EFFECT OF PRE-GERMINATION AND POST-GERMINATION TREATMENT WITH GROWTH HORMONES (KINETINE AND ABSCISIC ACID) ON ION CONCENTRATION AND BIOCHEMICAL CONTENTS OF FODDERBEET AND SEABEET UNDER SALINE CONDITIONS

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Summary. In a pot experiment fodderbeet (*Beta vulgaris* sp. Majoral) and seabeet (*Beta maritima*) were grown under saline soil conditions. The seeds and seedlings were treated with kinetine and abscisic acid (10^{-6} M) to study the effect of hormones on the ion concentration (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-) and biochemical relations (photosynthesis, sugar and glycinebetaine) in these plants. The concentration of Na^+ increased with increasing salinity in the growth medium in the presence of the hormones. The Na:K ratio was lower in the roots than in the shoots. The concentration of Ca^{2+} was low in the presence of NaCl but treatment with the two hormones enhanced its uptake. The Ca:Mg ratio was lower in the roots than in the shoots. Seabeet had comparatively higher Ca:Mg ratio. The concentration of Cl^- was high in both species. NaCl enhanced the uptake of Cl^- while kinetine and abscisic acid resisted it. Sugar content was increased in the presence of the two hormones. Pre-germination treatment with hormones enhanced sugar synthesis in fodderbeet while post-germination treatment showed a similar response in seabeet. Hormone treatment increased the glycinebetaine content in both species whereas no affect on net photosynthesis was observed. Differences in net photosynthesis were highly significant due only to different species. Reclamation of salt affected soils involves tremendous expenses for the re-

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source poor farmers of Pakistan. However, application of growth hormones may be helpful for growing plants in salt affected areas. It also helps in the improvement of plant growth under such problem soils conditions. Since saline sodic or sodic soils have different environments from simple saline soils and synthesis of growth hormones in plants is affected under these soil environments, the application of hormones to the plants grown under saline soils may help to make up the deficiency needs to be explored.

Keywords: abscisic acid, fodderbeet, glycinebetaine, ion concentration, kinetine, seabeet, salinity

INTRODUCTION

The effects of macronutrients on the growth of different plant parts are variable. But the presence of a macronutrient in the growth medium did not affect the concentration of a micronutrient (Mn, Zn, Fe and B) in different plant parts under saline conditions (Hu and Schmidhalter, 1997; 2001). The synthesis of growth hormones decreases under salt stress or they may undergo degradation (Kuiper et al., 1988). Addition of cytokinins in the growth medium can improve the salt tolerance of the plants (Flowers and Hajibagheri, 2002; Niazi et al., 2000). The cell stabilizing substances, like glycinebetaine, saccharose, and proteins accumulate in plants grown under unfavorable environmental conditions and protect different enzyme systems from the harmful effect of high salt concentration (Hose et al., 2002; Kuiper et al., 1988; Vivanco et al., 2002). A decrease in chlorophyll content has been observed in salinity sensitive rice, however, tolerant lines show a slight increase in the presence of hormones (Krishnamarthy et al., 1987). An antagonistic effect of abscisic acid and kinetine has been reported in a number of physiological responses that are light-dependent (Hose et al., 2002). The role of growth hormones in plant growth is suppressed due to their degradation and lower rate of synthesis under saline soil environments. Application of plant growth hormones, like kinetine and abscisic acid to the seeds at the time of sowing or directly to the seedlings may make up their deficiency. Moreover, information is lacking regarding the concentration of ions as affected by the application of growth hormones to fodderbeet and seabeet plants grown under saline conditions. The present study was conducted to determine the effect of pre-germination and post-germination treatments with growth hormones (kinetine and abscisic acid) on ion concentration and biochemical contents of fodderbeet and seabeet grown under saline conditions.

