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Salinity tolerance in *Chrysanthemum morifolium*

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Abstract

The scarcity of fertile land for growing ornamental crops has received attention on the utilization of salt affected soils for floriculture. Two cultivars of *Chrysanthemum morifolium viz.* 'Flirt' and 'Jayanti' were evaluated under three salinity levels (EC 4, 6 and 8 dS/m) of irrigation water along with control (irrigating with non-saline water). The experiment consisting of eight treatments with three replications was conducted in earthen pots with randomized block design. The pots were filled with sandy loam soil and 20 days old rooted cuttings were planted @ three cuttings per pot. The growth parameters *viz.*, plant height, number of buds and flowers per plant; fresh and dry weight as well as chlorophyll content increased significantly with increasing salinity levels. 'Jayanti' appeared to be more salt tolerant in comparison to 'Flirt' in their floral morphology as well as in productivity. Nitrogen and phosphorus concentrations were reduced in plants as salinity increased. There was a relatively high N concentration in 'Flirt' cultivar. The concentration of other nutrients such as potassium, calcium and magnesium increased significantly with increasing salinity levels. This increase in nutritional uptake did not show any detrimental effect of Na toxicity in the salinized plants. As a result, nutrient use efficiency of nitrogen and phosphorus was enhanced with increasing salinity levels. Growth and flower yield both indicated that *C. morifolium* which is a plant of halophytic origin can be raised successfully as an ornamental cash crop in moderate saline environment, particularly 'Jayanti' cultivar. However, its critical limit to higher salinity tolerance is yet to be worked out.

Key words: *Chrysanthemum morifolium*, 'Jayanti', 'Flirt', nutrient concentration, nutrient uptake, salinity levels

Introduction

In India 23.8 m ha salt affected wastelands are lying almost unutilized for agricultural purposes (Abrol *et al.*, 1988). Efforts are underway to identify plant species, which could be grown under these conditions. In most of the studies carried out so far, NaCl alone has been considered as a source of salinity to test the growth behaviour of plants under saline environment. But it is not the only salt which is found in salt affected soil or brackish irrigation water, more or less other cations and anions such as calcium, magnesium, potassium, carbonates, bicarbonates, chloride and sulphate also affect the physiology of growing plants. Use of different doses of NaCl as salinity standard in experiments may render misleading information. Therefore, over all salt concentrations should be considered for an appropriate screening of salt tolerance in plants. A more suitable and environmentally safe solution lies in selection and growing of those crops which can remove these salts from the site by their high salt uptake properties. Efforts have been made to develop suitable agro technology for the utilization of brackish water through selection of salt tolerant genotypes/ species, application of organic and inorganic amendments and different cultivation and soil conservation practices (Epstein *et al.,* 1980 and Neumann, 1977). Even then saline agriculture could not extend on a wide scale in India. The demand of ornamental plants and flowers is increasing worldwide day by day. While the availability of fertile land for floriculture would not be possible, growing of ornamental plants on salt affected wastelands may be a good venture for an additional source of income to the farmers. Salt tolerance limit of a good number of ornamental plants have been determined by several workers (Cooper and Link, 1953; Monk and Paterson, 1962; Bernstein *et al.*, 1972; François and Clark, 1978 and Rodriguez Perez *et al.*, 2000). Butterfield (1955) observed the response of saline and alkaline soil environment on ornamental plants. Day (1977) has screened out few rose varieties suitable for alkaline soil of West Bengal in India. Momonoki and Kamimura (1994) studied the salt tolerance mechanism in *Salicornia europea* for ornamental value. Rahi *et al.* (1998) studied the performance of marigold, narcissus and gladiolus grown under salt affected soil. Rahi and Datta (2000) worked on the chrysanthemum cultivation in the saline environment. In this study, the performance of two chrysanthemum cultivars *viz.* 'Flirt' and 'Jayanti' irrigated with saline water having different salinity levels was studied to assess the scope of its cultivation on salt affected wastelands in India and whether the nutrients concentration in plants are affected by salinity treatments and influence the flower yield or quality.

Materials and methods

Rooted cuttings of two cut flower cultivars of *Chrysanthemum morifolium* Ramat *viz.* 'Flirt' and 'Jayanti' were planted in 35 cm earthen pots filled with sandy loam soil having bulk density 1.33g/cm^3, organic carbon 1.01%, $CaCO_3$ 2.0%, water holding capacity 39.64%, pH 8.23, EC 0.600 dS/m. Cation and anion composition of the saturation extract of the soil was Na-3.65, K- 0.28, Ca-1.30, Mg-0.80 and CO_3, 0.80, HCO_3-4.2 and Cl-0.60 mg/L, respectively. The saline water of EC 4, 6 and 8 dS/m concentration was prepared artificially by dissolving various salts in non-saline water under different proportions. The composition of saline and non-saline water is given in Table 1. Salts used were NaCl, Na_2CO_3, Na_2SO_4, $MgCl_2.6H_2O$, $MgSO_4.7H_2O$, $CaCl_2$, $CaCO_3$ and $CaSO_4$ in different combinations to create required levels of EC. The composition of natural brackish water in most of dry regions in the state varied from EC 5 to 10 dS/m, which was the basis to set out EC 4-8 dS/m salinity levels in the experiment. Plants were irrigated with artificially prepared saline water along with a control (non-saline water with chemical composition pH 8.10, EC 1.37 dS/m, cations Ca-2.4, Mg-8.60, Na-1.3, K-1.45 and anions CO_3-7.4, HCO_3 4.6, Cl-0.2 mg/L). The experiment was conducted during winter season in a Factorial Randomized Block Design with eight treatments (2 cultivars x 4 EC levels including control) in three replications comprised of 2 pots per treatment in each replication. In each pot three rooted cuttings were planted and thus, total 144 rooted cuttings were established. Growth observations as plant height, top circumference, number of branches, leaves, buds and flowers were recorded periodically. The Chlorophyll content was analyzed spectrophotometrically at initiation of bud stage. At maturity the plants were harvested and weighed for fresh weight. Sample plants were washed with deionised water and oven dried weight was measured. These oven dried plants were divided in portion *viz.*, root, shoot and leaves separately, and further weighed to determine the proportion of root, shoot and leaves in the whole plant. Roots separated from the plants were further washed with distilled water and lastly with 0.1 normal HCl solution. Oven dried root, shoot and leaves were processed for nutrient analysis. One-gram oven dried powder of each plant component such as root, shoot and leaves was digested in digestion tubes with H_2SO_4- salicylic acid-H_2O_2 and selenium powder as catalyst mixture. Plant nutrients such as sodium, calcium and potassium were analyzed by flame photometer, magnesium through versinate method, nitrogen and phosphorus by spectrophotometer method given by Walinga *et al.* (1995). Water analysis was carried out following U.S.D.A. Handbook No. 60.

