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Influence of Seed Priming on Early Stages Growth of Cowpea [*Vigna unguiculata* (L.) Walp.] Grown under Salt Stress Conditions

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ABSTRACT

The study was carried out to assess the effect of seed priming to enhance salt tolerance in Algerian Maghreb Cowpea. Seeds of two cowpea landraces (A18 and TZ2) were soaked for 4 h at 25°C in the dark in distilled water (hydropriming) or 80 mM of NaCl, 80 mM of $CaSO_4$ or 80 mM of $CaCl_2$ (halopriming) separately. Untreated seeds were taken as control (unprimed seeds). Seeds were germinated under three salinity levels (0 (distilled water), 85 mM and 170 mM of NaCl). In general, germination traits of cowpea landraces decreased with increased salinity levels, however, seed priming significantly increased germination percentage, speed of germination, final germination percentage, radical length, hypocotyl length, epicotyl lengh and induced better vigour index under saline and non-saline conditions as compared to the unprimed seed. Hydropriming, or halopriming with NaCl 80 mM or $CaSO_4$ 80 mM proved to be effective methods.

Key words: Cowpea, Halopriming, Hydropriming, Salinity tolerance, Vigour index.

INTRODUCTION

Cowpea is considered an important part of cropping systems with a less developed value chain in many parts of Africa (Nkoana *et al.,* 2019). Its grain is considered an important source of proteins (about 25%) and carbohydrate (about 64%), vitamins and fiber (Hall, 2012). Cowpea is reputed to be the most drought- and heat-resistant crop in semi-arid Africa (Sadeghipour, 2017) and tolerate low soil fertility due to their high rate of nitrogen fixation (Hall 2012). However, germination of this species is adversely affected by salinity which is generated by irrigated agriculture (Nabi *et al.,* 2017). Salinity is one of the major abiotic stresses for crop production in many parts of the world (Jafar *et al.,* 2012) including Algeria (Nabi *et al.,* 2017). Salinity may cause significant reductions in the rate and final percentage of germination of Cowpea (Nabi *et al.,* 2017). Delayed and erratic germination and poor stand establishment are the major reasons of poor crop production on saline fields (Jafar *et al.,* 2012).

Among various strategies adopted to improve plant salt tolerance, seed priming is thought to be an easily applied, low-cost and effective approach (Gholami *et al.,* 2015; Miladinov *et al.,* 2019). Priming is a pre-germination physiological procedure that hydrates the seed in a specific environment, followed by drying the seed so that the germination processes begins, but radicle emergence does not occur (Ibrahim, 2016). This method improves seed performance and also provides faster and synchronized seed germination (Gholami *et al.,*2015).

Regardless of the great importance of cowpea, few studies are available for alleviation of adverse salinity effects in cowpea during germination and early seedling growth by seed priming. The aim of this work was to assess the treatment (s) which are able to stimulate and enhance germination of Cowpea seeds under salt stress. Furthermore, the study examined the possibilities to overcome salinity stress by using seed treatments with different salts (halopriming with NaCl, $CaSO_4$ and $CaCl_2$) and hydropriming.

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MATERIALS AND METHODS

The experiments were carried out at *École Nationale Supérieure Agronomique, Algeria.* Seeds of two cowpea landraces were obtained from a laboratory « Productions Végétales, École Nationale Supérieure Agronomique,

Algiers, Algeria ». The cowpea landraces were assigned the following names : A18 and TZ2 native respectively of Adrar (Sahara) and Tizi Ouzou (Kabylie). The selection of cultivated accessions was based on contrasting seed size, colour and origin. Before the start of the experiment, seeds were surface sterilized in 5% sodium hypochlorite solution for 3 min, then rinsed with sterilized water and air-dried to avoid fungus attack.

For halopriming**,** seeds were soaked in aerated 80 mmol solutions of $CaCl_2$ or NaCl, or $CaSO_4$ for 4h at 25°C in the dark separately. This concentration was chosen on the basis of preliminary experiments which showed no inhibition of germination (NABI *et al.,* 2017). The ratio of seed weight to solution was 1:5 (g/ml). After the priming period, seeds were rinsed three times with distilled water and then dried (at room temperature; 25 ± 2°C) up to original weight for two days (Mahmoudi *et al.,* 2012).