MATERIALS AND METHODS

Seeds of two species of fodderbeet (*Beta vulgaris* sp. Majoral) and seabeet (*Beta maritima*) were divided into two groups. The seeds of the first group were exposed to three treatments. They were separately soaked in distilled water, kinetine (1µM) or abscisic acid (1µM) for 24 hours and then sown in sand (pre-germination treatment). The seeds of the second group were directly sown in sand. After germination the untreated seedlings were sprayed separately with 200 ml of kinetine or abscisic acid twice a day for two days (post-germination treatment). All seedlings were then transplanted to pots containing one kg garden soil (Niazi et al., 2000) and were allowed to establish for 4 days. The soil was exposed to salinity (0 mM -control and 200 mM NaCl) by adding salt. Each treatment was repeated three times and randomized over the greenhouse bench. Salt was added to the pots in increments of 50 mM NaCl on alternate days and the final salt concentration was maintained till harvest. Plants were harvested after four weeks and were dried in an oven at 60°C till a constant dry weight. Dried plant material was subjected to chemical analysis for ion concentration (Na^+, K^+, Ca^{2+}, Mg^{2+}) using Atomic Absorption Spectrophotometer (Perkin Elmer 2100, USA). Chloride content was measured by Chloro-counter following the instructions in the instrument operating manual (Marius Instrumenten, Utrecht, The Netherlands). Sugar content was analyzed according to Bergmeyer (1974) while glycinebetaine content was measured according to Storey and Wyn-Jones (1977). Net photosynthesis was recorded by IRGA (ADC-LCA 3 system, The Analytical Development Company Ltd, Hoddedson, Herts, UK) and net photosynthesis calculated (Lambers et al., 1989). Data obtained were analyzed statistically by three way ANOVA as described by Sokal and Rohlf (1981).

RESULTS AND DISCUSSION

Ion concentration

Salt treatment increased the concentration of Na^+ in the root and shoot of both species (Table 1). Post-germination treatment with each of the hormones tested increased Na^+ in the shoot in the absence of salt but had no effect in the presence of 200 mM NaCl. The shoot had a higher Na^+ content than the root. Treatment with kinetine comparatively increased Na^+ concentration than abscisic acid. The concentration of Na^+ in fodderbeet was higher than in seabeet. Hormone treatment reduced Na^+ content in the root of fodderbeet. Post-germination treatment with the two hormones increased Na^+ in the root of both species.

The presence of high salt concentration in the growth medium favoured Na^+ concentration. Pre-germination treatment had no effect on the uptake of K^+ by the root and shoot of fodderbeet. The concentration of K^+ decreased in the presence of both

Table 1. Sodium content (mg kg^{-1}) in shoot and root of fodderbeet and seabeet plants treated with hormones under saline conditions.

SHOOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	10.75	10.44	10.49	17.32	14.35	16.47	**13.31 c**
	Seabeet	11.13	11.84	10.63	15.20	14.99	14.74	**13.09 c**
		10.94 hi	**11.14 h**	**10.56 i**	**16.20 c**	**14.67 e**	**15.61 d**	
Post-germination	Fodderbeet	9.17	13.29	13.01	15.96	17.76	15.79	**14.16 b**
	Seabeet	9.78	12.68	11.34	17.91	17.18	19.79	**14.78 a**
LSD (T*S*H) = 0.39		**9.48 j**	**12.98 f**	**12.17 g**	**16.94 b**	**17.47 a**	**1779 a**	LSD (sp*T) = 0.38
LSD (S*H) = 0.28		**10.21 e**	**12.06 c**	**11.37 d**	**16.60 a**	**16.07 b**	**1670 a**	

ROOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	4.27	3.73	3.10	11.09	5.06	6.10	**5.56 a**
	Seabeet	1.52	2.81	1.98	3.96	3.57	3.99	**2.97 b**
		2.89 g	**3.27 ef**	**2.54 h**	**7.53 a**	**4.31 d**	**5.04 c**	
Post-germination	Fodderbeet	2.50	4.97	4.05	8.61	8.11	6.33	**5.71 a**
	Seabeet	1.44	1.64	2.01	3.06	3.30	4.14	**2.60 c**
LSD (T*S*H) = 0.26		**1.97 I**	**3.30 f**	**3.03 fg**	**5.68 b**	**5.70 b**	**5.24 c**	LSD (SP*T) = 0.33
LSD (S*H) = 0.18		**2.43 e**	**3.29 c**	**2.79 d**	**6.60 a**	**5.01 b**	**5.14 b**	

Values followed by the same letter in each row are not significant at $P< 0.01$. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

Table 2. Potassium content (mg kg^{-1}) in shoot and root of fodderbeet and seabeet plants treated with hormones under saline conditions.

SHOOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	20.40	20.40	17.10	21.34	15.36	18.23	**18.81 b**
	Seabeet	2792	18.29	21.41	18.36	18.26	16.80	**20.17 a**
		24.16 a	**19.35 d**	**19.26 d**	**19.85 c**	**16.81 g**	**17.52 f**	
Post-germination	Fodderbeet	17.43	17.87	20.79	15.29	16.14	17.08	**17.43 c**
	Seabeet	20.59	18.78	20.44	19.67	15.95	15.62	**18.51 b**
LSD (T*S*H) = 0.44		**1901 d**	**18.32 e**	**20.62 b**	**17.48 f**	**16.04 h**	**16.35 h**	LSD (SP*T) = 0.50
LSD (S*H) = 0.31		**21.59 a**	**18.84 c**	**19.94 b**	**18.66 c**	**16.43 e**	**16.93 d**	

ROOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	18.39	19.11	18.57	24.42	15.83	17.65	**19.00 a**
	Seabeet	17.28	17.95	14.83	17.95	13.96	9.14	**15.18 c**
Mean		**17.83 c**	**18.53 b**	**16.70 d**	**21.19 a**	**14.89 g**	**13.39 i**	
Post-germination	Fodderbeet	12.	17.18	15.1	19.94	17.79	14.07	**16.10 b**
	Seabeet	12.28	13.32	13.13	16.06	14.05	14.22	**13.84 d**
LSD (T*S*H) = 0.29		**12.39 j**	**15.25 f**	**14.11 h**	**18.00 c**	**15.92 e**	**14.15 h**	LSD (SP*T) = 0.8.3
LSD (S*H) = 0.20		**15.11 d**	**16.89 b**	**15.41 c**	**19.59 a**	**15.40 c**	**13.77 e**	

Values followed by the same letter in each row are not significant at P< 0.01. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

hormones (Table 2). Salt treatment reduced the concentration of K^+ but the presence of hormones further decreased its uptake. The uptake of K^+ depended on the species, type of hormones and salt treatment. The concentration of K^+ in the root was enhanced in the absence of hormones. The two hormones tested interacted with salt, thus reducing the uptake of K^+ which resulted in a significantly lower concentration. The concentration of K^+ in fodderbeet was significantly higher than in seabeet. The Na:K ratio was significantly lower in the root than in the shoot. The concentration of Na^+ increased with increasing salinity. Post-germination treatment with hormones comparatively enhanced the Na:K ratio under saline conditions (Table 2).

The concentration of Ca^{2+} in the shoot was higher in fodderbeet (Table 3). The presence of high salt concentration in the absence of hormones increased the concentration of Ca^{2+} in the shoot. Hormones affected negatively the concentration of Ca^{2+}. The concentration of Ca^{2+} in the root in the presence of salt increased in fodderbeet due to the post treatment with abscisic acid. Kinetine increased the concentration of Ca^{2+} in the absence of salt. The increase in salt concentration reduced the uptake of Ca^{2+} by root.