Results and discussion

Growth and yield: No detrimental effect of applied irrigation water of various salinity levels, either on survival or growth of the plants was observed. There was 100 percent survival of all the rooted cuttings planted in the pots. All growth parameters *viz.*, height, number of branches and leaves per plant of both cultivars increased consistently with increasing salinity levels of irrigation water and also with the growth stages *i.e.*, days after plantation (DAP). Plant height differed significantly between cultivars, salinity levels and growth stages (Fig. 1). The branching performance of both cultivars was almost same and there was no significant difference amongst the salinity levels. However plants grown at EC 8 were significantly different from control plants (Fig. 2). Most of the studies have shown the growth retardation in plants grown under NaCl induced salinity stress (Gouia *et al.*,1994; Graifenberg *et al.*, 1996; Navarro *et al.*, 1999; Scholberg and Locassio, 1999 and Savvas and Lenz, 2000). When only NaCl is used to create salinity stress, it exhibits only negative effects of salinity on plant growth. On the other hand, salinity due to the presence of chlorides of Ca^{2+} and Mg^{2+} and sulphates of Na^{1+}, Ca^{2+} and Mg^{2+} stimulates the growth of plants and mitigate the negative effects of Na in the soil and plants. Cramer *et al.* (1986) found that supplementation with Ca^{2+} mitigated the inhibition of root growth caused by NaCl in cotton. A similar effect was also noticed in *Leucaeana leucocephala* and *Sesbania bispinosa* (Gorham *et al.*, 1988). El- Siddig and Ludders (1994) obtained the higher fruit yield in apple trees salinized with Na_2SO_4 as compared to NaCl. Wilson and Grieve (2000) reported the increased growth of Red-Orach between EC 4.2 and 13.7 dS/m created through $MgSO_4$, Na_2SO_4, NaCl and $CaCl_2$ salts in equal proportions in base nutrient solution. It was found that hydraulic conductance was markedly decreased in NaCl treated roots of Melon plant (*Cucumis melo*) as compared to $CaCl_2$, which causes the detrimental effect on plant growth (Carvajal *et al.*, 2000). Even in the *C. morifolium* salinity given by a mixture of chlorides, carbonates and sulphates of Na^{1+}, Ca^{2+} and Mg^{2+} in irrigation water promoted the growth in comparison to the non- saline control (Rahi and Datta, 2000).

The number of leaves increased significantly with salinity levels up to EC 6 and after that it decreased at EC 8 dS/m due to initiation of flower buds (Fig. 3). The growth of 'Jayanti' cultivar was superior to 'Flirt' at all salinity levels and duration and the growth pattern was almost identical in control as well as in treated plants. In first count of flower bud formation (90 DAP) no significant difference was found up to EC 8 salinity level in both cultivars, but at second count (105 DAP) this difference increased significantly with increasing salinity levels. The 'Jayanti' cultivar superseeded 'Flirt' in flower bud formation corresponding to their growth. Flower production followed the same trend as in case of flowers buds (Table 3). Additionally, 'Jayanti' appears to be more suitable in floral morphology under saline and non saline conditions in comparison to 'Flirt'. Like other characters fresh weight of shoot of both cultivars enhanced significantly at 6 and 8 EC levels than that of plants grown at 4 EC and in non saline pots. Shoot biomass of both the cultivars increased with EC levels, recording a relatively high in 'Jayanti' cultivar (Table 4). The fresh and dry weight of roots of both cultivars increased with increasing salinity levels, No significant difference was recorded between the two cultivars for root biomass (Table 4). The Root / shoot ratio decreased with respect to increasing salinity levels owing to a relatively large growth in shoot portion in comparison to root component particularly in 'Flirt' (Table 5). This disproportionate growth perhaps reduced the flower yield in 'Flirt' at EC 8 dS/m

Table 1. Cation and anion composition of artificial saline and non saline irrigation water

EC (dS/m)	Cations (mg/litre)			Anions (mg/litre)		
	Na^+	Ca^{2+}	Mg^{2+}	Cl^{1-}	CO^{2-}_3	SO^{2-}_4
4 EC	20.0	12.0	8.0	20.0	10.0	10.0
6 EC	30.0	18.0	12.0	40.0	15.0	15.0
8 EC	40.0	24.0	16.0	40.0	20.0	20.0
Control (Non saline water) pH 8.10, EC 1.37	Na^+2.52, K^+ 1.45, Ca^{2+}2.4, Mg^{2+}8.60			Cl^{1-}1.85, CO_3^{2-}5.2, HCO^{-1}_3 4.60, SO^{2-}_4 ND		

Table 2. Effect of saline water irrigation on plant height (cm)

Cultivars	Observation interval	Salinity levels (dS/m^{-1})				Mean
		Control	4 EC	6 EC	8 EC	
'Flirt'	90 DAP	13	14	15	19	15.25
'Jayanti'	90 DAP	11	14	16	20	15.25
'Flirt'	105 DAP	17	20	23	26	21.50
'Jayanti'	105 DAP	27	32	35	52	36.50
Mean		17.00	20.0	22.25	29.75	

LSD (P=0.01): Cultivar = 1.78; Salinity level = 4.53

Table 3. Effect of saline water irrigation on number of flower production of two cultivars of *C. morifolium* (120 DAP)

Cultivars	Observation interval	Salinity levels (dS/m^{-1})				Mean
		Control	4 EC	6 EC	8 EC	
'Flirt'	120 DAP	17.0	21.0	23.0	31.0	23.0
'Jayanti'	120 DAP	23.0	35.0	40.0	60.0	39.5
Mean		20.0	28.0	31.5	45.5	