Thereafter, seeds were immersed in distilled water for hydropriming, at 25°C for 4h in the dark, dried on blotting paper and then left overnight at room temperature. After drying, the moisture content of hydroprimed seeds was similar to the original moisture content as determined by comparing the total seed weights (Pirasteh Anosheh *et al.,* 2011).

Petri dishes (9 cm diameter) containing two layers of Whatman No. 1 filter papers were prepared. Ten seeds in each petri dish were arranged in triplicate under RBD and kept for germination testing in the germinator at 25 ± 0.5°C and 80 ± 1% of relative humidity. These seeds germinated in "germitest" papers imbibed in distilled water (H_2O) or in 85 and 170 mM of NaCl solutions. Petri dishes were tightly sealed using parafilm to prevent evaporation for minimizing changes in concentration of salt solutions. Germination was considered to have occurred when the radicles were 2mm long (Kaya *et al.,* 2006).

Germination parameters calculation

Germination percentage (%) was calculated by using the following equation :

$$GP = n/N * 100 \quad \text{.....(1)}$$

With n : number of germinated seeds on the n^{th} day and N : total number of seeds.

The final germination percentage was calculated by using the following equation:

$$FGP = N_g/N_t * 100 \quad \text{.....(2)}$$

N_g is the number of the germinated seeds on the last day of counting (day 7) and N_t is the total seeds in each treatment.

The speed of germination (SG, without unit), was calculated using the equation below, as described by Shahba *et al.* (2008), respectively.

$$SG = \sum i [gi - g(i - 1) / i] \quad \text{.....(3)}$$

g is the total germination percentage on an incubation day i, minus the total germination percentage on the previousday g (i - 1) and divided by the incubation day i.

Seedling vigour index was calculated by using the following formula, as described by Memon *et al.* (2013).

$$SVI = [\text{Seedling length (cm)} \times FGP] \quad \text{.....(4)}$$

Seedling growth features, radical, epicotyl, hypocotyl and total seedling length (cm), were measured with the aid of a ruler graduated in millimeters.

The statistical analyses of germination data were done using IBM statistics SPSS 21 software for Windows, for analysis of variance (ANOVA) and means were separated by least significant difference (LSD) using SPSS statistical software.

RESULTS AND DISCUSSION

All germination traits of both primed and unprimed seeds decreased gradually with increasing salt cocentration levels (Table 1 and Fig 1). The ANOVA for germination percentage, speed of germination and final germination perecentage showed that intration among salinity, genotype and priming were observed to be significant at $P < 0.05$ (Table 2). This may be because the germination process can be modified by delaying and decreasing germination percentage (Table 1) and was observed more for TZ2. On fifth day, germination percentage decreased with an increase in salt concentation and it was found 33% and 70% respectively for TZ2 and A18 under 170 mM of NaCl. Similar studies have also revealed that salt stress delay reduces germination of cowpea (Nabi *et al.,* 2017) and faba bean (Chaker-Haddadj *et al.,* 2014).

The results of the study indicated that germination traits of the primed seeds were observed higher than those of unprimed seeds under normal and salt stress conditions (Table 1). For example, on the second day, hydropriming of seeds led to an observed increase in the germination percentage up to 60% et 76.67% for TZ2 and A18, respectively in comparison to non-primed seeds (16.66 and 20 %, respectively) (Table 1). These findings were supported by earlier work on seed priming in okra (Sharma *et al.* 2014) and sunflower (Moghanibashi *et al.,* 2013). The accelerated germination rate after priming may be explained by an increased rate of cell division in the primed seed (Kubala *et al*. 2015) and stimulation of many metabolic activities involved in the early phases of seed germination (Ibrahim, 2016).

Under salt stress conditions, primed seeds showed significantly higher germination traits as compared to unprimed seeds (Table 1 and Fig 1). Priming of seed resulted in the accelerated germination for both landraces (Table 1). Under salt concentration of 85 mM of NaCl, priming with NaCl, increased germination of TZ2 as well as in final germination percentage (86.66%) in comparison to unprimed seeds (63.33%). On second day, hydropriming and halopriming with $CaSO_4$ increases germination of A18 up to 46% and 23% respectively in comparison to unprimed seeds (0%) under higher salinity (170 mM of NaCl).The higher speed of germination was achieved in hydropriming treatment (Fig1). Results obtained in this study suggest that

Table 1: Effects of different priming methods on germination percentage of Cowpea ladraces under salt stress and control conditions for 7 days.

