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ALLEVIATION OF SALINITY STRESS IN LETTUCE DURING GERMINATION BY SEED PRIMING

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ABSTRACT

Using seed priming as a tool to overcome salinity stress conditions on lettuce *Lactuca sativa* L. (White Paris cv.) was studied. Seeds were primed in 5 different priming agents (PEG, KNO_3, NaCl, $CaCl_2$, Mannitol) plus the control treatment (without priming) then germination under laboratory conditions using different salinity levels, i.e. 0.00, 1000, 3000, 5000 and 7000 ppm was evaluated .

Results indicated that primed seeds had a higher germination percentage than unprimed seeds under saline stress regardless of priming agent. Seed priming also reduced days required to 50% germination and promoted rapid and uniform germination under adverse conditions. Germination percentage and germination performance index were decreased with increasing saline stress while, uniformity of germination and days required to 50% germination were increased with increasing salinity levels. The low salinity level of 1000 ppm enhanced seed germination and seedling growth

Lettuce seed germination showed high response to seed priming under salinity conditions; the most effective agents were $CaCl_2$, PEG and Mannitol.
It could be concluded that seed priming agents have promotional effects on lettuce seed germination under salinity stress conditions
Keywords : seed priming ; *Lactuca sativa*; germination

INTRODUCTION

Nearly 20% of the world's cultivated area and half of the world's irrigated lands are affected by salinity (Zhu, 2001). Among various environmental stresses, salinity has become a critical problem worldwide due to its dramatic effects on plant physiology and performance (Janmohammadi et al 2008). The reduction of the germination percentage and delaying in the onset of germination (Scorer *et al.*, 1985), and poor seedling establishment (Afzal *et al.*, 2005) specially with increase in NaCl concentrations (Murillo-Amador, *et al.* 2002) are due to creating osmotic potential external to the seeds preventing water uptake or through the toxic effects of Na^+ and Cl^- ions on germinating seed (Khajeh-Hosseini *et al.*, 2003). Moreover, Salinity reduce plant growth and final crop yield (Ashraf and Foolad, 2005), and reduce root hair formation by increase solute concentration in the germination environment (Richards 2005).

Vegetable crops are generally salt sensitive (Shannon, 1997) even there are wide differences in the tolerance to salt among cultivars (Shannon *et al.*, 1983; Coons *et al.*, 1990), Lettuce is considered to be a relatively salt sensitive vegetable (Martinez *et al.*, 1996). At 80 m*M* NaCl, lettuce germinability is reduced in 50% (Odegbaro and Smith, 1969) even when salt

seemed to affect lettuce growth mainly through osmotic effects (Shannon, 1997). Recent results have shown that plant performance under different NaCl treatments was affected by ionic and osmotic effects in lettuce (Tarakcioglu and Inal, 2002).

Considerable work was carried to overcome negative effects of salinity on plant growth stages especially during seed germination that consider more sensitive to stress than mature plants because of exposure the dynamic environment close to the soil surface (Dodd and Donovan, 1999). One of the most successful methods was seed priming which defined; the presowing treatment in which seeds are soaked in an osmotic solution that allows them to imbibe water and go through the first stages of germination, but does not permit radical protrusion through the seed coat (Heydecker 1973).

