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Effect of seed priming on germination, emergence and seedling growth of cocks comb (*Celosia cristata* L.) under different salinity levels

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Abstract

Present study was carried out to investigate the effect of seed priming on seed germination; emergence and seedling growth of cocks comb (*Celosia cristata* L.) under different salinity levels in Post-harvest and Floriculture Laboratory, University of Agriculture Faisalabad. Five treatments were applied viz. Control, $CaCl_2$ (0.56%), H_2O_2 (0.41%), Moringa (3%) and Salicylic acid (0.004%) at three different levels of salinity (0, 50 and 100mM) with three replications. Both experiments were laid out according to Completely Randomized Design (CRD) under two factors factorial arrangement. The difference among treatment means were compared by using Least Significance Difference (LSD) test at 5% probability level. Data regarding germination and emergence tests was recorded and analyzed statistically. Various parameters were recorded in germination experiment viz. final germination percentage, germination energy, germination index, vigor index, radical length, plumule length, radical to plumule ratio, seedlings fresh weight, seedlings dry weight, time to first seed germination, time to 50% germination, mean germination time and same parameters were studied in emergence test. Results showed that all priming treatments improved germination and emergence parameters under saline and non-saline conditions as compared to non-primed seeds. Salinity levels significantly affected both primed and non-primed seeds. Germination and emergence traits were suppressed with increase of salinity levels. At lower and medium salinity levels (0mM and 50mM NaCl), H_2O_2 performed well and significantly improved most of the germination and emergence traits. $CaCl_2$, Moringa and Salicylic acid performed well at higher salinity level (100mM NaCl). So it can be concluded that H_2O_2 proved a best dose to enhance seed traits of cocks comb followed by moringa, $CaCl_2$ and salicylic acid respectively.

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Introduction

Cocks comb (*Celosia cristata* L.) belongs to genus Celosia. It is generally known as cocks comb because its flower resembles to the head of a cock. These non-woody plants usually grow up to 1 foot in height, but normally are smaller in size. It is grown commonly in Africa, South America, India and some parts of Asia. The plants are resistant to many diseases and these plants grow well indoor and outdoor. These plants grow best at non-shady places and well-drained soil is needed because these plants are very vulnerable to fungal diseases. The tight, velvety surface of Cocks comb flowers appear like brain tissue. The light, fluffy and hairy surface of the plume types blow freely in a wind and are more planted. The plants are very hardy and can be propagated easily from the seeds. In colder climate, these plants can be propagated in summer months. It's an annual plant and is grown for three months in a year. Ideal temperature for its growth and development is 60°F (Grant, 2012).

Cocks comb makes a striking display in beds and mixed borders. Their flowers and leaves can be consumed as vegetables. Cristata cultivars thrive in containers, and Plumosa and Spicata varieties work well for fresh flower arrangements. All types dry successfully. Preserve celosia by cutting the flower heads off before seed develops, removing the leaves and hanging the flowers upside down in a warm area with good air circulation. The flowers are bitter, styptic, astringent, depurative, utreine sadative, anti-bacterial, constipating and corrective ofalexeteric, febrifuge and urinary pigments. In India, the plant's leaves are edible and flowers serves as an astringent which are used to treat bloody stool, hemorrhoid bleeding and diarrhea (National Research Council, 2006). The seed decoction is used to treat dysentery (Shanmugam *et al.*, 2011). The leaves are also utilized in Chinese medicine for the treatment of dysentery, menstrual bleeding, inflammation and against worms (Navarra, 2004). The *C. cristata* seeds were reported to be hepatoprotective (Wang *et al.*, 2010). The plant also has antiaging and antioxidant properties (Pyo *et al.*, 2008). They are proved useful in the treatment of leprosy, skin diseases, burning sensation, diarrhoea, fever, headache, internal hemorrhage, herpes, *leukorrhea*, menorrhagia, liver disorders, wounds and ulcers. Juice of leaves is used for treating sickness. The seed is ophthalmic and hypotensive. It is used for the treatment of blurring of vision, bloodshot eyes, cataracts and hypertension (Cai *et al.*, 2001).