			Germination percentage (%)						
		Priming	Day1	Day2	Day3	Day 4	Day 5	Day 6	Day 7
TZ2	Control	Unprimed	0	16,66 ^{A}	56,66^{A}	83,33^{A}	86,66^{A}	86,66^{A}	86,66^{A}
		Hydropriming	0	60,00 ^{B}	76,66^{A}	93,33^{A}	93,33^{A}	93,33^{A}	93,33^{A}
		NaCl	0	53,33^{B}	60,00^{A}	80,00^{A}	83,33^{A}	83,33^{A}	83,33^{A}
		$CaSO_4$	0	73,33^{B}	83,33^{AB}	90,00^{A}	90,00^{A}	90,00^{A}	90,00^{A}
		$CaCl_2$	0	50,00^{B}	50,00^{AC}	70,00^{A}	70,00^{A}	70,00^{A}	70,00^{A}
		mean	0	50.66^{a}	65.33^{a}	83.33^{a}	84.66^{a}	84.66^{a}	84,66^{a}
	85 mM	Unprimed	0	16,66^{A}	33,33^{A}	56,66^{A}	56,66^{A}	56,66^{A}	63,33^{A}
		HP	0	76,66^{C}	83,33^{B}	90,00^{B}	90,00^{B}	90,00^{B}	96,66^{B}
		NaCl	0	40,00^{AB}	50,00^{AB}	76,66^{AB}	86,66^{B}	86,66^{B}	86,66^{AB}
		$CaSO_4$	0	46,66^{B}	50,00^{AB}	66,66^{AB}	70,00^{AB}	70,00^{AB}	70,00^{A}
		$CaCl_2$	0	46,66^{B}	53,33^{AB}	66,66^{AB}	73,33^{AB}	73,33^{AB}	76,66^{AB}
		mean	0	45.33^{b}	54^{b}	71.33^{b}	75.33^{a}	75.33^{a}	78,66^{a}
	170 mM	Unprimed	0	0,00^{A}	6,66^{A}	26,66^{A}	33,33^{A}	33,33^{A}	36,66^{A}
		HP	0	20,00^{B}	20,00^{A}	26,66^{A}	36,66^{A}	36,66^{A}	36,66^{A}
		NaCl	0	13,33^{AB}	13,33^{A}	23,33^{A}	33,33^{A}	33,33^{A}	36,66^{A}
		$CaSO_4$	0	3,33^{AB}	3,33^{A}	6,66^{A}	6,66^{B}	6,66^{B}	6,66^{B}
		$CaCl_2$	0	20,00^{B}	20,00^{A}	23,33^{A}	33,33^{A}	33,33^{A}	33,33^{AB}
		mean	0	11.33^{c}	12.66^{c}	21.33^{c}	28.66^{b}	28.66^{b}	30,00^{b}
A18	Control	Unprimed	0	20,00^{A}	63,33^{A}	93,33^{A}	93,33^{A}	93,33^{A}	93,33^{A}