LSD (P=0.01): Cultivar = 12.47; Salinity level = 7.20

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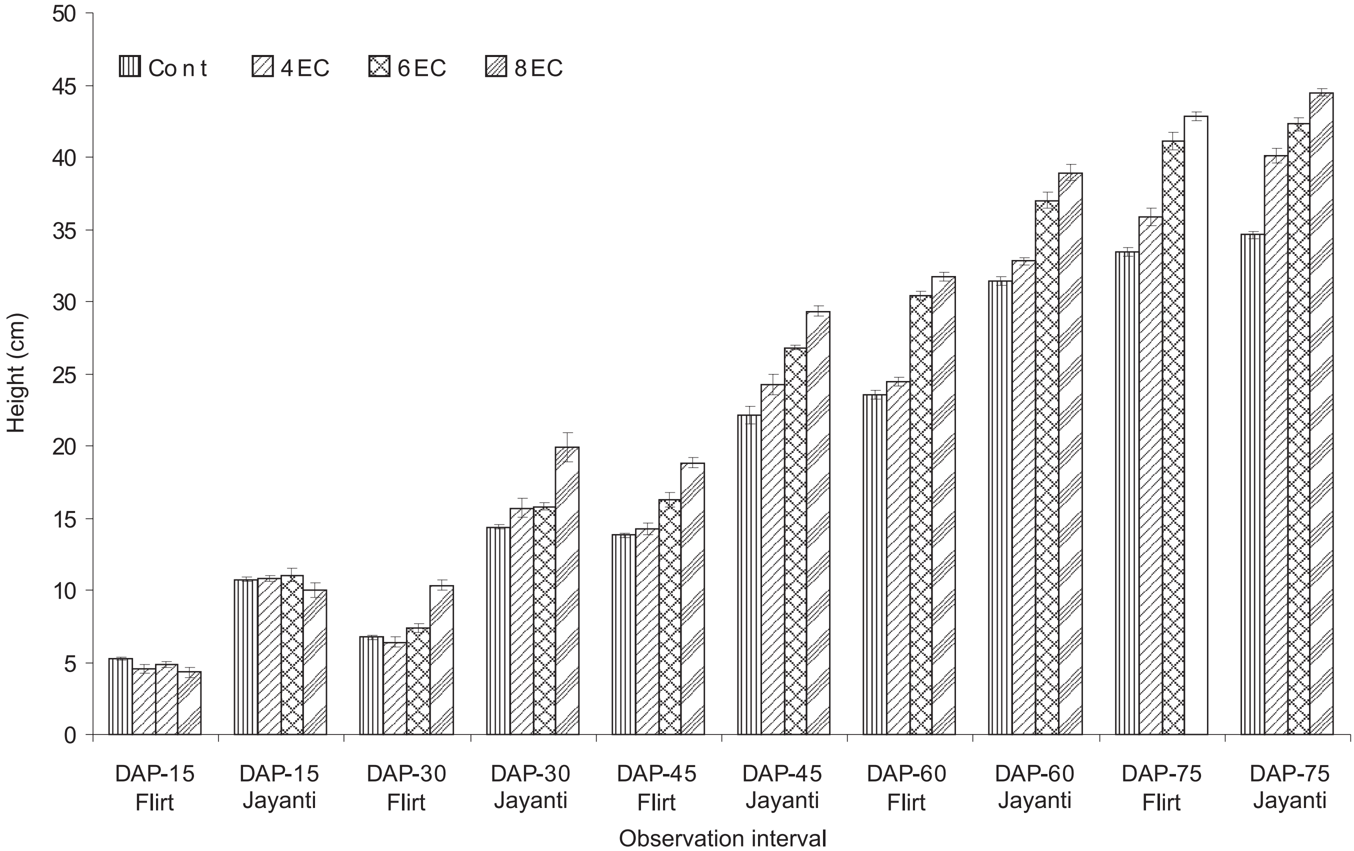

Fig.1. Growth of two *C. morifolium cv.* at different salinity levels along with control at various growth stages (DAP)

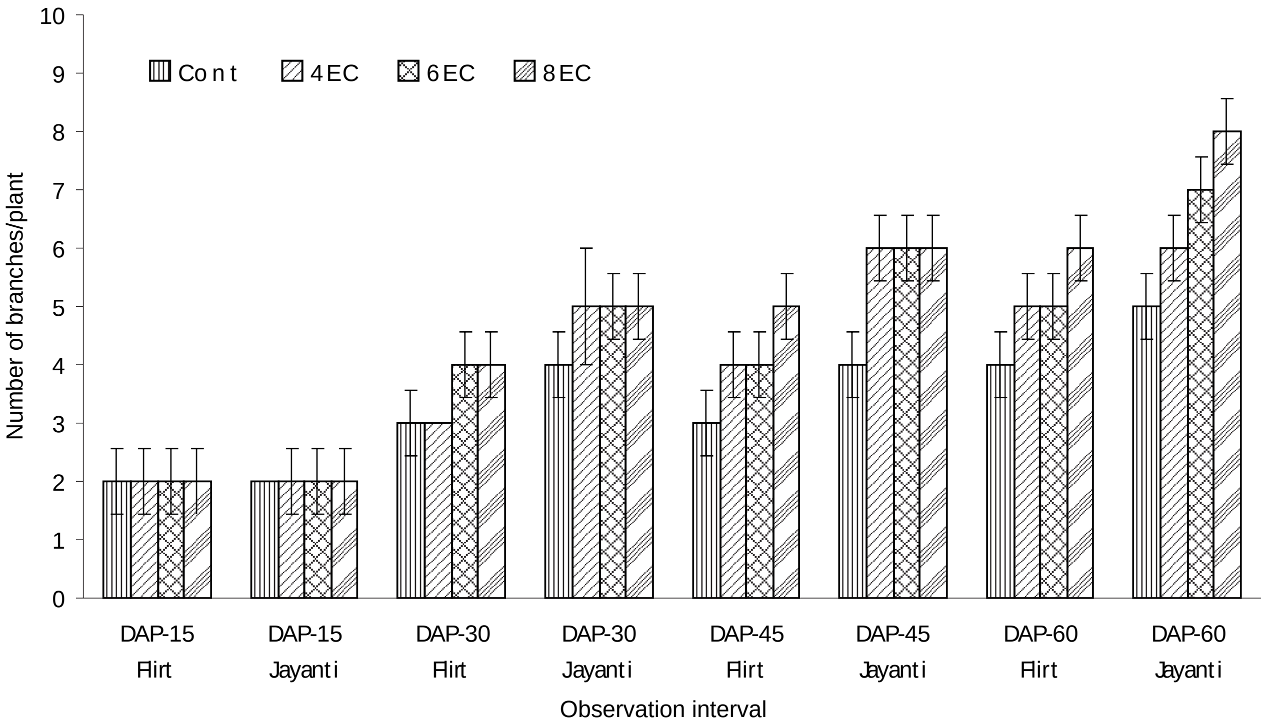

Fig. 2. Number of branches in two *C. morifolium cv.* at different salinity levels along with control at various growth stages (DAP)