Salinity affected about 1 billion hectares of agriculture land (Szabolcs, 1992), mostly situated in arid and semiarid areas. It is reported that 20 million hectares of land turns to zero or negative productivity each year (Malcolm, 1993). Salinity is one of the most severe environmental stresses decreasing the productivity of crops. It is unavoidable that the salt is accumulated when soil is irrigated with salty water. Saline soil and salty water causes various problems in crop production. When intensive chemicals and fertilizers are applied to crops for nutritional purposes, salt is accumulated in soil and ultimately reduce the quantity and quality of production (Quamme and Stushnoff, 1983; Sonneveld *et al.*, 1999). Water resources are not equally distributed over the world and are not easily available during growing period whereas irrigation is essential to get the best quality and quantity in agriculture production. Soluble salts are present in irrigation water. The amount and type of salts present in water is important to find its appropriateness for irrigation. Natural water resources have been polluted and decreasing due to global warming. So enough quality water is not available for irrigating the agricultural lands. When wrong irrigation is applied, especially in those areas where there is a drainage problem, it damages the soil and ultimately decreases the crop yield (Villora *et al.*, 2000). Usually, ornamental and vegetable plants are more susceptible to salinity stress than that of perennial plants. Salinity causes severe deterioration in the growth and development of annual plants and decrease agricultural productivity (Maas, 1984; Sonneveld and Burg, 1991; Sonneveld *et al.*, 1999). Cocks comb is not halophyte so it is affected by salinity. Saline water causes reduction in crop yield, length of stem, root, shoot, leaf number, leaf area, fresh and dry weight, change in color, chlorophyll amount and change in physical appearance (Munns and Termaat, 1986; Rhoades *et al.*, 1992).

Leaves are more sensitive to salinity stress rather than the plant roots (Hannah, 1998). In ornamental plants, plant length, flower and shoot length, number of flowers per plant, fresh and dry weights are decreased with increase of salinity level. Kandeel *et al.*, (1999) reported that as calcium, sodium, and chlorine contents rose in soil, nitrogen, phosphorus and potassium contents in flower and roots decreased. Carbohydrate deficiency in young leaves and water deficiency and ion toxicity in old leaves was noted when salinity stress were given to plants for a long period of time (Kotuby *et al.,* 1997; Sonneveld *et al.,* 1999; Picchioni and Graham, 2001).

Various seed priming techniques are used to shorten emergence time, achieve uniform emergence, better allometric characters and better stand in many horticultural plants (Ashraf and Foolad, 2005; Farooq *et al*., 2005). These methods included hydropriming, osmoconditioning, hardening, osmohardening, and hormonal priming (Basra *et al*., 2005; Ashraf and Foolad, 2005). Seed priming is also useful under sub-optimal field environment such as salinity stress, high or low temperature (Azal *et al*., 2005) and low moisture supply to plants with different seed priming methods have been completely elaborated in many plants (Basra *et al*., 2007; Farooq *et al*., 2007). Patade *et al*., (2009) suggested that halopriming is an efficacious pre-germination technique for overcoming drought and salinity induced adverse effects in sugar-cane. Afzal *et al.* (2008) observed that the priming induced salt tolerance which was linked with improved metabolism of reserves, seedling vigor as well as enhanced potassium and calcium and decreased Na+ accumulation in wheat crop plants. The objective of this study was to investigate the effect of seed priming solutions on seed germination, emergence and seedling growth of cocks comb (*Celosia cristata* L.) under different salinity levels to ameliorate the adverse effects of salt stress.

Materials and methods

Experiments for germination and emergence tests were carried out in Post-harvest and Floriculture Laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during 2011-2012.

Each experiment was arranged according to Completely Randomized Design (CRD) with two factors and was replicated thrice. Vigorous and viable seeds of cocks comb (*Celosia cristata* L.) were used in these experiments with total 375 number of seeds per replication. Seeds were bought from Pride Seed Nursery, Lahore. Total 1125 seeds were used for all treatments. The ratio of seed to working solution was kept 1:5 (Afzal *et al.,* 2009). All priming protocols were carried out in Seed Physiology Laboratory, Department of Crop Physiology and Post-harvest and Floriculture Laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during 2011-12. Seeds were soaked in 0.56% solution of $CaCl_2.2H_2O$ for 12 h. A solution of 0.41% was prepared after diluting the hydrogen peroxide (H_2O_2) with water. Then seeds were primed in that solution for 12h. Moringa extract was diluted with water and 3% solution was prepared. Then seeds of cockscomb were primed in that solution for 12h. A 0.004% aqueous solution of salicylic acid was prepared by adding salicylic in water and then heated and stirred until all salicylic acid dissolved in water and then seeds of cocks comb were primed in that solution for 12h. Seeds were re-dried after priming. Pure distilled water was taken as control (S0). Three salinity levels (0, 50 and 100mM) were developed artificially. A 50mM solution of NaCl was prepared by adding 2.93gm of NaCl in one litre of distilled water. A solution of 100mM NaCl was prepared by adding 5.85gm of NaCl in one litre of distilled water. These all solutions were prepared in the beaker. So, three salinity levels were developed by applying these saline solutions to filter paper present in the petri dish.

Data recording

Various parameters related to seed germination and emergence was studied using appropriate methods. Seed germination and emergence parameters include time to first seed germination (days), time to first seed emergence (days), time to 50% germination (days), time to 50% emergence (days), mean germination time (days), mean emergence time (days), final germination (%), final emergence (%), germination energy (%), emergence energy (%),

germination index, emergence index, vigor index, radical length (mm), plumule length (mm), radical to plumule ratio, seedling fresh weight (mg) and seedling dry weight (mg).