The concentration of Mg^{2+} was higher in the root than in the shoot. The concentration of Mg^{2+} in fodderbeet was higher than in seabeet. Salt treatment increased Mg^{2+}concentration in the root of fodderbeet. Hormones interacted with the salt which resulted in a significant decrease of Mg^{2+} concentration. However, a significant increase in Mg^{2+} due to the interaction of abscisic acid with the salt was observed in seabeet roots. The Ca: Mg ratio decreased in the roots of fodderbeet plants under hormone treatment. The concentration of Ca^{2+} in the shoot was higher than in the root showing low Mg^{2+} uptake. Fodderbeet had less Mg^{2+} content in the shoot as compared to seabeet (Table 4).

In the absence of salt, the concentration of Cl^- in the shoot of both species was significantly higher due to post-germination treatment compared to pre-germination treatment (Table 5). The concentration of Cl^- in fodderbeet was higher than in seabeet. Salt treatment increased significantly the Cl^- concentration while pre-germination treatment with the two hormones reduced Cl^- content even in the presence of salt. The concentration of Cl^- in the root was higher than in the shoot.

Sugar content

Sugar content in the shoots increased in the presence of hormones. Salt treatment reduced sugar content but hormones mitigated the effect of the salt and enhanced the synthesis of sugar (Table 6). Sugar content in fodderbeet was higher than in seabeet. Pre-germination treatment with kinetine and abscisic acid significantly increased sugar content in the roots in fodderbeet. Post-germination treatment increased sugar content in seabeet to a greater extent than in fodderbeet. Salt treatment increased significantly sugar content in fodderbeet.

Table 3. Calcium content (mg kg^{-1}) in shoot and root of fodderbeet and seabeet plants treated with hormones under saline conditions.

SHOOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	6.19	5.15	6.21	11.22	4.27	7.02	**6.68 a**
	Seabeet	3.04	7.44	5.06	5.32	2.96	4.51	**4.72 b**
		4.62 fg	**6.30 c**	**564 d**	**8.27 b**	**3.62 i**	**5.77 d**	
Post-germination	Fodderbeet	7.67	4.23	8.45	7.40	5.59	4.99	**6.39 a**
	Seabeet	1.79	6.54	9.27	1.54	6.76	3.79	**4.95 b**
LSD (T*S*H) = 0.209		**4.73 f**	**5.39 e**	**8.86 a**	**4.47 gh**	**6.18 c**	**4.39 h**	LSD (SP*T) = 0.379
LSD (S*H) = 0.148		**4.67 f**	**5.84 c**	**7.25 a**	**6.37 b**	**4.90 e**	**5.08 d**	

ROOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	6.12	12.97	8.39	10.85	7.94	7.82	**9.02 b**
	Seabeet	4.63	10.03	4.83	8.58	6.83	6.27	**6.86 d**
		5.37 j	**11.50 c**	**6.61 i**	**9.72 d**	**7.39 g**	**7.05 h**	
Post-germination	Fodderbeet	8.46	21.30	7.81	11.29	12.47	8.82	**11.69 a**
	Seabeet	7.65	6.11	9.75	5.95	14.10	5.78	**8.22 c**
LSD (T*S*H) = 0.300		**8.06 f**	**13.71 a**	**8.78 e**	**8.62 e**	**13.29 b**	**7.30 gh**	LSD (SP*T) = 0.442
LSD (S*H) = 0.212		**6.72 f**	**12.60 a**	**7.70 d**	**9.17 c**	**10.34 b**	**7.17 e**	

Values followed by the same letter in each row are not significant at $P< 0.01$. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

Table 4. Magnesium content (mg kg^{-1}) in shoot and root of fodderbeet and seabeet plants treated with hormones under saline conditions.