in comparison to 'Jayanti' cultivar. The chlorophyll contents ('a' and 'b') of both the cultivars rose with increasing salinity levels in comparison to plants grown with non- saline irrigations (Fig. 4). There was a significant difference between chlorophyll content 'a' and 'b' and chlorophyll 'a' remained always higher throughout the EC treatments than that of chlorophyll 'b'. The 'Jayanti' cultivar synthesized greater amount of chlorophyll 'a', 'b' and total fraction throughout all salinity treatments in comparison to cultivar 'Flirt'. However this difference was significant only for content 'a' and for total chlorophyll (Fig. 4). The growth and yield of both *Chrysanthemum* cultivars increased significantly with the increasing salinity levels and there was no stress effect up to EC-8 dS/m. Khan *et al.* (2000) observed that the dry weight of *Atriplex griffith* (var. stocksi) enhanced significantly between 90 and 180 mM NaCl Hoagland's nutrient solution in comparison to normal and 360 mM NaCl concentration. The different levels of adaptability and tolerance to salinity might occur in different species even in same genera. Johnson *et al.* (1966) observed that *C. articum* was growing naturally in saline areas and appeared to be relatively more different than others. Both cultivars of *C. morifolium* seem to be mild salt tolerant due to their better performance at 8 EC as compared to normal. It is, therefore, suggested that *C. morifolium* being a member of halophytic genera could be grown well in saline environment. Rahi and Datta (2000) reported a positive correlation between numbers of flower with increasing salinity levels up to 8EC in two other cultivars of *C. morifolium* (Basantika and Maghi). The increase in flower yield was associated with large growth and increased concentration of potassium in the plants grown on increased salinity levels. Likewise chlorophyll content had a direct correlation with rising salinity levels. Many workers have reported that chlorophyll content increased at medium salinity levels in barley, *Hibiscus tiliaceus* and *Amaranthus tricolor* (Abadia *et al.*, 1999; Santiago *et al.*, 2000 and Wang and Nii, 2000). Magnesium concentration also increased in plants with the rising salinity levels of the irrigation water. Since magnesium

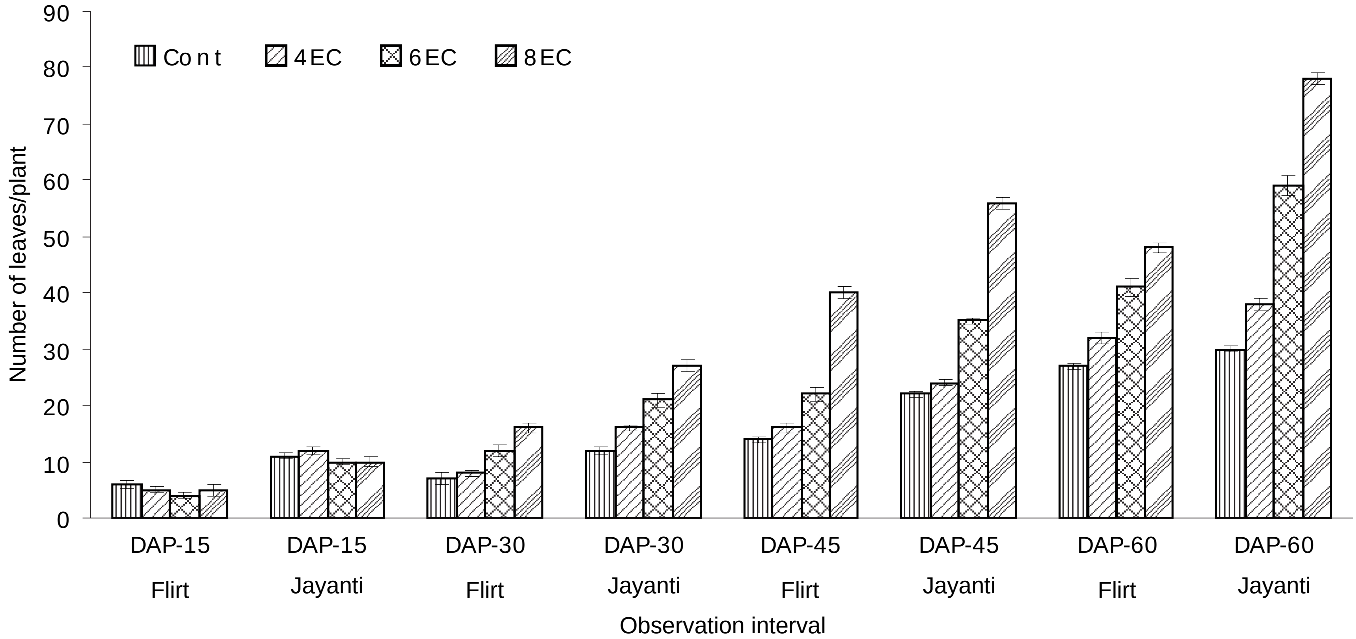

Fig. 3. Number of leaves in two *C. morifolium cv.* at different salinity levels along with control at various growth stages (DAP)