Statistical Analysis

Data collected was analyzed statistically by using analytical software, Statistics (version 8.1) and treatment means were compared by using Least Significance Difference (LSD) test at 5% probability level (Steel *et al.*, 1997).

Results and discussion

Germination experiment

Time to first seed germination (days)

Time to first seed germination was increased with increase of salinity levels. However, results showed that time to first seed germination (TFSG) was significantly reduced in case of primed seed than non-primed seeds under various salinity levels (Table 1). All priming agents significantly reduced time to first seed germination at 0 mM NaCl. At 50 mM NaCl, H_2O_2 (0.41%), Moringa (3%) and SA (0.004%) significantly affected time to first seed germination. H_2O_2 and SA showed same results at 100 mM NaCl and reduced the time to first seed germination as compared to non-primed seeds. So it was concluded that higher salinity levels increased (TFSG) but seed priming significantly reduced TFSG rather than non-primed seeds.

Time to 50% germination (days)

Higher salinity levels increased time to 50% germination (T50G). Minimum T50G was recorded at 0mM of NaCl. H_2O_2 showed best results at 0mM of NaCl and significantly reduced the T50G while $CaCl_2$ and Moringa behaved non-significantly to each other by showing same effect on T50G. Moringa performed best at 50mM of NaCl and reduced T50G as compared to other primed and non-primed seeds. At higher salinity level (100mM NaCl), $CaCl_2$ gave best performance (Table 2). Overall results indicated that primed seeds performed significantly as compare to non-primed seeds and reduced T50G was recorded in primed seeds and H_2O_2 showed best results as compared to other treatments.

Table 1. Effect of different priming techniques on time to first seed germination (days) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	1.33	1.00	2.67	1.67A
$CaCl_2$ (0.56%)	1.00	1.33	1.67	1.33AB
H_2O_2 (0.41%)	1.00	1.00	1.33	1.11B
Moringa (3%)	1.00	1.00	1.67	1.22B
SA (0.004%)	1.00	1.00	1.33	1.11B
Mean	1.07B	1.07B	1.73A	

Table 2. Effect of different priming techniques on time to 50% germination (days) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	1.44fg	1.80d	3.56a	2.26A
$CaCl_2$ (0.56%)	1.04h	1.57ef	1.88d	1.50BC
H_2O_2 (0.41%)	0.58j	1.43fg	2.33b	1.45C
Moringa (3%)	1.11h	1.41g	2.15c	1.56B
SA (0.004%)	0.90i	1.63e	2.20bc	1.58B
Mean	1.01C	1.57B	2.42A	

Mean germination time (days)

Results showed that salinity significantly affected the primed and non-primed seeds and higher salinity stress increased the mean germination time (MGT). H_2O_2 performed significantly, at 0mM of NaCl and reduced the mean germination time. At 50mM and 100mM NaCl, Moringa proved helpful in eliminating the salinity stress on seeds and significantly reduced the mean germination time (MGT) under salt stress.

Salicylic acid also behaved little bit like Moringa while all other priming agents behaved non-significantly at higher salinity levels. Thus it was concluded from results that priming agents were successful to eliminate the salt stress and significantly reduced the MGT than non- primed seeds (Table 3).

Final germination percentage

It was observed that salinity significantly affected the final germination percentage (FGP) and salinity stress hindered the seed growth and ultimately reduced the final germination percentage. Salinity effect was higher at 100mM NaCl. At 50mM NaCl, final germination percentage was reduced as compared to control. Priming solution did not show any effect on final germination percentage of cocks comb as shown in Table 4.

Germination energy (%)

It is indicated from results that moderate salinity stress significantly acted on seed and increased the germination energy (%) while higher salinity levels adversely affected and ultimately reduced the germination energy.

Germination energy (%) was satisfactory under non-saline conditions. H_2O_2 performed best than all other priming agents under saline conditions and significantly maximized the germination energy while Moringa and SA behaved almost non-significantly to each other and showed same results.

At moderate salinity level, all priming agents significantly increased the germination energy. Under higher salinity stress, $CaCl_2$ proved a successful priming agent by minimizing the effect of salinity and increased the germination energy. Overall results showed that maximum germination energy was noted in seeds primed with Moringa and SA as compared to all other seeds (Table 5).