SHOOT

Treatment	Crop Species	NaCl 0mM			NaCl 200 mM			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	4.67	4.80	4.56	4.67	4.44	4.36	**4.58 a**
	Seabeet	5.81	4.12	4.64	4.49	4.15	4.15	**4.56 a**
		5.24 a	**4.46 cde**	**4.60 bc**	**4.58 bcd**	**4.29 fg**	**4.25 gh**	
Post-germination	Fodderbeet	4.06	4.37	4.44	4.46	3.74	4.32	**4.23 b**
	Seabeet	4.16	4.46	4.87	4.87	4.50	4.55	**4.57 a**
LSD (T*S*H) = 0.15		**4.11 h**	**4.42 ef**	**4.65 b**	**4.67 b**	**4.12 h**	**4.44 def**	LSD (SP*T) = 0.15
LSD (S*H) = 0.10		**4.68 a**	**4.44 b**	**4.63 a**	**4.62 a**	**4.21 c**	**4.34 b**	

ROOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	14.70	14.76	13.60	14.81	13.84	14.58	**14.38 b**
	Seabeet	14.50	16.39	13.60	13.58	12.64	12.92	**13.94 c**
		14.60 c	**15.58 a**	**13.60 e**	**14.19 d**	**13.24 f**	**13.75 e**	
Post-germination	Fodderbeet	12.16	16.04	15.83	15.27	15.52	14.91	**14.95 a**
	Seabeet	12.97	14.07	12.80	13.98	13.29	15.12	**1370 c**
LSD (T*S*H) = 0.32		**12.56 g**	**15.05 b**	**14.31 cd**	**14.63 c**	**14.40 cd**	**15.01 b**	LSD (SP*T) = 0.31
LSD (S*H) = 0.23		**13.58 g**	**15.31 a**	**13.96 c**	**14.41 b**	**13.82 c**	**1438 b**	

Values followed by the same letter in each row are not significant at $P< 0.01$. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

Table 5. Chloride content (mg kg^{-1}) in shoot and root of fodderbeet and seabeet plants treated with hormones under saline conditions.

SHOOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	3.07	2.85	2.77	5.69	5.88	5.61	**4.31 c**
	Seabeet	2.66	2.15	2.14	2.08	3.87	2.76	**2.61 d**
		2.87 h	**2.50 i**	**2.46 i**	**3.88 g**	**4.88 d**	**4.19 f**	
Post-germination	Fodderbeet	3.45	4.95	6.93	6.35	7.96	9.29	**6.49 a**
	Seabeet	5.08	3.91	4.04	4.94	5.26	5.66	**4.82 b**
LSD (T*S*H) = 0.16		**4.26 f**	**4.43 e**	**5.49 c**	**5.65 c**	**6.61 b**	**7.48 a**	LSD (SP*T) = 0.05
LSD (S*H) = 0.11		**3.56 d**	**3.46 d**	**3.97 c**	**4.79 b**	**5.74 a**	**5.83 a**	

ROOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	3.72	3.60	3.67	11.99	5.02	6.53	**5.76 b**
	Seabeet	2.78	3.55	2.20	5.39	3.18	3.34	**3.41 c**
		3.25 I	**3.58 h**	**2.93 j**	**8.69 a**	**4.10 g**	**4.94 d**	
Post-germination	Fodderbeet	2.93	6.60	2.40	10.57	7.72	5.69	**5.98 a**
	Seabeet	2.15	2.14	2.36	2.83	3.18	3.89	**2.93 d**
LSD (T*S*H) = 0.14		**2.54 k**	**4.37 f**	**2.38 l**	**7.20 b**	**5.45 c**	**4.79 e**	LSD (SP*T) = 0.19
LSD (S*H) = 0.10		**2.90 d**	**3.97 c**	**2.65 e**	**7.94 a**	**4.77 b**	**4.86 b**	

Values followed by the same letter in each row are not significant at $P< 0.01$. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

Biochemical content

Glycinebetaine content in the shoots of fodderbeet was higher in pre-treated plants but the difference was not significant (Table 7). Post-germination treatment with kinetine and abscisic acid increased glycinebetaine content in the shoots of seabeet. Glycinebetaine in the roots and shoots was increased in the presence of high salt concentration. Glycinebetaine content in the roots was significantly higher in pre-treated fodderbeet plants, while post-germination treatment increased glycinebetaine content in seabeet. Addition of salt increased glycinebetaine content in both species.