The most important priming treatments are hydropriming (soaking of seed in water before sowing), and osmopriming which refers to soaking seed in solutions of sugars, polyethylene glycol (PEG), glycerol, sorbitol (Ashraf and Foolad, 2005) or fertilizers such as urea (Al-Mudaris and Jutzi, 1999), followed by drying the seed before sowing. Seed priming treatment proved significant valuable effects on seed germination and seedlings establishment parameters in several vegetable seeds included carrot (Balbinot & Lopes, 2006) and lettuce (Khah and Passam, 2005) . These effects are prevent the occurrence of thermodormancy in high temperature (Valdes and Bradford, 1987), break dormancy and secondary dormancy (Weges *et al.*, 1991), improve root growth, germination rate and longevity, and reduced the mean time to germination (Tarquis and Bradford , 1992), improve emergence rates and reduced post-emergence damping off symptoms (Jacqmin *et al.* 1993), reduce seedling emergence time and rate (Duman *et al.* 1995) and increase activity of endo- beta -mannanase enzyme (Bonina *et al.* 2007). These effects of priming are more evident under field stress conditions, such as low and high temperatures (Demir & Oztokat, 2003; Bittencourt *et al.*, 2004), water stress (Bittencourt *et al.*, 2004), and salinity stress (Pill *et al.*,1991). Moreover, previous work (Afzal, 2005; Afzal *et al.*, 2005; Ashraf and Rauf, 2001; Basra *et al.*, 2006; Roy and Srivastava, 2000; Bradford, 1986) suggested that the adverse and depressive effects of salinity and water stress on germination can be alleviated by various seed priming treatments.
Thus, the objectives of this work was to determine the effects of different seed priming agents and salinity levels on seed germination of lettuce; foster seed germination and seedling establishment of lettuce under salt stress conditions ; overcoming erratic germination and prolong germination period of lettuce; and find the best priming agent to alleviate the salinity stress during seed germination and seedling growth stage of lettuce. .

MATERIALS AND METHODS

Two laboratory experiments were carried out during the period 2008 – 2009 at Seed Laboratory of Vegetable Seed Production and Technology Department, Horticulture Research Institute, Agricultural Research Center, Egypt, to investigate the response of White Paris cultivar of Romine lettuce to priming treatments under salt stress.

The seeds were primed in 5 priming solutions PEG, KNO_3, NaCl, $CaCl_2$, Mannitol plus control for 144 hours in 18 ± 2 °C, then the primed seeds dried to its originally moisture content.

Polyethylene glycol (PEG 6000), KNO_3 and NaCl solutions were prepared at -1Mega Pascal (MPa) while, Mannitol and $CaCl_2$ were prepared at -2MPa to avoid over priming (personal observation). Osmotic potential of KNO3, NaCl, Mannitol and $CaCl_2$ was calculated according to Van't Hof expression , while -1 MPa of PEG was calculated according to (Michel and Kaufmann , 1973).

After priming, primed seeds were allowed to germinate under different salinity levels i.e. Zero, 1000, 3000, 5000 and 7000 ppm.

Laboratory germination tests were done on four replications of 100 seeds each. Seeds were sown on rolled filter paper and placed in plastic boxes. The boxes were held for 7 days in a germination cabinet at a constant temperature of 20^0C according to ISTA rules (ISTA 1999).

A 6 X 5 factorial experiment in a randomized complete block design was used with 4 replicates for each treatment. The first factor was seed priming treatments (PEG, KNO_3, NaCl, $CaCl_2$, Mannitol and control) and the second factor was salinity levels (Zero-1000-3000-5000-7000 ppm).

The following data were recorded :-

1- Germination percentage (GP) was measured according to the ISTA rules (ISTA, 1999).
2- Mean time to germination in days (MGT) was calculated according to the formula MGT=Σnd/N where n is the number of germinated seed on each day, d the number of days from the beginning of the test, and N the total number of germinated seeds (Edwards and Sundstrom, 1987).
3- Coefficient of velocity was calculated according to the formula Coefficient of velocity = 1/ MGTX 100 where MGT is mean time to germination in days (Edwards and Sundstrom, 1987).
4- Germination performance index (GPI) was calculated according to the formula GPI= GP/MGT where GP is germination percentage and MGT is mean time to germination in days (Pill and Fieldhouse, 1982)
5- Time to reach 50% germination (T50), days required to 50% germination.
6- Uniformity of germination, the time in days occurring between 25% and 75% of germination (T75-T25).
7- Seedling length (cm) was measured on ten seedlings randomly taken from each replicate and the mean length of seedlings was calculated.
8- Seedling fresh weight (mg) was measured on ten seedlings randomly taken from each replicate, weighed.
9- Seedling dry weight was measured using the same seedlings taken for the determination of fresh weight.

The data obtained were similar in the two experiments so it combined analysis as one experiment and presented as mean of two experiments. Data subjected to statistical analysis by the technique of analysis of variance (ANOVA) according to Snedecor and Cochran (1982). The treatments mean were compared using Duncan multiple range test at 5 % level of probability as described by Steel and Torrie (1980).