		HP	0	76,66^{C}	90,00^{A}	96,66^{A}	96,66^{A}	96,66^{A}	100,00^{A}
		NaCl	0	63,33^{BC}	83,33^{A}	90,00^{AB}	93,33^{A}	93,33^{A}	93,33^{A}
		$CaSO_4$	0	76,66^{C}	86,66^{A}	93,33^{A}	93,33^{A}	93,33^{A}	93,33^{A}
		$CaCl_2$	0	60,00^{B}	70,00^{A}	76,66^{B}	86,66^{A}	86,66^{A}	90,00^{A}
		mean	0	59.33^{a}	78.66^{a}	90^{a}	92.66^{a}	92.66^{a}	94.00^{a}
	85 mM	Unprimed	0	13,33^{A}	53,33^{A}	76,66^{AB}	90,00^{A}	90,00^{A}	96,66^{A}
		HP	0	56,66^{B}	86,66^{B}	90,00^{A}	96,66^{A}	96,66^{A}	100,00^{AB}
		NaCl	0	56,66^{B}	73,33^{AB}	93,33^{A}	96,66^{A}	96,66^{A}	96,66^{A}
		$CaSO_4$	0	53,33^{AB}	66,66^{AB}	80,00^{AB}	86,66^{A}	86,66^{A}	90,00^{A}
		$CaCl_2$	0	53,33^{AB}	63,33^{AB}	66,66^{AB}	83,33^{A}	83,33^{A}	83,33^{AC}
		mean	0	46.66^{b}	68.66^{b}	81.33^{b}	90.66^{a}	90.66^{a}	93,33^{a}
	170mM	Unprimed	0	0,00^{A}	23,33^{A}	50,00^{A}	70,00^{A}	70,00^{A}	73,33^{A}
		HP	0	46,66^{C}	50,00^{AC}	76,66^{B}	86,66^{A}	86,66^{A}	86,66^{A}
		NaCl	0	6,66^{A}	30,00^{A}	73,33^{AB}	90,00^{A}	90,00^{A}	90,00^{A}
		$CaSO_4$	0	23,33^{B}	23,33^{A}	60,00^{AB}	73,33^{A}	73,33^{A}	76,66^{A}
		$CaCl_2$	0	0,00^{A}	0,00^{AB}	50,00^{A}	66 ,66^{A}	66,66^{A}	66 ,66^{A}
		mean	0	15.33^{c}	25.33^{c}	62,00^{c}	77.33^{b}	77.33^{b}	78,66^{b}
SEM			0	8.00	9.20	8.14	8.27	8.27	7.98
Salinity (df=2)			0	75,02***	92,65***	83,80***	53,61***	53,61***	58,57***
Genotype (df=1)			0	2,54 ^{ns}	16,24***	41,31***	63,04***	63,04***	69,07***
Priming (df=4)			0	26,16***	8,56***	5,43***	3,80**	3,80**	4,16**