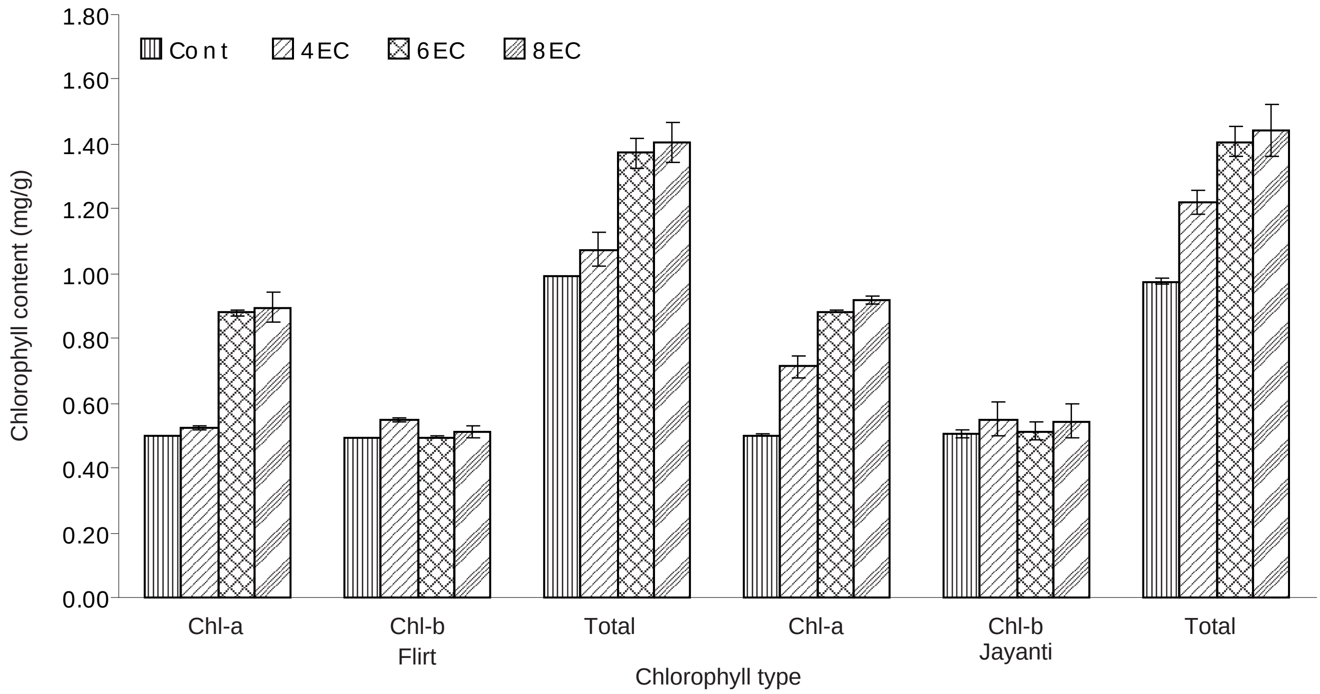

Fig.4. Chlorophyll content in two *C. morifolium cv.* at different salinity levels along with control

Table 4. Fresh and oven dried weight of root and shoot of two cultivars of *C. morifolium* irrigated with different levels of saline water

Salinity treatments	Cultivars		Mean
	'Flirt'	'Jayanti'	
Fresh weight of shoot (g/plant)			
Control	7.33	7.47	7.40
4-EC	8.08	8.68	8.38
6-EC	11.32	18.44	14.88
8-EC	23.48	24.56	24.02
Mean ± LSD 01	12.55	14.70	
LSD (P=0.01): Cultivar = 2.41; Salinity level = 1.39			
Oven dried weight of shoot (g/plant)			
Control	1.15	1.51	1.33
4-EC	1.44	2.4	1.92
6-EC	1.89	2.99	2.44
8-EC	3.8	4.48	4.14
Mean	2.07	2.85	
LSD (P=0.01): Cultivar = 0.57; Salinity level = 0.33			
Fresh weight of root (g/plant)			
Control	1.23	1.03	1.13
4-EC	1.26	1.18	1.22
6-EC	1.45	1.39	1.42
8-EC	2.15	2.16	2.16
Mean	1.52	1.44	
LSD (P=0.01): Cultivar = 0.57; Salinity level = 0.33			
Oven dried weight of root (g/plant)			
Control	0.34	0.42	0.38
4-EC	0.42	0.58	0.50
6-EC	0.66	0.78	0.72
8-EC	0.86	0.94	0.90
Mean	0.57	0.68	
LSD (P=0.01): Cultivar = NS; Salinity level = 0.13			

Table 5. Root and shoot ratio in two cultivars of *C. morifolium* irrigated with different levels of saline water

Salinity treatments	Cultivars	Root biomass (g/plant)	Shoot biomass (g/plant)	Root/shoot ratio
Control	'Flirt'	0.34	1.09	0.312
4 EC		0.42	1.44	0.292
6 EC		0.61	2.10	0.290
8EC		0.86	3.80	0.230
Control	'Jayanti'	0.42	1.51	0.280
4 EC		0.58	2.39	0.243
6 EC		0.77	3.18	0.242
8EC		0.94	4.48	0.210

plays a vital role in chlorophyll synthesis, increase in chlorophyll content might have been related with magnesium impact, which was rich in saline water. The high Mg and chlorophyll content in 'Jayanti' rendered its better flower yield than the 'Flirt'. Waisel (1972) observed that plants like Zostera require a steady and constant level of salinity. If salinity levels are lowered by dilution of sea water with fresh water, yellowing of leaves occurs and is followed by necrosis and death of plants.

Nutrients concentration in plants: Nitrogen and phosphorus were neither applied additionally with irrigation water nor as basal dose in pots and therefore, their concentrations decreased in proportion with the increasing salinity levels as well as plant growth of both the cultivars. N and P concentrations varied significantly in increasing order from root to leaves in both cultivars (Table 6). 'Flirt' showed relatively high N and P concentration in comparison to 'Jayanti' cultivar. The greater concentration of nitrogen in 'Flirt' cultivar might be associated with its intrinsic requirement for physiological activities. Although, potassium too was not applied at any stage of growth, its concentration increased significantly with the increasing salinity treatments over control plant populations. A high nitrogen concentration in the plants grown in saline environment may probably be due to reduced growth (Chippa and Lal, 1985 and Rodriguez- Perez *et al.,* 2000). Whereas in this study, salinity stimulated the plant growth due to which nitrogen concentration defused in overall large growth of plants. As a consequence nitrogen concentration decreased in plants with increasing salinity. Since the growth of 'Flirt' was significantly less than 'Jayanti', particularly leaf and flower components, it has shown a relatively high nitrogen concentration. Further, the decrease in nitrogen concentration in salinized plants ultimately promoted the nitrogen use efficiency.

