeds seems to be resulted from higher capacity of these plants for osmotic adjustment, since plants from P seeds have more Na and Cl in roots and more sugars and organic acids in leaves than plants from non-primed (NP) seeds. This study was conducted to examine the effect of NaCl priming on salt tolerance of Iranian cucumber cultivars at the seedling stage and to evaluate the physiological effects of priming.

MATERIALS AND METHODS

This experiment was carried out at the Plant Physiology Laboratory in Baku State University in Azerbaijan. Four common cultivars (Armawireski, Airfloure, Alestar and Ismailli) of spring *Helianthus annuus* L., were primed with KNO_3 solution (-1.0 MPa) for one day in 30℃. Seeds were rinsed over tap water and distilled water and dried with Whatman paper. Seeds were planted in 5-litre pots filled with medium grade perlite. Pots were placed in greenhouse with ambient temperature, relative humidity and light intensity of 25 - 30℃, 50% and 400 μ mol $m^{-2}s^{1}$, respectively. Pots were daily irrigated with solutions containing different levels of salinity (5, 10, 15, 20 and 25 dS m^{-1}) based on NaCl. Experimental design was factorial based on CRD with three replications. Emerged plantlets were counted daily for evaluation of mean emergence time (MET) described by Al-Mudaris and Jutzi, (1999) and Khajeh-Hosseini et al. (2003). Root length, plant height and leaf number were measured immediately. After 4 weeks, plants were harvested from trays and radicle length of them was measured and then above-ground parts of seedlings were harvested for evaluation of their responses to salinity. In order to determine shoot dry weight (mg/plant) and to analyses ion concentrations in seedlings, plant materials were dried for 48 h at 70℃. Na, K and Ca concentrations of seedlings were determined, using flame-photometry following nitric-perchloric acid digestion. Proline contents of seedlings were determined according to Bates et al. (1973). Arial parts of seedlings were weighed and then they were dried in an air forced oven at 45℃ for 48 h in order to dry weight measurement. Na and K contents of plants were measured with flame-photometer. All the data were subjected to an analysis of variance, using MSTAT C software and the means were compared by Duncan tests at p = 0.01.

RESULTS AND DISCUSSION

Total emergence, mean emergence time (MET), radicle length and shoot dry weight of sunflower seedlings were not significantly affected by cultivar (Figure 2), but the effects of NaCl priming, salinity and their interaction on these traits were significant (Table 1). Total emergence of seedlings from both P and NP seeds decreased with increasing NaCl salinity. However, this reduction in total emergence was higher for NP seeds, compared to P seeds. Percentage of seed germination decreased with raising of salinity levels in both primed and un-primed

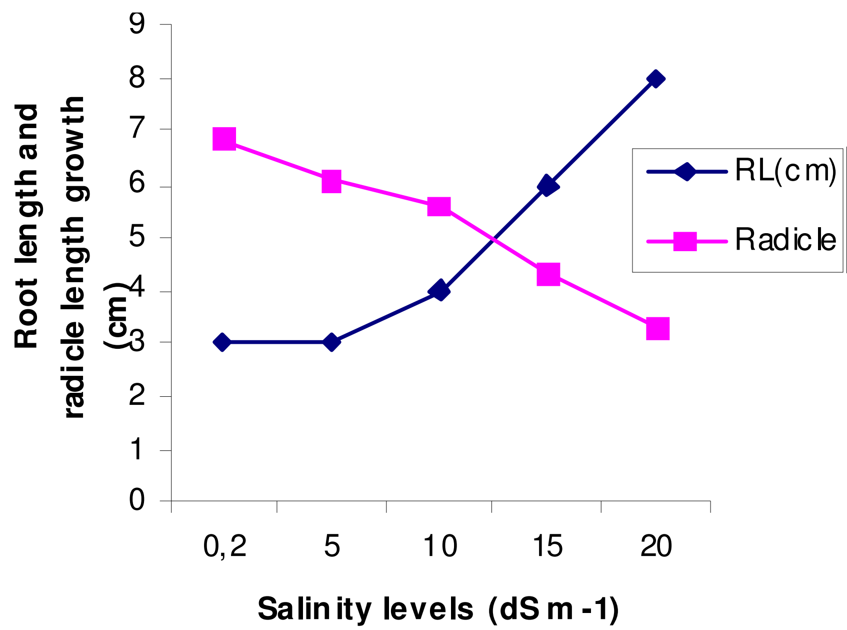

Figure 2. The effect of NaCl priming on root length and radicle length of Sunflower cultivars under salinity conditions.

Table 1. The effect of NaCl priming on seed germination, seedling emergence and growth of four Sunflower cultivars under salinity conditions.