Both the pre-germination treatment and post-germination treatment did not affect net photosynthesis of the plants (Table 8). Differences in the rate of photosynthesis were significant in both species. Net photosynthesis in seabeet was comparatively higher than that in fodderbeet. Net photosynthesis increased in the presence of high salt concentration after hormone treatment in both species (Table 8). Pre-germination treatment with kinetine reduced the rate of photosynthesis in fodderbeet in the presence of 200 mM NaCl while it increased upon pre-treatment with abscisic acid. However, the response of seabeet plants pre-treated with kinetine or abscisic acid differed from the response observed in fodderbeet.

Analysis of ion concentration in different plant parts revealed higher Na^+ content in the shoot than in the root indicating that Na^+ absorbed by the root was translocated to the shoot. Our results on Na^+ content measured both in the shoot and the root are in accordance with previous observations (Niazi et al., 2000). The accumulation of Na^+ has been reported to be in cell vacuoles. In the present study low Na^+ concentration was observed. Application of hormones in the presence of saline growth medium increased the concentration of Na^+ in the shoot (Table 1). In seabeet lower Na^+ concentration was measured than in fodderbeet. Root had significantly lower Na^+ than the shoot indicating an effective translocation to the shoot. The concentration of K^+ was higher suggesting an antagonistic effect between the two ions. Post-germination treatment with hormones was more effective in reducing Na^+ content than pre-germination treatment.

The concentration of Ca^{2+} and Mg^{2+} increased significantly in the presence of 200 mM NaCl. Application of hormones suppressed the Ca^{2+} and Mg^{2+} contents in both plant parts. The two plants showed highly significant species differences. Fodderbeet possessed higher Ca^{2+} and Mg^{2+} contents than seabeet except for Mg^{2+} in shoot. Post-germination treatment with the two hormones enhanced the uptake of the above ions. The enhanced uptake of Ca^{2+} and Mg^{2+} has an ameliorative role on the growth of plants specifically under saline environment conditions. A lower Na: Ca ratio is believed to be beneficial for plant growth. A higher concentration of Ca^{2+} supports the strength of cell wall that in turn increases the tolerance of the plant. It is known that Mg^{2+} is involved in various biochemical processes, especially photosynthesis. Therefore, the presence of an adequate Mg^{2+} content could directly support

Table 6. Sugar content (mg kg^{-1}) in shoot and root of fodderbeet and seabeet plants treated with growth hormones under saline conditions.

SHOOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	5.01	3.99	6.03	3.89	6.87	4.98	**5.13 b**
	Seabeet	3.26	3.12	2.67	2.93	2.83	2.80	**2.93 c**
		4.14 f	**3.55 h**	**4.35 e**	**3.41 h**	**4.85 d**	**3.89 g**	
Post-germination	Fodderbeet	5.47	5.16	5.13	5.89	6.12	4.51	**5.38 a**
	Seabeet	7.08	3.46	6.94	4.95	5.04	4.92	**5.40 a**
LSD (T*S*H) = 0.209		**6.28 a**	**4.31 ef**	**6.04 b**	**5.42 c**	**5.58 c**	**4.72 d**	LSD (SP*T) = 0.128
LSD (S*H) = 0.148		**5.21 a**	**3.93 c**	**5.19 a**	**4.42 b**	**5.22 a**	**4.30 b**	