Table 6. Nutrient concentration in two cultivars of *C. morifolium* irrigated with different levels of saline water

Nutrient (%)	Cultivars	Plant components	Salinity levels (dS/m^{-1}) Control	4 EC	6 EC	8 EC
N	'Flirt'	Root	2.663	2.493	2.393	1.850
	'Jayanti'	Root	1.937	1.647	1.450	1.337
	'Flirt'	Shoot	3.660	2.900	2.800	2.410
	'Jayanti'	Shoot	2.453	2.320	2.220	2.020
	'Flirt'	Leaves	6.243	4.200	2.903	2.600
	'Jayanti'	Leaves	2.950	2.840	2.400	2.00
LSD (P=0.01) Salinity = 0.049 , Cultivars = 0.12, Plant parts = 0.085						
P	'Flirt'	Root	0.570	0.450	0.420	0.357
	'Jayanti'	Root	0.460	0.443	0.373	0.263
	'Flirt'	Shoot	0.643	0.520	0.483	0.447
	'Jayanti'	Shoot	0.550	0.540	0.530	0.480
	'Flirt'	Leaves	0.770	0.700	0.630	0.500
	'Jayanti'	Leaves	0.770	0.640	0.640	0.560
LSD (P=0.01) Salinity = 0.018 , Cultivars = 0.030, Plant parts = 0.022						
K	'Flirt'	Root	0.110	0.117	0.117	0.140
	'Jayanti'	Root	0.040	0.070	0.103	0.140
	'Flirt'	Shoot	0.117	0.150	0.156	0.196
	'Jayanti'	Shoot	0.156	0.185	0.200	0.211
	'Flirt'	Leaves	0.100	0.250	0.274	0.282
	'Jayanti'	Leaves	0.156	0.253	0.344	0.350
LSD (P=0.01) Salinity = 0.009 , Cultivars = 0.015, Plant parts = 0.011						
Ca	'Flirt'	Root	0.730	0.750	0.860	0.970
	'Jayanti'	Root	0.729	0.750	0.870	0.997
	'Flirt'	Shoot	0.743	0.817	0.920	1.150
	'Jayanti'	Shoot	0.770	0.860	1.040	1.170
	'Flirt'	Leaves	0.750	0.870	1.150	1.250
	'Jayanti'	Leaves	0.777	0.877	1.180	1.257
LSD (P=0.01) Salinity = 0.025 , Cultivars = 0.044, Plant parts = 0.031						
Mg	'Flirt'	Root	0.245	0.262	0.310	0.364
	'Jayanti'	Root	0.230	0.300	0.350	0.380
	'Flirt'	Shoot	0.230	0.285	0.320	0.450
	'Jayanti'	Shoot	0.330	0.380	0.393	0.510
	'Flirt'	Leaves	0.265	0.405	0.477	0.682
	'Jayanti'	Leaves	0.310	0.500	0.585	0.792
LSD (P=0.01) Salinity = 0.030 , Cultivars = 0.052, Plant parts = 0.037						
Na	'Flirt'	Root	0.055	0.761	1.070	1.210
	'Jayanti'	Root	0.032	0.467	0.850	1.160
	'Flirt'	Shoot	0.023	0.460	0.821	0.950
	'Jayanti'	Shoot	0.027	0.350	0.741	0.940
	'Flirt'	Leaves	0.016	0.321	0.561	0.885
	'Jayanti'	Leaves	0.018	0.256	0.430	0.645
LSD (P=0.05) Salinity = 0.021 , Cultivars = NS, Plant parts = 0.026						

Table 7. Nutrient concentration ratios in two cultivars of *C. morifolium* irrigated with different levels of saline water

Nutrient/ Nutrient	Cultivars	Salinity treatments Control	4-EC	6-EC	8-EC
K/Na	'Flirt'	3.48	0.51	0.22	0.20
	'Jayanti'	4.57	0.47	0.32	0.30
Ca/Na	'Flirt'	23.65	1.58	1.19	1.21
	'Jayanti'	29.56	2.32	1.53	1.48
Mg/Na	'Flirt'	7.88	0.63	0.45	0.49
	'Jayanti'	11.3	1.10	0.66	0.73

Table 8. Nutrient uptake (mg/pot) in two cultivars of *C. morifolium* irrigated with different levels of saline water

Nutrients	Cultivar	Salinity levels (dS/m^{-1})					LSD
		Control	4-EC	6-EC	8-EC	Mean	(P=0.01)
N	'Flirt'	65.99	61.60	69.69	111.11	77.10	NS
	'Jayanti'	48.94	71.17	69.69	102.64	73.11	
Mean		57.47	66.38	69.69	106.87		
LSD (P=0.01) Salinity level = 10.14							
P	'Flirt'	10.06	10.68	13.29	21.07	13.78	2.10
	'Jayanti'	11.81	16.68	20.23	25.79	18.63	
Mean		10.94	13.68	16.76	23.43		
LSD (P=0.01) Salinity level = 2.97							
K	'Flirt'	1.62	3.37	4.84	10.29	5.03	0.99
	'Jayanti'	2.53	5.64	8.92	13.89	7.75	
Mean		2.07	4.51	6.88	12.09		
LSD (P=0.01) Salinity level = 1.39							
Ca	'Flirt'	10.82	15.05	25.24	53.96	26.26	4.64
	'Jayanti'	14.98	25.11	39.73	63.75	35.90	
Mean		12.90	20.08	32.48	58.86		
LSD (P=0.01) Salinity level = 6.56							
Mg	'Flirt'	3.68	6.10	9.59	24.62	10.10	2.21
	'Jayanti'	5.80	12.25	17.32	32.74	17.03	
Mean		4.74	9.18	13.45	28.68		
LSD (P=0.01) Salinity level = 3.13							
Na	'Flirt'	0.42	8.82	20.12	45.27	18.66	NS
	'Jayanti'	0.47	9.95	24.07	36.74	17.81	
Mean		0.44	9.39	22.10	41.01		
LSD (P=0.01) Salinity level = 4.07							

Similarly, the P decrease with increasing salinity levels enhanced the phosphorus use efficiency particularly in 'Flirt' cultivar. Wilson and Grieve (2000) reported a reduced concentration of phosphorus in Red –Orach plants grown at high salinity levels, which enhanced the P use efficiency. Conversely, the increase in potassium concentration at high EC from the control seems to have accelerated the metabolic activities of plants for efficient utilization of nitrogen, phosphorus, calcium and magnesium and inhibited the negative effect of sodium on plants. Similarly K concentration was observed in root < shoot < leaves. It might be concluded that superior growth of 'Jayanti' *cv.* was influenced by the relatively high K concentration in shoot and leaves followed by the better growth and flower yield. In many other nutritional studies, the higher concentration of K^{1+} in young expanding tissues has been understood to resist with injurious Na salt concentration (Gorham, 1993; Storey *et al.*, 1993; Khatun and Flower, 1995). The high K^{1+} content in the plants is supposed to influence the flower yield as salinity increases. Thomas and Lingdale (1980) observed higher potassium concentration in Bermuda grass in saline areas as compared to non-saline areas. Thus a high K concentration acts to neutralize the salinity stress.