RESULTS

1- Germination Behavior

Data presented in Table 1 indicated that germination percentage was increased with the low level of salinity i.e. 1000 ppm and recorded the highest value in comparison with control and other salinity levels. All seed priming treatments significantly increased the germination percentage and $CaCl_2$, PEG followed by KNO_3 were the most superior priming agents.

It is obvious from Table 2 that seed priming treatments significantly enhanced the germination percentage under salinity stress . $CaCl_2$ was the best agent in improving the germination percentage under the first three salinity levels (1000, 3000 and 5000 pm) while PEG was the best treatment under the highest salinity level as it recorded 91.83 % comparing with 67.00% for the control.

Data presented in Table 1 showed that seeds primed in $CaCl_2$ and Mannitol were characterized by a reduction in germination time mean as compared with other priming agents . Mean of germination time was increased with increasing the salinity levels gradually the highest salinity level used , the long time required to complete the germination process. Concerning the interaction between salinity and seed priming agents, it is clear from Table 2 that priming agents had ameliorative role on salt stress since it decreased the mean germination time except with NaCl especially with high salinity level which increased it dramatically (Table 2) .This may be due to the high toxic effect of Na^+ and Cl^- ions of salinity and NaCl as priming agent on germinating seed (Khajeh-Hosseini *et al.*, 2003).

Coefficient of velocity of germinated lettuce seeds tended to increase with priming treatments. There were significant differences among treatment means. The highest values were recorded by after $CaCl_2$ and Mannitol treatments (Table 1). There are no significant differences between check treatment and the low salinity level treatment of 1000 ppm in increasing the coefficient of velocity of germinated lettuce seeds while there are significance differences between these treatments and the other salinity levels i.e. 3000, 5000 or 7000 ppm.

Mannitol significantly played an important role in increasing the coefficient of velocity of germinated lettuce seeds under the low and moderate salinity levels i.e. 1000 and 3000 ppm, while calcium chloride $CaCl_2$ acts well in increasing the coefficient of velocity under high salinity level of 5000 and with no significance difference from KNO_3 at 7000 ppm (Table 2).

Germination Performance index (GPI) was calculated to integrate mean time to germination (MGT) and germination percentage (GP). The greater the GPI value, the greater the seed germination performance. Data tabulated in Table 1 showed that seed priming treatments significantly increased GPI while salinity levels decreased it. The highest value for GPI as affected by interaction between seed priming and salinity levels was obtained from the priming in Mannitol then germinating the lettuce seeds in low salinity level of 1000 ppm (Table 2). It is obvious from the same table that all priming agents

had a promotional effects of GPI except NaCl at high salinity level which decreased it .

Data presented in Table 1 reveal that seed priming caused a significant reduction in time required to reach 50% germination (T50) as compared with control. Seed priming was effective in improving T50 of lettuce seeds germinated under laboratory conditions. It appears that it can easily place priming agents into 3 groups according to their potential for reducing T50. The first group included $CaCl_2$, PEG and Mannitol, the second group included KNO_3 and the third group included NaCl.

Table (1): Effect of salinity stress and priming solutions on lettuce seed germination behavior and seedlings characteristics (Average of two experiments)