ROOT

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	2.02	18.98	22.11	5.49	29.05	29.47	**17.85 b**
	Seabeet	18.14	9.52	13.52	8.04	9.75	14.47	**12.24 c**
		10.08 h	**14.25 g**	**17.82 f**	**6.76 i**	**19.40 e**	**21.97 d**	
Post-germination	Fodderbeet	21.63	11.02	5.09	23.44	4.29	12.18	**12.94 c**
	Seabeet	30.49	40.36	30.39	34.92	31.21	35.21	**33.76 a**
LSD (T*S*H) = 1.445		**26.06 b**	**25.69 b**	**17.74 f**	**29.18 a**	**17.75 f**	**23.69 c**	LSD (SP*T) = 2.022
LSD (S*H) = 1.022		**18.07 c**	**19.97 b**	**17.78 c**	**17.97 c**	**18.57 c**	**22.83 a**	

Values followed by the same letter in each row are not significant at $P< 0.01$. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

Table 7. Glycinebetaine content (mg kg^{-1}) in shoot and root of fodderbeet and seabeet plants treated with growth hormones under saline conditions.

SHOOT

Treatment	Crop Species	NaCl (0 m M)			NaCl (200 m M)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	9.30	8.39	7.85	9.75	7.51	9.82	**8.77 b**
	Seabeet	8.79	6.99	10.27	8.58	8.52	7.81	**8.49 bc**
		9.05 bcd	**7.69 fg**	**9.06 bcd**	**9.16 bc**	**8.01 ef**	**8.81 bcd**	
Post-germination	Fodderbeet	5.39	7.70	8.29	7.49	8.89	11.28	**8.17 c**
	Seabeet	9.05	9.53	8.84	8.33	9.60	10.53	**9.31 a**
LSD (T*S*H) = 0.563		**7.22 g**	**8.61 cd**	**8.56 de**	**7.91 f**	**9.24 b**	**10.91 a**	LSD (SP*T) = 0.485
LSD (S*H) = 0.398		**8.13 d**	**8.15 cd**	**8.81 b**	**8.54 bc**	**8.63 b**	**9.86 cd**	

ROOT

Treatment	Crop Species	NaCl (0 m M)			NaCl (200 m M)			Mean
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	9.71	11.46	10.29	11.90	12.53	11.05	**11.16 a**
	Seabeet	10.49	8.46	10.41	11.05	10.85	8.70	**9.99 b**
		10.1 bcd	**9.96 cd**	**10.35 bc**	**11.47 a**	**11.69 a**	**9.87 cd**	
Post-germination	Fodderbeet	8.74	10.77	7.66	12.09	10.76	9.00	**9.84 b**
	Seabeet	8.67	8.26	12.57	10.50	10.08	12.28	**10.39 b**
LSD (T*S*H) = 0.619		**8.71 e**	**9.51 d**	**10.1 bcd**	**11.29 a**	**10.42 bc**	**10.64 b**	LSD (SP*T) = 0.640
LSD (S*H) = 0.437		**9.40 c**	**9.74 c**	**10.23 b**	**11.38 a**	**11.05 a**	**10.26 b**	

Values followed by the same letter in each row are not significant at $P< 0.01$. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

Table 8. Net photosynthesis (mg g^{-1} leaf FW) of fodderbeet and seabeet plants treated with growth hormones under saline conditions.

Treatment	Crop Species	NaCl (0 mM)			NaCl (200 mM)			Means
		Control	Kinetine	ABA	Control	Kinetine	ABA	
Pre-germination	Fodderbeet	8.71	8.06	8.06	9.77	7.71	9.4	**8.63 b**
	Seabeet	8.28	10.18	12.79	9.13	11.91	10.30	**10.43 a**
		8.49 fg	**9.12 de**	**10.42 b**	**9.45 cd**	**9.81 bc**	**9.89 bc**	
Post-germination	Fodderbeet	8.26	9.92	6.22	9.86	7.05	6.99	**8.05 c**
	Seabeet	10.66	10.30	11.11	13.09	9.79	8.83	**10.63 a**
LSD (T*S*H) = 0.623		**9.46 cd**	**10.11 b**	**8.66 ef**	**11.47 a**	**8.42 fg**	**7.91 g**	LSD (SP*T) = 0.488
LSD (S*H) = 0.440		**8.98 d**	**9.62 b**	**9.54 bc**	**10.46 a**	**9.11 cd**	**8.90 d**	

Values followed by the same letter in each row are not significant at $P< 0.01$. Same applies to means in the last column.
SP = Species, T = Pre-germination and post-germination treatment, S = Salt treatment, H = Hormone type.

some biochemical processes by energy production, thus increasing salt tolerance of the plant.