Table 3. Effect of different priming techniques on mean germination time (days) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	1.90hi	4.00b	4.51a	3.47A
$CaCl_2$ (0.56%)	2.06h	3.01e	3.83bc	2.97BC
H_2O_2 (0.41%)	1.70i	2.60fg	4.30a	2.87CD
Moringa (3%)	2.60fg	2.40g	3.44d	2.81D
SA (0.004%)	2.68f	2.81ef	3.69cd	3.06B
Mean	2.19C	2.96B	3.95A	

Table 4. Effect of different priming techniques on final germination percentage of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	96.00	96.00	41.33	77.78
$CaCl_2$ (0.56%)	94.67	98.67	62.67	85.33
H_2O_2 (0.41%)	100.00	97.33	38.67	78.67
Moringa (3%)	97.33	97.33	42.67	79.11
SA (0.004%)	100.00	97.33	44.00	80.44
Mean	97.60A	97.33A	45.87B	

Table 5. Effect of different priming techniques on germination energy (%) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	96.00ab	89.33c	29.33g	71.56C
$CaCl_2$ (0.56%)	70.67d	94.67b	60.00e	75.11B
H_2O_2 (0.41%)	100.00a	96.00ab	29.33g	75.11B
Moringa (3%)	96.00ab	97.33ab	41.33f	78.22A
SA (0.004%)	98.67ab	98.67ab	38.67f	78.67A
Mean	92.27B	95.20A	39.73C	

Germination index

Salinity adversely affected the germination index. As the salinity levels increased, the value of germination index decreased. Overall results showed that primed seeds with H_2O_2 and SA had high germination index value (Table 6). Maximum value of germination index was recorded at 0 mM NaCl in those which were primed with Salicylic acid (SA) than all other seeds. H_2O_2 performed well at 50mM of NaCl and increased germination index while at 100mM NaCl maximum germination index value was recorded in $CaCl_2$ primed seeds.

Table 6. Effect of different priming techniques on germination index of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	15.00g	27.99d	5.64k	16.21D
$CaCl_2$ (0.56%)	29.09cd	25.32ce	15.06g	23.16B
H_2O_2 (0.41%)	36.78b	29.21c	10.72i	25.57A
Moringa (3%)	24.61ef	23.60f	8.47j	18.90C
SA (0.004%)	40.53a	24.64ef	12.10h	25.76A
Mean	29.20A	26.15B	10.40C	

Table 7. Effect of different priming techniques on vigor index of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	1850.53d	1341.93h	226.40l	1139.62D
$CaCl_2$ (0.56%)	1589.60g	1575.07g	647.60i	1270.76C
H_2O_2 (0.41%)	2300.00a	1665.07ef	325.80k	1430.29A
Moringa (3%)	2150.57b	1682.40e	295.27k	1376.08B
SA (0.004%)	2066.67c	1634.40f	443.47j	1381.51B
Mean	1991.47A	1579.77B	387.71C	

Vigor index

Cocks comb seeds were severely affected by salinity stress which ultimately reduced its vigor index value. Maximum vigor index value was recorded under non-saline conditions while minimum value was recorded at higher salinity level. H_2O_2 significantly increased the vigor index value at 0mM of NaCl as compared to other priming agents. Moringa significantly maximized the value of vigor index at moderate salinity level while $CaCl_2$ performed well at higher salinity levels (Table 7). It was concluded from results that primed seeds performed well than non-primed seeds and H_2O_2 performed well among all other priming agents and increased the vigor index value.

Radical length (mm)

Radical is very important in plant life because it absorbs water and nutrients for plant. Results indicated that higher salinity levels significantly decreased the radical length. H_2O_2 primed seeds showed maximum radical length at 0mM NaCl. Higher salinity levels adversely affects the radical length that's why at higher salinity level (100mM), radical length was minimum. Under non saline conditions, H_2O_2 showed best results as compared to all other treatments. Moringa performed better under moderate salinity stress and increased the radical length. Salicylic acid gave best result at 100mM of NaCl. It was concluded that H_2O_2, Moringa and SA improved the radical length while $CaCl_2$ showed non-significant results (Table 8).

Plumule length (mm)

Overall results showed that salinity significantly affected the growth of cocks comb seedlings. Plumule length was significantly reduced by salinity. Primed seeds significantly increased plumule length as compared to non-primed seeds (Table 9). Priming was helpful to eliminate the effect of salinity and ultimately increased the plumule length under saline conditions. H_2O_2 and Moringa performed very well under non saline condition and significantly increased the plumule length. All priming agents performed better under moderate salinity level. $CaCl_2$ prominently increased the plumule length at 100mM NaCl by minimizing the effect of salinity.

Table 8. Effect of different priming techniques on radical length (mm) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	5.30c	3.62f	0.80l	3.24D
$CaCl_2$ (0.56%)	4.13e	2.97h	1.83i	2.98E
H_2O_2 (0.41%)	6.53a	4.17e	1.43j	4.04B
Moringa (3%)	5.79b	4.67d	1.10k	3.85C
SA (0.004%)	5.93b	3.73f	3.27g	4.31A
Mean	5.54A	3.83B	1.69C	

Table 9. Effect of different priming techniques on plumule length (mm) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	14.00c	10.33f	4.23j	9.52D
$CaCl_2$ (0.56%)	12.46de	13.00d	8.27g	11.24C
H_2O_2 (0.41%)	16.27a	12.93de	7.07h	12.09A
Moringa (3%)	16.23a	12.60de	5.93i	11.59B
SA (0.004%)	14.73b	12.40e	6.67h	11.27BC
Mean	14.74A	12.25B	6.43C	

Radical to plumule ratio

Radical to plumule ratio was maximum under non-saline conditions. Those seeds, which were primed with salicylic acid, showed maximum radical to plumule ratio. Among all priming agents, salicylic acid showed better performance and significantly increased the radical to plumule ratio. H_2O_2 and salicylic acid significantly increased the radical to plumule ratio at 0mM NaCl whereas moringa at moderate salinity level showed best performance and salicylic acid at 100mM significantly increased the radical to plumule ratio (Table 10).