Concentration of calcium and magnesium increased significantly corresponding to salinity levels. Leaves had higher contents of these nutrients than root with increasing salinity level. These elements showed greater concentration in 'Jayanti' than cultivar 'Flirt'. Further, the high concentration of calcium in plants grown at high saline medium (EC 8) might have encountered the negative effect of sodium being a divalent cation. As a consequence, salinized plants attained better growth than normal plant population. Scholberg and Locassio (1999) described it as defence mechanism of cell wall from high salt (NaCl) injury in snap bean plants. Osmond (1965) and Greenway (1968) observed that Ca^{2+} is better known for its stimulative effect for the greater uptake of potassium and inhibitory effects on transport of sodium, lithium and hydrogen ions. A high concentration of magnesium with increasing salinity levels not only alleviate the negative effect of sodium on plants but also stimulated higher synthesis of chlorophyll content in salinized plants than non- salinized plant population. Kovacs *et al.* (1995) observed a high magnesium concentration in most of the halophytes of Asteraceous and Chenopodiaceous plants grown on highly saline soils. It is surprising that even after great reduction in K: Na and Ca: Na in plants of saline environment from the non-saline due to a relatively high uptake of Na, growth and flower yield were increased, perhaps due to integrated role of all the nutrients in aggregate response. Sodium concentration enhanced significantly as salinity levels were increased, but in plant components it was reduced in order of root > shoot > leaves. As a whole, cultivar 'Flirt' showed significantly greater concentration of Na in comparison to 'Jayanti' cultivar (Table 6). In general, the nutrient ratios K/Na, Ca/Na and Mg/Na decreased at higher salinity levels in comparison to plants grown in control pots (Table 7). The plants irrigated with a solution of high concentration of sodium salts contain high Na concentration in their parts; however, its role in better nutrition of plants is still questioned. Yet, it is universally found high in the plants of salt affected land. Ramadan (2001) noticed that *Sporobolus spicatus* grown on salt affected lands accumulated more Na^{+} content because of its predominance in soil solution but whether it favours the growth or flower yield is still not clear. These two cultivars, 'Flirt' and 'Jayanti', of *C. morifolium* are better than Basantika & Maghi earlier studied (Rahi and Datta, 2000) in respect of large flower size, better yield and early blooming in winter season. Some minor deviations from EC 6 to 8 dS/m were observed against this pattern. This reduction in ratio of nutrient concentrations at increasing salinity levels was more pronounced in 'Flirt' cultivar than that in 'Jayanti' (Table 7).

Nutrient uptake: The uptake of N, P, K, Ca, Mg and Na enhanced significantly in both the cultivars with increasing salinity levels in comparison to control plants. It was higher in 'Jayanti' cultivar to maintain the physiological requirements for a relatively high growth. The nitrogen uptake was greater in 'Flirt' cultivar in comparison to 'Jayanti'; however, the difference between them was not significant up to salinity of 6 dS/m however, it was significantly higher in cultivar 'Flirt' over 'Jayanti' at high (8 EC) salinity level (Table 8).

Results of the present investigation revealed *C. morifolium* which is a plant of halophytic origin can be raised successfully as an ornamental cash crop in moderate saline environment, particularly 'Jayanti' cultivar. However, its critical limit to higher salinity tolerance is yet to be worked out.

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References

Abadia, A., R. BelKhodja, F. Morales and J. Abadia, 1999. Effects of salinity on the photosynthetic pigment composition of barley (*Hordeum vulgare* L.) grown under a triple-line-source sprinkler system in the field. *J. Plant Physiol.,* 254: 392-400.

Abrol, I.P., J.S.P. Yadav and F.I. Massoud, 1988. Management of salt affected soils. FAO Soils Bull. No. 39. United Nations, Rome.

Bernstein, L., L.E. Francois and R.A. Clark, 1972. Salt tolerance of ornamental shrubs and ground covers. *J. Amer. Soc. Hort. Sci.*, 97: 550-556.

Butterfield, H.M. 1955. Ornamental plants tolerant of saline and alkali soils. Cal. Uni. Agril. Ext. Count. Cir. 40.

Carvajal, M., A. Cerda and V. Martinez, 2000. Does calcium ameliorate the negative effect of NaCl on melon root water transport by regulating aquaporin activity? *New Phytol*., 145: 439-44.

Chhippa, B.R. and P. Lal, 1985. Effect of soil salinity and yield, yield attributes and nutrient uptake by different varieties of wheat. *Anales de Edafologia Agrobiologia,* 44: 1681-1691

Cooper, W.C. and H. Link, 1953. Salt tolerance of subtropical ornamental plants. *Yearbook Texas Avocado Society,* pp 47-50.

Cramer, G.R., A. Lauchli and E. Epstein, 1986. Effects of NaCl and $CaCl_2$ on ion activities in complex nutrient solutions and root growth of cotton. *Plant Physiol.*, 81: 792-797.

Day, S.C. 1977. Management of alkaline soil in Bengal. *Rose world,* 2: 20.

El-Siddig, K. and P. Ludders, 1994. Interactive effects of nitrogen nutrition and salinity on reproductive growth of apple trees. *Gartenbauwissenschaft*, 59: 127-131.

Epstein, E., J.D. Norlyn, D.W. Rush, R.W. Kingsbury, D.B. Kelley, G.A. Cunningham and A.F. Wrona, 1980. Saline culture of crops: A genetic Approach. *Science*, 210: 399-404.

Francois, L.E. and R. A. Clark, 1978. Salt tolerance of ornamental shrubs, trees and ice plant. *J. Amer. Soc. Hort. Sci*., 103: 280-283.