Treatment		GP%	MGT	Coefficient of velocity	GPI	T 50	Uniformity (T25 -T75)	Seedling F.W	Seedling D.W	Seedling length
Salinity Levels										
Salinity Levels	Zero ppm	90.25 b	1.01 d	103.50 a	93.60 a	1.19 d	0.66 d	0.24 b	0.0096 d	9.24 a
	1000 ppm	91.72 a	1.00 d	102.19 a	93.97 a	0.88 e	0.95 c	0.26 a	0.0126 a	8.19 b
	3000 ppm	88.44 c	1.37 c	76.12 b	86.95 b	1.37 c	0.90 c	0.24 b	0.0052 e	7.14 c
	5000 ppm	86.33 d	1.62 b	67.11 c	58.07 c	1.76 b	1.63 b	0.2 c	0.0109 b	7.22 c
	7000 ppm	81.25 e	2.56 a	43.07 d	35.32 d	2.95 a	2.11 a	0.16 d	0.0103 c	5.76 d
Priming Agents										
Priming Agents	PEG	92.1 b	1.46bc	78.94 b	73.21 b	1.4 d	1.18 b	0.23 b	0.0097 b	8.48 a
	KNO_3	87.7 d	1.57 b	73.58 c	65.45 c	1.56 c	1.16 b	0.23 b	0.0106 a	8.25 a
	NaCl	85.6 e	1.99 a	65.89 d	58.30 d	1.91 b	0.7 e	0.22 c	0.0106 a	7.82 b
	$CaCl_2$	94.4 a	1.32 d	82.03 b	78.16 a	1.11 e	0.86 d	0.22 bc	0.0095 b	8.58 a
	Mannitol	90.73 c	1.37cd	89.78 a	81.68 a	1.33 d	1.01 c	0.24 a	0.0104 a	7.72 b
	Control	75.06 f	1.37cd	80.17 b	60.70 d	2.48 a	2.6 a	0.16 d	0.0076 c	4.21 c

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range at 5% level.

Regarding to the effect of salinity levels on T50, data in Table 1 indicate that T50 was significantly reduced by using low salinity level 1000 ppm comparing with control whereas it significantly increased with moderate and high salinity levels of 3000, 5000 and 7000 ppm.

Concerning the interaction between salinity levels and priming agent on T50, data in Table 2 indicated that all interactions involving priming treatments significantly reduced time required to 50% germination, as compared with the control. The most effective treatments in decreasing T50 were Mannitol x 1000 or 3000 ppm salinity .

Uniformity of germination index was calculated as the time in days occurring between 25 and 75% of germination. The greater the uniformity value, the less uniformity, or more variability, occurred. It is clear from data in Table 1 that uniformity was significantly increased (i.e., Uniformity of germination index was reduced) by priming lettuce seeds. All treatments were superior to the control. More uniformity (low uniformity index value) was

obtained by priming lettuce seeds in NaCl or $CaCl_2$. The higher salinity levels , the higher uniformity index value obtained which means more variability occurs with increasing the salinity levels.

As for interaction between seed priming and salinity , data presented in Table 2 show that uniformity of germination index was significantly affected by the interaction. Generally priming lettuce seeds in $CaCl_2$ or Mannitol and germinating them in any salinity level improve the uniformity of germination.

Table (2): Effect of interaction between salinity stress and priming solutions on lettuce seed germination behavior (Average of two experiments)