Values represent the mean of threereplicates.Withineachcolumn, the differentlower case letters and the different capital letters indicates significant differences at LSD test p≤0.05.The values of F are presented. ns: not significant, * P<0.05, ** P<0.01 and *** P<0.001. SEM: standard error of the mean.

seed priming is an effective pre-germination practice for overcoming salinity induced negative effects. Jafar *et al.* (2012) found that beneficial effect of priming treatments in alleviating salt stress effects can be attributed to increased accumulation of soluble proteins, phenolics, soluble sugars and $K^+$with simultaneous decrease in Na^+ uptake.

The salinity had also considerable effects on epicotyl, radical, hypocotyl and total seedling lengths while different priming methods positively affected primary seedling growth under control and salt stress conditions (Table 3 and Table 4). Under 85 mM of NaCl, total seedling length was recorded higher in hydroprimed seeds (13, 9cm) followed by NaCl

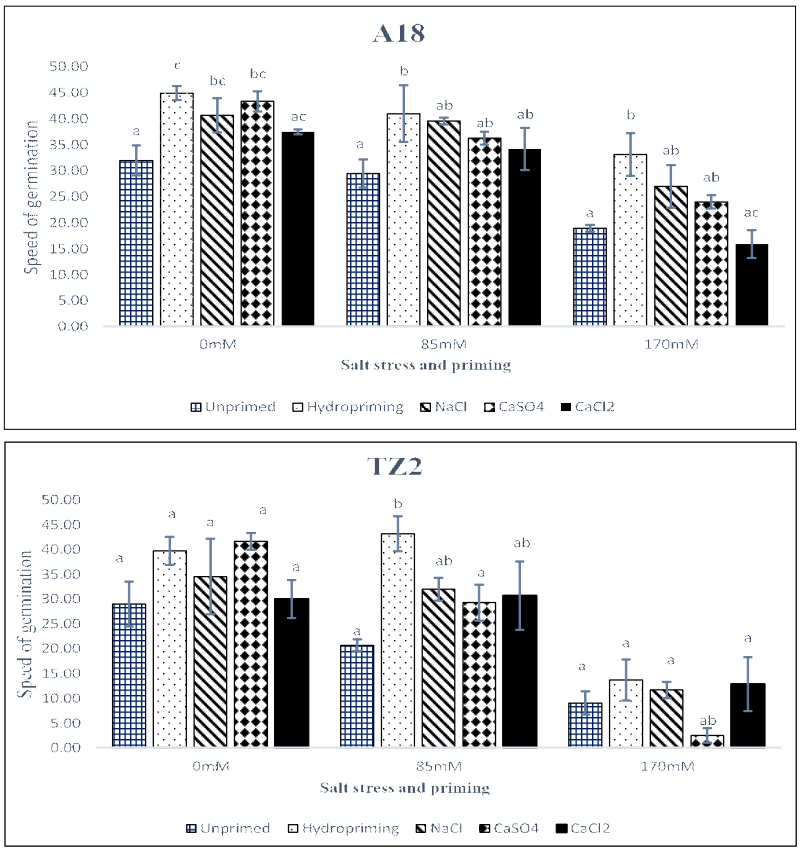

Fig 1: Speed of germination of two cowpealand races under different salinityand priming. Values represent the mean of threereplicates and error bars represent standard deviation. Means followed by different letters indicate significant difference at LSD test p ≤ 0.05among priming for each salt stress treatments.

Table 2: Effects of salt stress and priming on the final germination percentage and speed of germination of cowpeaseeds : summary of anovaresults.

		Final germination percentage (%)				Speed of germination		
Source of variation	df	Mean square	F value	P level	df	Mean square	F value	P level
Salinity	2	11194.44	58.57	0.000***	2	3573,41	98,12	0,000***
Genotype	1	13201,11	69,07	0,000***	1	1371,08	37,65	0,000***
Priming	4	7,95,556	4,16	0,005**	4	405,68	11,14	0,000***
Salinité *Genotype	2	34,14,444	17,86	0,000***	2	203,67	5,59	0,006**
Salinity *priming	8	1,68,056	0,87	$0,539^{ns}$	8	51,78	1,42	$0,206^{ns}$
Genotype *priming	4	95,556	0,50	$0,736^{ns}$	4	21,23	0,58	$0,676^{ns}$
Salinity*Genotype *priming	8	2,54,722	1,33	$0,245^{ns}$	8	50,50	1,38	$0,221^{ns}$
Error	60	191,11			60	36,41		
Total	90				90			

ns: not significant, * P<0.05, ** P<0.01 and *** P<0.001.

Table 3: Effects of differentpriming methods on radical length, epicotyl length, hypocotyl length, total seedling length and seedling vigour index of Cowpea under salt stress and control conditions.