Gorham, J. 1993. Genetics and physiology of enhanced K/Na discrimination. pp 151-159. In: *Genetic Aspect of Plant Nutrition*. P. Randall (ed.). Kluwer Academic Publishers Dordrecht, The Netherlands 1.

Gorham, J., O.S. Tomar and J.R.G. Wyn, 1988. Salinity induced changes in the chemical composition of *Leucaena leucocephala* and *Sesbania bispinosa, Plant Physiol*., 132: 678-682.

Gouia, H., M.H. Ghorbal and B. Touraine, 1994. Effects of NaCl on flow of N and mineral ions and on NO_3^- reduction rate within whole plants of salt-sensitive bean and salt-tolerant cotton. *Plant Physiol*., 105: 1409-1418.

Graifenberg, A., L. Botrini, L., Giustiniani and D.P.M. Lipucci, 1996. Salinity affects growth, yield and element concentration of fennel. *Hort. Science*, 31: 1131-1134.

Greenway, H. 1968. Growth stimulation by high chloride concentration in halophytes. *Israel J. Bot*., 17: 169-177.

Johnson, A.W., L.A. Viereck, R.E. Johnson and H. Melchior, 1966. Vegetation and flora. In: *Environment of the Cape Thompson, Alaska*. Ed. By Wilimavsky, N.J. and Wolfe, J.N. U.S. Atomic energy Comm. Division of Technical Information, Washington, D.C. pp 277-354.

Khan, A.M., A.I. Ungar and M.S. Allan, 2000. Effects of salinity on growth, water relations and ion accumulation of the subtropical Perennial Halophytic *Atriplex griffth* var. stocksi. *Ann. Bot*., 85: 225-232.

Khatun, S. and T.J. Flower, 1995. Effect of salinity on seed set in rice. *Can. J. Soil Sci*., 67: 619-629.

Kovacs, M., K. Penksza, G. Turcsanyi, L. Kaszab and E. Divos, 1995. Element concentration cadastres of halophytic plant communities in Hungary. *Acta Bot. Hung.*, 39 (1-2): 3-16.

Momonoki, Y.S. and H. Kamimura, 1994. Studies on the mechanism of salt tolerance in (*Salicornia europaea* L.). *Japan J. Crop Sci*., 63: 518-523.

Monk, R. and H.B. Peterson, 1962. Tolerance of some trees and shrubs to saline conditions. *Pro. Amer. Soc. Hort. Sci.*, 81: 556-561.

Navarro, J.M., M.A. Bottella and V. Martinez, 1999. Yield and fruit quality of melon plants grown under saline conditions in relation to phosphorus and calcium nutrition. *J. Hort. Sci. Biotech*., 74: 573-578.

Neumann, P. 1997. Salinity resistance and plant growth revisited. *Plant Cell Environ*., 20: 1193-1198.

Osmond, C.B. 1965. Divalent cation and observation and interaction in *Atriplex*. *Aus. J. Biol. Sci*., 19: 37-48.

Rahi, T.S. and S.K. Datta, 2000. Performance of chrysanthemum (*Chrysanthemum morifolium*) cut flower varieties in saline water irrigated soil. *Ind. J. Agric. Sci.*, 70: 469-471.

Rahi, T.S., R. Shukla, R.K. Pandey and S.K. Datta, 1998. Performance of ornamental crops in salt affected soils and use of gamma rays to develop salt resistant strains. *J. Nucl. Agric. Biol*., 27: 253-263.

Ramadan, T. 2001. Dynamics of salt secretion by *Sporobolus spicatus* (Vahl) Kunth from sites of differing salinity. *Ann. Bot*., 87: 259-266.

Rodriguez-Perez, J.A., M. Fernandez-Falcon and A.R. Scocorro-Monzon, 2000. The effect of salinity on growth and nutrition of *Protea obtusifolia. J. Hort. Sci. Biotech.*, 75: 97-104.

Santiago, L.S., T.S. Lau, P. J. Melcher, O.C. Steele and G. Goldstein, 2000. Morphological and physiological response of Hawaiian *Hibiscus tiliaceus* populations to light and salinity. *Int. J. Plant Sci.*, 161: 99-106.

Savvas, D. and F. Lenz, 2000. Response of eggplants grown in recirculating nutrient solution to salinity imposed prior to the start of harvesting. *J. Hort. Sci. Biotech.*, 75: 262-267.

Scholberg, J.M.S. and S.J. Locascio, 1999. Growth response of snap bean and tomato as affected by salinity and irrigation method. *Hort. Science*, 34: 259-264.

Storey, R., P.M.C. Gorham, M.G. Hanson and D. Gage, 1993. Response of *Melanthara biflora* to salinity and water stress. *J. Exp. Bot*., 44: 1551-1561.

Thomas, J.R. and G.W. Langdale, 1980. Ionic balance in costal Bermuda grass influenced by nitrogen fertilization and soil salinity. *Agron. J.*, 72: 449-451

USDA Hand Book No.60, 1954. *Diagnosis and Improvement of saline and alkali soils*. Agricultural Hand Book # 60. United States Department of Agriculture. Oxford and IBH Publishing Company, Pvt. Ltd., New Delhi, Bombay and Calcutta (Indian Edition).

Waisel, Y. 1972. *Biology of Halophytes*. Academic Pres, New York and London. p 49.

Walinga, L., L. Vander, J.J. Houba, J.G. Vanvark and W. Novozamsky, 1995. *Plant Analysis Manual*. Kluwer Academic Publishers Dordrecht/ Boston/ London.

Wang, Y. and N. Nii, 2000. Changes in chlorophyll, ribulose bisphosphate carboxylase-oxygenase, glycine betaine content, photosynthesis and transpiration in *Amaranthus tricolor* leaves during salt stress. *J. Hort. Sci. Biotech*.,75: 623-627

Wilson, L.S. and C.M. Grieve, 2000. Growth stage modulates salinity tolerance of New Zealand Spinach (*Tetragonia tetragonioides,* Pall) and Red Orach (*Atriplex hortensis* L.). *Ann. Bot.*, 85: 501-509.

Zahran, M.A. 1986. Forage potentialities of *Kochia indica* and *K. scoparia* in arid lands with particular reference to Saudi Arabia. *Arabian Gulf J. Sci. Res*., 4: 53-68.

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