Treatments		GP%	MGT	Coefficient of velocity	GPI	T 50	Uniformity (T25 -T75)
Salinity Levels	Priming Agents						
Zero ppm	PEG	93.33 ab	0.71 e	116.23 abc	108.46 abc	0.91 def	0.5 de
	KNO_3	90.5 abc	0.84 de	122.06 ab	110.40 ab	0.83 ef	0.5 de
	NaCl	90abc	1.07 bcde	102.35abcde	92.19abcdefg	1 def	0.5 de
	$CaCl_2$	96.33 a	1.19 bcde	92.26abcdefgh	88.67abcdefg	1 def	0.5de
	Mannitol	92 abc	1.03 bcde	97.36 abcdefg	89.56abcdefg	1 def	0.5de
	Control	79.33 cdef	1.20 bcde	90.76abcdefgh	72.10bcdefghi	2.41 bcde	1.5bcde
1000 ppm	PEG	91.33 abc	0.89 de	110.47 abcd	103.23 abcd	0.58 f	0.91cde
	KNO_3	93.16 ab	1.10 bcde	90.72abcdefgh	85.06 abcdefg	1def	0.83 cde
	NaCl	91.83 abc	1.17 bcde	84.37abcdefgh	78.44abcdefghi	1 def	1 cde
	$CaCl_2$	94.16 ab	1.00 cde	98.48 abcdef	95.16 abcde	1def	0.83cde
	Mannitol	92.33 abc	0.76 e	135.10a	122.03 a	0.58 f	0.58 de
	Control	87.5 abc	1.10 bcde	93.99abcdefgh	79.93 abcdefgh	1.16 def	1.58 bcde
3000 ppm	PEG	93.5 ab	1.50 bcde	67.52bcdefghi	62.99bcdefghij	1.5 cdef	0.5 de
	KNO_3	88.33 abc	1.73 bcde	58.08 defghi	51.27 efghij	1.5 cdef	0.5 de
	NaCl	88.5 abc	1.47 bcde	68.07bcdefghi	60.22 cdefghij	1.58 cdef	0.5de
	$CaCl_2$	95.33 a	1.49 bcde	67.28bcdefghi	64.15bcdefghij	1.08 def	0.5de
	Mannitol	92.33 abc	0.96 cde	104.93 abcde	97.01abcde	0.5f	1 cde
	Control	72.66 def	1.10 bcde	90.85abcdefgh	66.03bcdefghij	2.08bcdef	2.41 bcd
5000 ppm	PEG	90.5 abc	1.64 bcde	61.39 cdefghi	55.46 defghij	1.5 cdef	1.5bcde
	KNO_3	85 abcd	2.41 bcd	41.55 ghi	35.30 hij	2 bcdef	1.5 bcde
	NaCl	85.66 abc	1.99 bcde	50.35efghi	43.13 ghij	2 bcdef	1.5bcde
	$CaCl_2$	95.66 a	1.02 cde	97.76 abcdefg	93.57 abcdef	1def	1.16 bcde
	Mannitol	92.33 abc	1.44 bcde	71.48bcdefghi	65.80bcdefghij	1.33cdef	1.16 bcde
	Control	68.83 f	1.25 bcde	80.12abcdefghi	55.17 defghij	2.75 abc	3ab
7000 ppm	PEG	91.83 abc	2.56 bc	39.08 hi	35.88hij	2.5 abcd	2.5 bc
	KNO_3	81.5 bcde	1.80 bcde	55.48 defghi	45.23 fghij	2.5 abcd	2.5 bc
	NaCl	72ef	4.23 a	24.29i	17.51 j	4a	0e
	$CaCl_2$	90.5 abc	1.91 bcde	54.36 defghi	49.05 efghij	1.5 cdef	1.33 bcde
	Mannitol	84.66 abcd	2.66 b	40.03 hi	34.00 hij	3.25 ab	1.83bcde
	Control	67f	2.22 bcde	45.16 fghi	30.24 ij	4 a	4.5a

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range at 5% level.

2- Seedling Characteristics

Data presented in Table 1 indicated that significant differences were obtained between control and seed priming treatments, in addition to significant differences among priming agents themselves. Mannitol recorded the highest value in seedling fresh weight with only slight differences compared to from that of PEG and KNO_3. The same table also showed that

seedling fresh weight was negatively affected by increasing salinity levels i.e. 3000, 5000 and 7000 ppm while, the low salinity level enhanced seedling fresh weight over control.

As regards to the effect of interaction between salinity levels and priming agents, data in Table 3 showed that priming lettuce seeds in Mannitol increased the fresh weight among all of the applied salinity levels. The highest value was recorded by priming in Mannitol under 1000 ppm of salinity.

Seedling dry weight followed more or less the trend of fresh weight in response to seed priming treatments and salinity levels (Table 1), however, for interaction the highest values in this connection were recorded by priming in $CaCl_2$ or NaCl under the low salinity level of 1000 ppm. The higher seedling dry weight under 3000 and 5000 ppm of salinity was obtained by priming in PEG, while under 7000 ppm was obtained by priming in NaCl (Table 3).

Tabulated Data in Table 1 revealed that significant differences occurred between priming treatments means in seedling length. $CaCl_2$, PEG and KNO_3 were the best treatments in this regard followed by Mannitol and NaCl PEG ones. As salinity level increased , seedling length decreased i.e. the shortest seedlings were obtained from the high salinity level of 7000 ppm.

As for the effect of the interaction between priming treatment and salinity on lettuce seedling length, data presented in Table 3 showed that all interaction treatments significantly increased seedling length over the control within the same salinity level. Priming lettuce seed in $CaCl_2$ and germinating them under non saline conditions resulted in the highest seedling length values. KNO_3, $CaCl_2$ and Mannitol were the superior treatments under low salinity level of 1000 ppm. PEG was the best treatment under salinity levels of 3000 and 5000 ppm while $CaCl_2$ was most effective treatment in increasing seedling length under high salinity level of 7000 ppm.