Seedling fresh weight (mg)

It was evaluated from results that salinity adversely affected the seedling fresh weight and significantly reduced the seedling fresh weight. Primed seeds showed increase in seedling fresh weight giving significant results. H_2O_2 showed best result at non-saline and moderately saline conditions. $CaCl_2$ reduced the effect of salinity and increased the seedling fresh weight.

Overall results indicated that H_2O_2 proved a best priming agent as compared to other agents (Table 11).

Table 10. Effect of different priming techniques on radical to plumule ratio of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	0.38bc	0.35cd	0.19g	0.31B
$CaCl_2$ (0.56%)	0.33de	0.23f	0.22fg	0.26C
H_2O_2 (0.41%)	0.40b	0.32de	0.20fg	0.31B
Moringa (3%)	0.36cd	0.37bc	0.19g	0.30B
SA (0.004%)	0.40bc	0.30e	0.49a	0.40A
Mean	0.37A	0.31B	0.26C	

Table 11. Effect of different priming techniques on seedling fresh weight (mg) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	3.20c	2.30g	1.20j	2.23D
$CaCl_2$ (0.56%)	2.53f	2.97de	2.20g	2.57B
H_2O_2 (0.41%)	3.87a	3.60b	1.53i	3.00A
Moringa (3%)	3.00de	2.90e	1.97h	2.62B
SA (0.004%)	3.07cd	2.67f	1.47i	2.40C
Mean	3.13A	2.89B	1.67C	

Seedling dry weight (mg)

It was concluded that salinity had significantly adverse effects on seedling growth and ultimately reduced the seedling dry weight. Seedling dry weight was reduced from non-saline to higher salinity level. H_2O_2 performed significantly at 0 mM and 50mM of NaCl and significantly increased the seedling dry weight. At higher salinity, all priming agents performed better as compared to control (Table 12). Overall results showed that primed seeds were better than non-primed ones and increased the seedlings dry weight.

Emergence experiment

Time to first seed emergence (days)

Results indicated that time to first seed emergence increased with increase of salinity stress. At higher salinity level, time to first seed emergence (TFSE) was more while at 0mM of NaCl it was reduced. At lower salinity level (0mM NaCl), all priming agents affected significantly and reduced the time to first seed emergence as compared to other salinity levels. At 50mM NaCl seeds, primed with $CaCl_2$ and H_2O_2, grew early as compared to other primed and non-primed seeds (Table 13). All priming agents acted non-significantly at 100mM NaCl. Overall results depicted that non-primed seeds and primed seeds with H_2O_2 significantly decreased time to first seed emergence.

Time to 50% emergence (days)

Results depicted that moderate salinity stress lengthened the time to 50% emergence (T50E) as compared to lower and higher salinity levels. At 0 mM NaCl, H_2O_2 acted significantly and shortened the time to 50% emergence. At 50 and 100 mM NaCl, all priming agents lengthened the time to 50% emergence (table 14).

Table 12. Effect of different priming techniques on seedling dry weight (mg) of cocks comb under various salinity levels

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	1.06c	0.76h	0.40k	0.74D
$CaCl_2$ (0.56%)	0.84g	0.90f	0.73h	0.82C
H_2O_2 (0.41%)	1.37a	1.23b	0.51j	1.04A
Moringa (3%)	1.02cd	0.97e	0.65i	0.88B
SA (0.004%)	1.00de	0.92f	0.49j	0.81C
Mean	1.06A	0.96B	0.56C	

Table 13. Effect of different priming techniques on time to first seed emergence (days) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	2.00d	2.33cd	2.33cd	2.22B
$CaCl_2$ (0.56%)	2.00d	2.00d	3.00bc	2.33B
H_2O_2 (0.41%)	2.00d	2.00d	2.67cd	2.22B
Moringa (3%)	2.00d	2.33cd	3.67ab	2.67AB
SA (0.004%)	2.00d	2.67cd	4.33a	3.00A
Mean	2.00B	2.27B	3.20A	

Table 14. Effect of different priming techniques on time to 50% emergence (days) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	0.65g	2.56de	0.92g	1.37D
$CaCl_2$ (0.56%)	0.62g	5.29a	2.00ef	2.64A
H_2O_2 (0.41%)	0.57g	4.10b	1.42fg	2.03BC
Moringa (3%)	0.61g	3.90bc	2.99cd	2.50AB
SA (0.004%)	0.77g	3.00cd	1.35fg	1.71CD
Mean	0.64C	3.77A	1.73B	

Mean emergence time (days)

It is clear from results that salinity significantly increased the mean emergence time. Seedlings took more time to emerge at moderate salinity stress than at lower and higher salinity levels. At 0 and 100mM NaCl, all priming agents had non-significant effect on seeds and lengthened the mean emergence time, but at 50mM NaCl, H_2O_2 significantly reduced the mean emergence time. Overall results showed that all priming agents lengthened the mean emergence time as compared to control treatment (Table 15).