Treatment		Total Emergence (%)	MET* (day)	Root length (cm)	Plant height (cm)	Seedling dry weight (mg)	Leaf number	Radical length (mm)	Proline (%mg/f. w)
Cultivar	Armawireski	83a	4.0a	11.6a	1780a	6.7a	8.3a	0 .94a
	Airfloure	86a	3.5a	10.6a	1800a	6.5a	6.8b	1.04a
	Alestar	69c	3.1a	8.7a	1713a	6.2a	7.1b	0.89a
	Ismailli	76b	2.93a	9.8a	1763a	5.8a	6.7b	1.21a
Priming	P	90a	3.5a	10.1a	1850a	7.2a	7.23b	0.94b
	NP	81b	4.8b	11.3b	1400b	6.1b	9.39a	1.41a
Salinity ($dS\ m^{-1}$)	5	98a	3.0a	12.4a	1800a	7.7a	6.84a	0.47a
	10	90a	3.0a	10.6b	1200b	7.0ab	6.12b	0.61a
	15	80c	4.0ab	5.4c	880c	4.5c	5.61c	0.87b
	20	74cd	6.0b	4.0d	350d	3.1d	4.33d	1.59c
	25	65d	7.9c	3.2e	200e	1.2e	3.29e	1.86d

Different letters in columns show significant difference based on Duncan's multiple range test at P< 0.01.

seeds (Table 1). Meanwhile, germination percentage in primed seeds at all salinity levels was higher than that of un-primed seeds. Primed seeds had better efficiency for water absorption from growing media and it is obvious that metabolic activities in seed during germination process commence much earlier than radicle and plumule appearance, that is, emergence (Hopper et al., 1979). Like germination percentage, prime seeds had lower MET compared with un-primed seeds. These positive effects are probably due to the stimulatory effects of priming on the early stages of germination process by mediation of cell division in germinating seeds (Szabolcs, 1994; Sivriteps et al., 2003). There are several reports that seed priming can homogenize seed germination in a short period of time (Khajeh-Hosseini et al., 2003; Numjun et al., 1997; Zhu, 2002). Root length significantly decreased by increasing salinity levels in both primed and un-primed seeds (Figures 1 and 2). However, root length of primed seeds was greater than that of unprimed ones (Table 2). Salt deposit in the root growing medium is the main reason for physiological drought and subsequently reduced cell division and/or enlargement in the root growing

Table 2. The interaction effects of NaCl priming and salinity levels on seed Germination, seedling emergence and growth of four *Helianthus annuus* L. cultivars under salinity conditions.

Salinity (dSm-1)	KNO3 priming	Total Emergence(%)	MET* (day)	Root Length (cm)	Plant Height (cm)	Seedling dry weight (mg)	Leaf number	Radical Length (mm)	Proline (%mg/f.w)
5	P	99a	3.6a	12.1a	11.2a	1800a	7.9a	17.69a	0.38h
	PN	96ab	4.0a	11.4b	11.0a	1700ab	7.1ab	15.29ab	0.29h
10	P	96b	4.5ab	10.6c	4.1b	1500b	7.0ab	14.18b	0.56fg
	PN	89c	5.6b	9.3cd	8.3bc	1270bc	6.6b	10.31c	0.42g
15	P	87cd	6.4bc	8.7d	7.2c	700c	5.7c	10.74cd	1.03c
	PN	77d	7.3c	6.1de	5.0d	587d	4.5d	8.52dc	0.83f
20	P	70de	8.2d	4.8e	4.1e	490de	4.1de	3.12e	1.94c
	PN	65e	9.6de	3.9f	3.7ef	360e	3.2e	1.41e	1.58d
25	P	62ef	10.1e	3.8fh	3.5ef	350ef	3.1e	1.01e	2.97a
	PN	34f	12.7f	2.1h	2.0f	1.98f	1.2f	0.73e	2.14b

Different letters in columns show significant difference based on Duncan's multiple range test at P < 0.01.

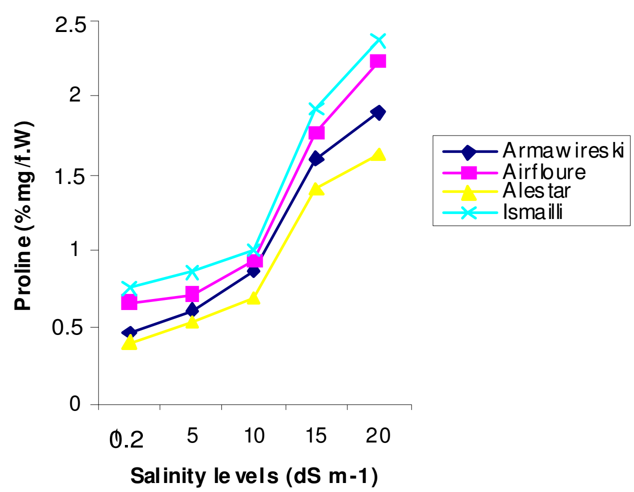

Figure 3. The interaction effect of NaCl priming and salinity levels on proline and radicle length of four Sunflower cultivars under salinity conditions