		Radical length (cm)			Epicotyl length (cm)			hypocotyl length (cm)			Total seedling length (cm)			Seedling vigour index		
		T0	85mM	170mM	Control	85Mm	170mM	Control	85mM	170mM	Control	85Mm	170mM	Control	85mM	170mM
	Unprimed	$3,43^{A}$	$3,45^{A}$	$0,4^{A}$	$1,51^{A}$	$0,58^{A}$	$0,00^{A}$	$3,39^{A}$	$3,60^{A}$	$1,38^{A}$	$8,33^{A}$	$7,64^{A}$	$1,8^{A}$	736^{A}	479^{A}	$78,6^{A}$
	Hydropriming	$3,74^{A}$	5,24AB	$0, 9^{A}$	$3,28^{AB}$	$3,60^{B}$	$0,00^{A}$	$5,13^{AB}$	$5,11^{C}$	$1,12^{A}$	$12,1^{AB}$	$13,9^{B}$	$2,1^{A}$	1153^{AB}	1354^{B}	$77,1^{A}$
TZ2	NaCl	$4,45^{AB}$	2,55AC	$0,2^{AB}$	$3,47^{AB}$	$1,53^{A}$	$0,00^{A}$	$4,29^{AB}$	$2,7B^{C}$	$1,93^{A}$	$12,2^{AB}$	$6,82^{A}$	$2,1^{A}$	1053^{B}	593^{A}	$75,7^{A}$
	$CaSO_4$	$6,43^{B}$	3,92A	0.04^{AB}	$4,50^{B}$	$0,40^{A}$	$1,07^{B}$	$6,21^{B}$	$3,17^{AB}$	3.6^{A}	$17,14^{B}$	$7,50^{A}$	$1,4^{A}$	1550^{B}	528^{A}	$11,4^{A}$
	$CaCl_2$	$2,84^{A}$	$3,26^{A}$	0.15^{AB}	$0,94^{A}$	$0,60^{A}$	$0,00^{A}$	$3,71^{A}$	$2,94^{AB}$	$2,79^{AB}$	$7,50^{A}$	$6,81^{A}$	$2,9^{A}$	$593,2^{AB}$	531^{A}	$121,1^{A}$
	mean	$4,18^{a}$	$3,68^{a}$	0.36^{b}	$2,74^{a}$	$1,34^{b}$	$0,21^{c}$	$4,54^{a}$	$3,51^{b}$	$1,51^{c}$	$11,4^{a}$	$8,54^{b}$	$2,1^{c}$	1017^{a}	697^{b}	$72,8^{c}$
	Unprimed	$5,03^{A}$	$3,27^{A}$	$0,2^{A}$	$1,85^{A}$	$0,31^{A}$	0.00	$6,11^{A}$	$3,22^{A}$	$1,74^{A}$	$13,0^{A}$	$6,81^{A}$	$1,9^{A}$	1215^{A}	661^{A}	$142,7^{A}$
	Hydropriming	$6,15^{A}$	$4,74^{AB}$	$0,8^{A}$	$3,32^{B}$	$1,75^{B}$	0.00	$6,38^{AB}$	$4,60^{BC}$	$1,52^{A}$	$15,8^{AB}$	$11,1^{B}$	$2,3^{A}$	1585^{AB}	1110^{B}	$205,1^{AB}$
A18	NaCl	$7,31^{A}$	$5,33^{B}$	$1,6^{A}$	$3,34^{B}$	$0,43^{A}$	0.00	$7,73^{C}$	$3,96^{AB}$	$1,44^{A}$	$18,3^{B}$	$9,73^{B}$	$3,1^{A}$	1717^{AB}	938^{AB}	$281,2^{B}$
	$CaSO_4$	$6,99^{A}$	$4,16^{AB}$	$1,0^{A}$	$3,36^{B}$	$0,27^{A}$	0.00	$7,00^{BC}$	$5,06^{C}$	$1,84^{A}$	$17,3^{B}$	$9,51^{AB}$	$2,8^{A}$	1621^{B}	855^{AB}	$216,4^{AB}$
	$CaCl_2$	$6,10^{A}$	$4,46^{AB}$	$0,9^{A}$	$3,75^{B}$	$0,32^{A}$	0.00	$6,57^{AB}$	$4,02^{AB}$	$1,31^{A}$	$16,4^{B}$	$8,81^{AB}$	$2,2^{A}$	1467^{A}	739^{A}	$150,8^{A}$
	mean	$6,31^{a}$	$4,39^{b}$	$0,9^{c}$	$3,12^{a}$	$0,62^{b}$	0.00c	$6,76^{a}$	$4,17^{b}$	$1,57^{c}$	$16,2^{a}$	$9,19^{b}$	$2,5^{c}$	1521^{a}	861^{b}	$199,2^{C}$
	SEM	0.64	0.64	0.64	0.82	0.82	0.82	4.65	4.65	4.65	1.11	1.11	1.11	131	131	131

Values represent the mean of three replicates. Within each column, the different lower case letters and the different capital letters indicates significant differences at LSD test p = 0.05. SEM : standard error of the mean.

Table 4: Effects of salt stress and priming on radical length, hypocotyl length, total seedling length and seedling vigour index : summary of anova results.