Final emergence percentage

Salinity is highly dangerous for seed. Sometimes, it delays the emergence and some time it completely inhibits the seed emergence. Results showed that final emergence percentage was significantly reduced at higher salinity levels. Maximum emergence percentage was observed at non-saline condition. Results showed that primed seeds had significant effect on final emergence percentage.

At lower salinity level, Moringa and H_2O_2 significantly increased the final emergence percentage. Overall results showed that H_2O_2 significantly increased the final emergence percentage (Table 16).

Emergence energy (%)

At non-salinity levels emergence energy was maximum, but emergence energy was decreased with increase in salinity. H_2O_2, moringa and non-primed seeds showed the high emergence energy percentage at 0mM NaCl (Table 17). H_2O_2 improved the emergence energy at moderate salinity level. Emergence energy was recorded minimum at 100mM NaCl. Overall results showed that H_2O_2 proved as best priming agent among all other treatments as it significantly increased the emergence energy.

Table 15. Effect of different priming techniques on mean emergence time (days) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	2.74f	4.64bc	2.97f	3.45C
$CaCl_2$ (0.56%)	3.58e	4.60bc	4.49bc	4.22AB
H_2O_2 (0.41%)	3.04f	4.34cd	4.68bc	4.02B
Moringa (3%)	3.47e	4.41bcd	5.36a	4.41A
SA (0.004%)	4.04d	4.76b	4.47bc	4.42A
Mean	3.37B	4.55A	4.39A	

Table 16. Effect of different priming techniques on final emergence percentage of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	97.33a	25.33g	8.00i	43.56D
$CaCl_2$ (0.56%)	86.67b	66.67c	17.33h	56.89B
H_2O_2 (0.41%)	94.67a	80.00b	13.33h	62.67A
Moringa (3%)	96.00a	60.00e	22.67g	59.56B
SA (0.004%)	88.00b	52.00fc	8.00i	49.33C
Mean	92.53A	56.80B	13.87C	

Emergence index

Results indicated that there is high value of emergence index at 0mM NaCl. At higher salinity there is less emergence index value. At 0mM NaCl, all priming agents significantly affected the cocks comb seed and finally increased the emergence index value. Primed seeds also increased. emergence index value at 50mM NaCl as compared to non-primed seeds. At higher salinity levels, $CaCl_2$, H_2O_2 and moringa showed better results and increased the emergence index values. Overall results showed that primed seeds significantly increased the emergence index value as compared to non-primed seeds (Table 18).

Table 17. Effect of different priming techniques on emergence energy (%) of cocks comb under various salinity levels

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	97.33a	14.67f	4.00g	38.67C
$CaCl_2$ (0.56%)	82.67b	52.00d	9.33fg	48.00B
H_2O_2 (0.41%)	94.67a	65.33c	8.00fg	56.00A
Moringa (3%)	93.33a	49.33d	9.33fg	50.67AB
SA (0.004%)	78.67b	36.00e	4.00g	39.56C
Mean	89.33A	43.47B	6.93C	

Table 18. Effect of different priming techniques on emergence index of cocks comb under various salinity levels

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	19.28b	3.02f	1.48f	7.93C
$CaCl_2$ (0.56%)	24.70a	13.48cd	2.32f	13.50AB
H_2O_2 (0.41%)	23.58a	15.76bc	2.24f	13.86A
Moringa (3%)	26.84a	10.72de	2.98f	13.52AB
SA (0.004%)	25.08a	8.77e	0.55f	11.47B
Mean	23.90A	10.35B	1.92C	

Vigor index

Vigor index depicts the ability of seed to germinate. Salinity significantly reduced the vigor index. High vigor index was observed at 0mM of NaCl. As salinity levels increased, vigor index significantly reduced (Table 19). $CaCl_2$, H_2O_2 and moringa showed best results at 0mM NaCl and significantly increased the vigor index. At moderate salinity level, $CaCl_2$ and H_2O_2 significantly increased the vigor index value. It was also observed that priming had no significant effect under higher salinity levels. Overall results showed that $CaCl_2$ and H_2O_2 and moringa significantly increased the vigor index value.