region and ultimately reduced root growth (Munns, 1993). High levels of salinity reduced leaf number and subsequently aerial parts dry weight (Table 2). This is likely due to the interference of salinity stress on the phytohormones biosynthesis and action (Cuartero et al., 2006). Furthermore, there is evidence that high levels of salinity inhibit growth of plants by retarding leaf primordia initiation (Mauromicale and Cavallaro 1997). Reduced leaf number and area lead to a low level of photosynthesis and photosynthate production and conse-quently lower plant production and biomass (Afkari et al., 2009).

Increasing salinity significantly increased Na content of plants in both primed and un-primed derived plants. Meanwhile, Na content of plants derived from primed seeds was lower than that of un-primed ones. In contrast, K content of both primed and un-primed plants decreased with raising salinity levels. Results of this experiment showed that primed seeds had greater vigor for germination and subsequent seedling and plant establishment (Figure 1). Finally, we can claim that positive effects of priming relates to the suitable and efficient osmosis regulation of priming derived plants compared with unprimed counterparts. Ultimately, this trend led to an increased salinity tolerance of plants (Afkari, 2009; Harris et al., 2001). The results showed that the NaCl salinity caused growth inhibition in sunflower seedlings, due to an increase in MET and decreases in total emergence and dry weight. The interaction effect of NaCl priming and salinity levels on proline and radicle length of four Sunflower cultivars under salinity conditions (Figure 3) and growth of Iranian sunflower has been shown as in other crops (Afkari, 2009). Total emergence, emergence

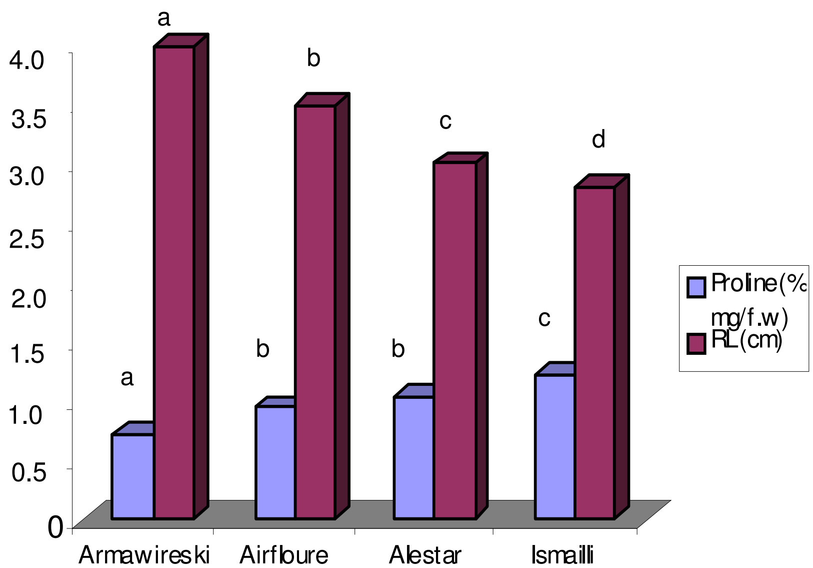

Figure 4. The interaction effect of NaCl priming and salinity levels on proline and radicle length of four Sunflower cultivars under salinity conditions

rate, radicle length and dry weight of sunflower seedlings derived from P seeds were higher than those derived from NP seeds.

Results showed that NaCl salinity causes increase in Na concentration and decrease in K and Ca concentration of sunflower seedlings derived from NP seeds (Table 2). The results suggested that NaCl priming increased salt tolerance of Sunflower seeds by promoting K and Ca accumulation and inducing osmoregulation by the accumulation of proline (Figure 4), but the effect of NaCl priming of sunflower seeds on salt tolerance in later growth stages of this plant still requires more investigations.

Conclusions

There is evidence that in most field and horticultural crops, priming led to improvement of germination and seedling establishment (McDonald, 2000). Improvement in seedling growth, development and establishment correlates with efficient water uptake of prime derived plants. In the present study, KNO_3 primed seeds had increased seed germination percentage and MET with strong seedlings and subsequently higher number of established plants per unit area. Therefore, NaCl priming with KNO_3 may be an efficient method to overcome seed germination problems and to improve seedling growth in field, especially under salinity conditions. Furthermore, this technique has other advantages, such as feasibility and low cost. It is noteworthy that KNO_3 priming technique and other priming methods need further studies in other oil crops under field conditions to get more favorable results, especially on yield components under common growing conditions.

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