		Radical Length			Hypocotyl Length			Epicotyl Length			Total Seedling Length			Seedling Vigour Index		
	df	Mean square	F value	P level	Mean square	F value	P level	Mean square	F value	P level	Mean square	F value	P level	Mean square	F value	P level
Salinity	2	171,3	139,5	0,000***	127,18	195,7	0,000***	62,94	143	0,000***	1006,2	269,7	0,000***	901559	185,8	0,000***
Genotype	1	28,59	23,2	0,000***	21,4	33,0	0,000***	0,76	1,75	$0,19^{ns}$	82,86	22,21	0,000***	1571149	30,09	0,000***
Priming	4	4,21	3,43	0,014*	1,6	2,53	$0,05^{ns}$	4,82	11,0	0,000***	29,09	7,79	0,000***	398734	7,63	0,000***
salinity*Genotype	2	5,56	4,53	0,015*	9,2	14,3	0,000***	2,31	5,27	0,008**	44,09	11,81	0,000***	323171	6,19	0,000***
salinitéy**priming*	8	2,30	1,87	$0,08^{ns}$	2,4	3,70	0,001**	3,10	7,07	0,000***	19,36	5,19	0,000***	209708	4,01	0,001***
Genotype**priming*	4	3,34	2,72	0,038*	2,3	1,26	$0,2^{ns}$	1,89	4,32	0,004*	8,35	2,24	$0,07^{ns}$	68131,6	1,30	$0,27^{ns}$
salinity*Genotype**priming*	8	0,86	0,70	$0,6^{ns}$	0,65	3,55	0,002	1,24	2,83	0,010*	8,27	2,21	0,038*	79696,1	1,52	$0,16^{ns}$
Error	60	1,22						0,43			3,73			5221,2		
Total	90															

ns: not significant, *P <0.05, **P <0.01 and ***P <0.001.

priming (9. 73 cm), $CaSO_4$ (9. 51 cm) and $CaCl_2$ priming (8,81 cm) respectively (Table 3).

Vigour index was also significantly affected by salt stress, priming, genotype and interaction between priming and salt concentration ($p<0.05$) (Table 4). Priming significantly increased seedling vigour index under control and salt stress conditions (Table 3 and Table 4). Under salt stress (85 mM), higher seedling vigour index (1354) was recorded in the seeds of TZ2 primed with hydropriming in comparison to the unpriming under the same salt concentraton (479) followed by NaCl and $CaSO_4$ priming (593 and 528, respectively) (Table 3). Our results were also in agreement with Sharma *et al*. (2014) who reported the increased development of stronger and more efficient root and shoot system and vigour index by hydropriming in okra seeds.

Although salinity significantly reduced germination potential, seedling growth and vigour index, priming provided better protection to both cowpea landraces against salinity stress. All studied priming agents; hydropriming, halopriming with $CaSO_4$ were found to be the most effective in enhancing germination, seedling growth and vigour index in cowpea landraces under normal and saline conditions. In this experiment, hydropriming was found to be the most effective method for improving seed germination and salt tolerance of cowpea. The results were in line with the findings of Sharma *et al*. (2014) in okra. The faster rate of germination was obtained by seeds soak-ing in water probably due to faster water uptake and earlier initiation of metabolism processes which de-termine radicle protrusion (Kaya *et al.* 2006). Jorjandi and Sharifi Sirchi (2012) found that soaking alfalfa seed in water (hydropriming) enhanced hypocotyl length and radicle length under saline conditions.

The data of the results indicated that halopriming with NaCl was also found to be very effective in encouraging germination. It was found to alleviate the adverse effects of salinity. These results confirmed the findings of Gholami *et al.* (2015). According to Kaya *et al.* (2006), the better germination performance in NaCl may be due to Na^+ uptake maintaining a water potential gradient allowing water uptake during seed germination. In mungbean, pretreatment with NaCl was able to overcome the adverse effects of salt stress by increasing growth and photosynthetic pigments of the seedlings, modifying the activities of antioxidant enzymes and increasing accumulation of osmolytes like proline (Saha *et al.,* 2010).

The beneficial effects of $CaSO_4$ on performance of cowpea seed germination and seedling growth were found in this study. These results were supported by Afzal *et al.* (2008) in wheat. Beneficial effects of $CaSO_4$ may have resulted from the role of calcium as a second messenger in plant cells, from the protective role of membranes against adverse environmental stress or the effects of calcium on hormonal balance (Rahman *et al.,* 2016).

CONCLUSION

Seed hydropriming, halopriming with NaCl and halopriming with $CaSO_4$ were the most effective in alleviating salt stress effects on germination performance and seedling growth and vigour index of Cowpea landraces. These treatments are reported to be simple, economical and safe techniques and can therefore be employed to improve the performance of cowpea under saline conditions. Further, it is suggested that the results of this study should tested under farming conditions.

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