Radical length (mm)

It was observed that radical length was decreased with increase of salinity stress. Maximum radical length was observed in those seeds which were grown at 0 mM NaCl and minimum radical length was recorded at 100mM NaCl. $CaCl_2$, H_2O_2 and moringa showed best results at 0mM NaCl and significantly increased the radical length. At 50mM NaCl, control, $CaCl_2$ and H_2O_2 had same results. At 100mM NaCl, no priming agent showed significant result. Overall results showed that $CaCl_2$ and H_2O_2 performed best and significantly increased the radical length (Table 20).

Table 19. Effect of different priming techniques on vigor index of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	1844.00b	181.33efg	49.60fg	691.64B
$CaCl_2$ (0.56%)	2296.80a	486.80d	22.00fg	935.20A
H_2O_2 (0.41%)	2469.33a	483.47d	24.92fg	992.57A
Moringa (3%)	2348.80a	281.05de	46.19fg	892.01A
SA (0.004%)	1535.73c	232.21ef	13.07g	593.67B
Mean	2098.93A	332.97B	31.15C	

Table 20. Effect of different priming techniques on Radical length (mm) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	6.00b	2.93c	1.12def	3.35B
$CaCl_2$ (0.56%)	9.53a	2.73c	0.40f	4.22A
H_2O_2 (0.41%)	9.13a	2.57c	0.60ef	4.10A
Moringa (3%)	9.37a	1.61d	0.57f	3.85AB
SA (0.004%)	5.70b	1.55de	0.57f	2.60C
Mean	7.95A	2.28B	0.65C	

Plumule length (mm)

Results showed that plumule length was shortened under salinity stress. Plumule length was decreased with increase in salinity level. Maximum plumule length was recorded at non-saline conditions while minimum plumule length was observed at higher salinity level as shown in (Table 21). Two treatments ($CaCl_2$ and H_2O_2) showed best results at 0mM NaCl and significantly increased the plumule length. $CaCl_2$ performed better at 50mM NaCl. At 100mM NaCl, no priming agent improved the plumule length as compared to control treatment.

Radical to plumule ratio

Radical to plumule ratio was increased at moderate level of salinity (50mM NaCl). At 0mM NaCl, maximum radical to plumule ratio was observed in those seeds which were primed with moringa.

At 50mM NaCl, no priming agent significantly increased the radical to plumule length as compared to control treatment. At 100mM of NaCl, no priming agent behaved significantly. Overall result showed that radical to plumule ratio was less as compared to control treatment (Table 22).

Table 21. Effect of different priming techniques on plumule length (mm) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	12.97c	3.13fg	1.48h	5.86C
$CaCl_2$ (0.56%)	16.87a	4.30e	0.87i	7.34A
H_2O_2 (0.41%)	16.93a	3.57f	1.26hi	7.25A
Moringa (3%)	15.10b	3.03	1.30hi	6.48B
SA (0.004%)	11.77d	2.87g	0.90hi	5.18D
Mean	14.73A	3.38B	1.16C	

Table 22. Effect of different priming techniques on radical to plumule ratio of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	0.46ef	0.94a	0.76b	0.72A
$CaCl_2$ (0.56%)	0.57de	0.64cd	0.46ef	0.55B
H_2O_2 (0.41%)	0.54def	0.72bc	0.48ef	0.58B
Moringa (3%)	0.62cd	0.53def	0.44f	0.53B
SA (0.004%)	0.48ef	0.54def	0.63cd	0.55B
Mean	0.54B	0.67A	0.55B	

Seedling fresh weight (mg)

It was concluded that salinity stress adversely affected the seedling fresh weight (SFW) and maximum seedling fresh weight was observed at non-saline conditions and minimum seedling fresh weight was observed at higher salinity stress. At 0 mM of NaCl, H_2O_2 significantly increased the seedling fresh weight. H_2O_2 also performed better at 50mM of NaCl as compared to other treatments while at 100mM of NaCl, $CaCl_2$ showed best results and significantly increased the SFW. Overall results showed that H_2O_2 performed better than all other treatments (Table 23).

Seedling dry weight (mg)

It was shown that seedling dry weight (SDW) was decreased with increase of salinity. At 0 mM and 50mM NaCl, H_2O_2 indicated best results as compared to other treatments and significantly.

Increased the seedling dry weight. $CaCl_2$ performed better at 100mM NaCl as compared to all other treatments. Overall results showed that all priming treatments performed better as compared to non-primed seeds and significantly increased the seedling dry weight (Table 24).

Table 23. Effect of different priming techniques on seedling fresh weight (mg) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	3.20c	2.30g	1.20j	2.23D
$CaCl_2$ (0.56%)	2.53f	2.97de	2.20g	2.57B
H_2O_2 (0.41%)	3.87a	3.60b	1.53i	3.00A
Moringa (3%)	3.00de	2.90e	1.97h	2.62B
SA (0.004%)	3.07cd	2.67f	1.47i	2.40C
Mean	3.13A	2.89B	1.67C	

Table 24. Effect of different priming techniques on seedling dry weight (mg) of cocks comb under various salinity levels.