DISCUSSION

Germinating seeds typically exhibit a triphasic pattern of water uptake that starts with rapid imbibitions (phase I), followed by a plateau or lag phase in which there is little change in water content (phase II) and finally, an increase in water content coinciding with radical growth (phase III) (Bewley and Black, 1994). During phase II, physiological and anatomical changes occur. These changes prepare the seed for later expansive growth. Thus, phase II serves as the major control point for germination of seeds (Bradford, 1990).

Seed priming is a controlled hydration procedure followed by redrying. During priming, seeds progress through phase I and phase II. seeds do not progress to phase III, because the uptake of additional water needed for the initiation of expansive embryo growth is blocked. Evidence suggests that many of the physiological and anatomical changes that characterize phase II are largely completed during priming, this causes seeds to germinate faster upon rehydration. Seed priming appears to be an effective physiological

treatment to improve germination behavior. It also results in better homogeneity of germination.

The positive effects of priming on germination performance have been attributed to the induction of biochemical repair mechanisms. Metabolic events such as synthesis of protein, RNA and DNA are initiated within minutes of seed hydration (Osborne, 1983). Mitochondria increase in number during leek priming (Bray, 1995).

Pre-sowing seed treatments have potential in saline areas (Ashraf and Ruaf, 2001; Basra *et al.*, 2005). It is thought that the depressive effect of salinity on germination could be related to a decline in endogenous levels of hormones (Debez *et al.*, 2001). Results show that lettuce (*Lactuca sativa* L.) is moderately sensitive to salt, the degree of sensitivity varying with the cultivar (Pasternak *et al.*, 1986). Also, Lettuce is sensitive during the early seedling stages and at flowering (Shannon *et al.*, 1983).

Seed priming have increased seed germination and seedlings emergence under all levels of salinity stress compared with control. Most effective priming solutions were PEG and $CaCl_2$. Also, seed priming increased fresh and dry weight of seedlings under all levels of salinity compared with non primed seeds.

Osmoconditioning of lettuce (*Lactuca sativa* L) seed improved tolerance to salinity, resulting in a higher rate and percentage of germination and increased seedling , fresh and dry weight . It is proposed that osmoconditioning offers a practical means of confronting problems of salinity in regions where lettuce is sown and irrigated with low quality water. Osmoconditioning significantly increased the rate of emergence of seedlings at the higher salinity level and increasing the germination (Khan and passam., 2005).

Obtained results indicated osmopriming is a successful practice for improving seed germination performance under salt stress. These findings are supported by the earlier work on improved germination by osmopriming in wheat (Basra *et al.*, 2002). Faster germination rate after osmopriming may also be explained by an increased rate of cell division in the seed as previously found for wheat (Bose and Mishra, 1992). In addition to, the increase in emergence with priming might be due to initialing metabolic events in primed seeds (Ghiyasi *et al.* 2008).

Seed priming may readily cross the cell membrane into the cytoplasm of the cell unless an active metabolic pump prevents accumulation of the ions. The physical process of water uptake leads to the activation of metabolic processes as the dormancy of the seed is broken following hydration (Katember *et al.*, 1998).

Obtained results also indicated that seed priming proved to be an effective technique in improving seed germination and seedling growth of lettuce and alleviating the harmful effects associated with salinity stress.