The uptake of Cl^- under saline environment is enhanced in both the shoots and roots (Ashraf et al., 2003). Our results showed that hormone treatment enhanced further uptake of Cl^-. The Cl^- content was lower than the Na^+ content. Cl^- ions contribute considerably to the osmotic adjustment and are more readily absorbed. Our results are in agreement with those reported by Mass and Nieman (1978) showing that the cation uptake exceeds that of the anions in the presence of predominantly monovalent cations Na^+ and K^+. Due to treatment with hormones both species accumulated more Cl^- in the shoot and root. Application of abscisic acid affected the absorption of Cl^- to a greater extent compared with kinetine. The interaction of macronutrients with salinity has previously been reported (Ashraf et al., 2003; Hu and Schmidhalter, 1997, 2001). Therefore, it may be suggested that undisturbed status of the micronutrients played their role as a positive response to the function of hormones in the synthesis of biochemicals like sugar, glycinebeteine and chlorophyll. As these organic molecules are considered as indicators of salt tolerance, their higher concentration in the plant organs improved the salt tolerance capacity of the studied species. The synthesis of sugar was affected significantly by the application of hormones. Presence of salt in the growth medium decreased sugar content but treatment

with hormones enhanced the sugar content. Roots contained significantly higher sugar content than the shoots. Roots of seabeet showed highest sugar content when being post-treated with hormones. Species' difference was also observed in sugar content. Highly salt tolerant fodderbeet and seabeet have been reported to synthesize less sugar under saline environment. Application of hormones accelerated synthesis of sugar, thus indicating the better salt tolerance of these plants. Seabeet showed comparatively increased degree of salt tolerance than fodderbeet. Leaves of salt stressed plants contained higher concentration of sugar which may be due to the effects of the stress on phloem translocation or on reduced sink size because of reduced growth (Nieman and Clark, 1976). This may help in maintaining turgor under stress environment.

Glycinebeteine is considered as a good indicator of salt tolerance. The presence of higher amounts of glycinebeteine in the plant organs indicates a higher degree of salt tolerance as observed in the present study. Application of hormones favored the synthesis of glycinebeteine. Seabeet showed higher glycinebeteine content than fodderbeet, thus indicating its better salt tolerance. Salt-stressed plants showed higher net photosynthesis. The net photosynthesis of seabeet was significantly higher compared with fodderbeet. The effect of kinetine was stronger compared with abscisic acid. Plants growing under salt stress conditions experience artificial drought (Ober and Luterbacher, 2002). A high salt concentration in the growth medium prohibits the water absorption. Such type of water stress conditions caused stomatal closure, but radiant energy was regularly intercepted and absorbed by leaves resulting in synthesis of carbohydrates (Salisbury, 1988). Reclamation of salt affected soils involves tremendous expenses for the resource poor farmers of Pakistan. Improvement of plant growth through biological methods needs less labour and minimum deterioration in soil environments compared to chemical reclamation of such problem soils. Nevertheless, application of growth hormones to plants or seeds is comparatively cheaper and successful for the plant growth in these areas as revealed by the present study. It also helps in the amelioration of such problem soils by providing better vegetation cover. Saline sodic or sodic soils have different environments than simple saline soils (Qadir et al., 2000, 2001). Synthesis of hormones is significantly affected at higher salt concentrations in the growth medium. Under these circumstances application of growth hormones to the plants grown under saline sodic soils helps to overcome the deficiency. However, their role under saline sodic environments needs to be explored.

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