Treatments	Salinity Levels (NaCl)			Mean
	0 mM	50 mM	100 mM	
Control	1.06c	0.76h	0.40k	0.74D
$CaCl_2$ (0.56%)	0.84g	0.90f	0.73h	0.82C
H_2O_2 (0.41%)	1.37a	1.23b	0.51j	1.04A
Moringa (3%)	1.02cd	0.97e	0.65i	0.88B
SA (0.004%)	1.00de	0.92f	0.49j	0.81C
Mean	1.06A	0.96B	0.56C	

Discussion

Salinity is a major limiting factor that seriously decreases crop productivity of cultivated soils. The results of the present study showed that seed germination and formation of cockscomb seedling were inhibited gradually by increasing the salt stress. Seed priming with CaCl2, H2O2, Moringa, Salicylic Acid significantly increased the germination rate, germination index, vigor index, germination energy, radical to plumule ratio and other parameter investigated in this study (as mentioned in the result part). The results are in accordance with the previous studies demonstrating a decrease in α-Amylase activity by starch remobilization and causing a negative effect on crop productivity in wheat crop (Almansouri, Kinet and Lutts 2001). The seed priming appeared to be able to alleviate the effect of salt stress applied at 50 to 100mM, decreasing the germination time by increasing seed germination index and germination energy and resulted in increase of normal germination. The early emergence of the radical can be induced in saline stress by seed priming. The results in this study are in line with previously investigated studies demonstrating the role of seed priming in an osmotic solution may improve seed germination through synthesizing proteins, nucleic acid, enzymes; increasing respiratory action and energy reutilization.

CaCl2, H_2O_2 and moringa significantly increased the final emergence percentage in cocks comb, The role of Cacl2 might be explained by the osmo priming effect of Ca2+ which diminishes Na+ and enhances K + absorption as reported in other studies. Similar results are reported by many other studies indicating the effectiveness of CaCl2 and other priming agents for yield parameter in maize (Ashraf and Rauf, 2001), rice (Farooq *et al.*, 2006) and wheat (Farooq *et al.*, 2008). Roots is the firstly component very prone to adverse conditions. The salt stress may affect the germination process much earlier than plumule appearance. Primed seed might have better water absorption which enable better metabolic activities. The earlier and superior germination of cockscomb seed may also be correlated with breakdown of dormancy in primed seeds. The results in the present study are also supported by previous studies reporting the quicker emergence of germination, by enhancing its vigor index as well as emergence energy and finally rise of radicle and plumule in primed seeds. This may also be explained by the synthesis of DNA, RNA and protein as well as enzyme activity during priming.

All treatments with salt stress had significantly reduced the plumule length of cocks comb in both primed and unprimed seed.

However the growth rate and plumule length improved by the treatment of priming i.e. Cacl2, H2O2, Moringa and Salysallic Acid Table ..... The treatments with CaCl2 and H2O2 showed best results at 0 to 100 mM NaCl and significantly increased the plumule length. Decrease in unprimed plumule growth as a result of increased salinity levels has been reported by many other studies on different crops (Ahmadvand *et al*. 2012; Elouaer and Hannachi 2012). This decrease might probably be due to specific ionic or osmotic effect on seedlings. Similarly, toxic ion accumulation (Na+ and Cl–) in the microsphere of root zone may negatively affect plant metabolism. It may also be explained by the factor of remobilization of reservoirs from cotyledons to embryo axis during high salinity levels. The similar factors also effect the growth rate of the plumula and embryo axis.

Mean of cockscomb root growth was also significantly ($P < 0.05$) influenced by salinity and priming treatments. (Table 1). The treatment with CaCl2 and H_2O_2 significantly improved the root length as compare to Moringa and Salicylic Acid with seed treated with different salinity levels. This might possibly be explained by the fact of embryo cell wall expansion as well as rise the free radical scavenging enzymes i.e. Catalase peroxidase, superoxide dismutase as reported in other studies (Shafi *et al*. 2009).

The seedling fresh and dry weight was decreased with increase of salinity. At 0 mM and 50 mM CaCl, H_2O_2, indicated best results as compared to other treatments, however at 100 mM NaCl the treatment with $CaCl_2$ were having comparatively better results as compare to H2O2 and other priming treatments. The minimum dry and fresh weight were noticed in Moringa treatments. The result in this study are in accordance with previous studies. These findings in the present study may help farmer community as well as researchers working with stress conditions under arid and semi-arid regions of the country.

Conclusion

During germination test, salinity significantly affected the germination and growth of cocks comb (*Celosia cristata* L.) and ultimately reduced the all the parameters studied.

While seed priming significantly affected all the studied attributes. So it can be concluded that H_2O_2 proved a best dose to enhance seed traits of cocks comb followed by moringa, $CaCl_2$ and salicylic acid respectively.

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