Table (3): Effect of interaction between salinity stress and priming solutions on lettuce seedlings Characteristics (Average of two experiments)

Treatments		Seedlings F.W	Seedlings D.W	Seedling length
Salinity Levels	Priming Agents			
Zero ppm	PEG	0.24 abcd	0.0103 abcd	9.45 abc
	KNO_3	0.24 abcd	0.0103 abcd	10.21 ab
	NaCl	0.28ab	0.0095 abcd	10.24ab
	$CaCl_2$	0.25 abc	0.011abc	10.96 a
	Mannitol	0.26 ab	0.0103 abcd	9.48 abc
	Control	0.15 def	0.0063 cdef	5.11hi
1000 ppm	PEG	0.27 ab	0.0119 abc	8.98abc
	KNO_3	0.28ab	0.0133 ab	9.2 abc
	NaCl	0.24 abc	0.0140 a	7.86 cde
	$CaCl_2$	0.26 ab	0.0141a	8.95abc
	Mannitol	0.30a	0.0115 abc	8.85 abc
	Control	0.20 bcdef	0.0108 abc	5.3 ghi
3000 ppm	PEG	0.24 abc	0.0075 bcdef	8.91 abc
	KNO_3	0.25 abc	0.0065 cdef	7.96 cde
	NaCl	0.22 abcde	0.004ef	7.46cdefg
	$CaCl_2$	0.26 ab	0.0045 def	7.47 efgh
	Mannitol	0.22 abcde	0.0063 cdef	6.44 efgh
	Control	0.23 abcde	0.0026 f	4.63 hi
5000 ppm	PEG	0.21 bcde	0.012 abc	8.65bcd
	KNO_3	0.22 abcde	0.0116 abc	7.29cdefg
	NaCl	0.23 abcde	0.0125 abc	7.89cde
	$CaCl_2$	0.17 cdef	0.0108 abc	7.82cdef
	Mannitol	0.23 abcd	0.0121 abc	7.97 cde
	Control	0.12 f	0.0065 cdef	3.73 ij
7000 ppm	PEG	0.18 cdef	0.0071 bcdef	6.42efgh
	KNO_3	0.16 def	0.0115 abc	6.61 defgh
	NaCl	0.15 ef	0.0128 ab	5.65 fghi
	$CaCl_2$	0.17 cdef	0.0071 bcdef	7.71 cdef
	Mannitol	0.21 bcde	0.012 abc	5.9 efgh
	Control	0.13 f	0.01166 abc	2.28j

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range at 5% level.

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تخفيف إجهادِ الملوحةِ في الخسّ أثناء الإنبات باستخدام مهيئات الإنبات

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تم دراسة استخدام مهيئات الإنبات كوسيلة للتغلب على إجهاد الملوحةِ في الخسّ أثناء مرحلة الإنبات حيث تم تهيئة البذور فى ٥ محاليل تهيئة و هى ١- البولى اثيلين جليكـول ٢- نتـرات البوتاسيوم ٣- كلوريد الصوديوم ٤- كلوريد الكالسيوم ٥- المـانيتول بالإضـافة إلـى معاملـة الكنترول وهى بدون تهيئة ثم تم اجراء الإنبات المعملى للبذور المهيئة تحت ٥ مستويات مختلفـة من الملوحة و هى صفر و ٣٠٠٠و ٥٠٠٠و ٧٠٠٠ جزء فى المليون .

أوضحت النتائج أن نسبة انبات البذور المهيئة أعلى من غير المهيئة تحت ظروف إجهـاد الملوحةِ بغض النظر عن مادة التهيئة . كما أن مهيئات الإنبات قللت من عـدد الأيـام اللازمـة للوصول إلى ٥٠% إنبات و شجعت الإنبات السريع و المتماثل تحت الظروف المعاكسة.

مع زيادة مستوى الملوحة تأثرت نسبة الإنبات معنويا بالسالب و كذلك دليل كفاءة الإنبـات بينما ازداد الزمن اللازم للوصول إلى ٥٠% إنبات و كذلك فترة تماثل الإنبات. و مـن الجـدير بالذكر أن مستوى الملوحة المنخفض ١٠٠٠ جزء فى المليون حسن سلوك الإنبات و نمو البادرات بصورة ملحوظة .

كانت استجابة الخس أثناء الإنبات واضحة لمعاملات مهيئـات الإنبـات المختلفـة تحـت ظروف اجهاد الملوحة و كان كلوريد الكالسيوم و البولى اثيلين جليكول و المـانيتول هـى أكفـا معاملات التهيئة.

و بصفة عامة فان مهيئات الإنبات المختلفة لها تأثير مشجع وواضح على إنبات بذور الخس تحت إجهادِ الملوحةِ.

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