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Salt Tolerance of *Atriplex* During Germination and Early Growth

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تحمل نباتات الأتربلكس للملوحة خلال الإنبات والنمو المبكر

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خلاصة: تم تقييم أداء خمسة أنواع من نبات الأتربلكس في مركزات أملاح مختلفة النسب. وتم استخدام مياه البحر المالحة كمصدر للمركزات الثلاثة المطلوبة وهي: ١٢ و ٢٤ و ٣٦ ديسيميمنز / متر. كما تم استخدام الماء المقطر، المحتوي على محلول هوقلاند المعدل بنسبة ١٠٪ من الحجم، كتجربة حاكمة. لقد أدت زيادة التركيز في الأملاح إلى تقليل الإنبات. إلا أنه أمكن تمييز زيادات في مكونات الأملاح المعدنية في النباتات، في المعاملات التي احتوت على تركيز عال من الأملاح، دون نقص في الإنتاج مما يعني تحمل الأتربلكس للملوحة.

ABSTRACT: Five *Atriplex* species were evaluated under the different salt concentrations. Sea water of specific electrical conductivity was used as a source of salinity at three different concentrations: 12, 24 and 36 $dS{\cdot}m^{-1}$: Distilled water containing one-tenth volume modified hougland solution served as a control. An increase in salt concentration resulted in a significant reduction in germination. However, increases in mineral composition in the plants were observed without a reduction in yield under high salt treatments. This was an indication of salinity tolerance in *Atriplex* spp.

The soil salinity problem is a serious threat reducing crop productivity in arid and semi-arid areas. Salt affected soils hinder agricultural development unless preventive practices are taken (Ibrahim and Gafaar, 1987; Gafaar *et al*, 1992). Regions now ruled out for agricultural use might be usable for selected salt-tolerant strains. Plant species that can survive high soil salinity could provide fodder for goats, cattle and camels. Epstein (1985) reported the use of Australian salt-bushes, *Atriplex* spp., as fodder for livestock.

Generally, coastal deserts are known to host many halophytes and salt tolerant plants (Paylore, 1982; Epstein, 1983 and 1985; Epstein and Rains 1987; O'Leary, 1984, Mohammed *et al*, 1991 and McFarland *et al*, 1992). Ibrahim *et al*, (1991) and Modawi *et al*, (1993) reported on the productivity of forage plants under salt stress.

The process of gradual soil salinization and the preponderance of saline water sources points to an increased future reliance on salt resistant crops (Waisel, 1972). The ability of the floras of saline deserts to cope with highly saline conditions, indicates that salinity is not necessarily prohibitive to growth in all plants. A considerable variability in tolerance to salinity has been observed by Mohammed *et al*, (1991) with the halophytic species found in Indian Salines. Similarly, the United Arab Emirates, has a wide range of diversity of desert plants (Ibrahim, 1992). However, little or no work has been conducted to investigate these plants. The present study was carried out to evaluate the variability in salt tolerance of five common *Atriplex* species.

Materials and Methods

Five *Atriplex* species were chosen in RCB experiments with four replications. They were: Quali Saltbush *(Atriplex lentiformis* L); Fourwing Saltbush (*Atriplex canescens* [pursh]Nutt); Creeping Saltbush (*Atriplex semibaccata* R. Br. L.); Oldman Saltbush (*Atriplex nummularia* Lindl L.); and California Saltbush (*Atriplex polycarpa* L.). The study was conducted at the Crop Production Laboratory, United Arab Emirates University at Al-Ain in 1992.

The seeds were pretreated with 10^{-3} mercuric chloride solution followed by a thorough washing. Fifty seeds of each species were planted in four replications in folded germination paper "sandwiches". They were irrigated with distilled water for two days, then with different salinity treatments for five months.

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Sea water of electrical conductivity 46.3 $\pm$2 dS·m^{-1} was used as a source of salinity as it incorporates several salt compositions commonly encountered in saline soils, namely, high concentrations of sodium, chloride, sulfate and boron, and a low calcium to magnesium ratio. The solutions consisted of distilled water containing one-tenth volume modified houghland solution, 25% sea water (11.58 $\pm$2 dS·m^{-1}), 50% sea water (23.11 $\pm$ 2 dS·m^{-1}), 75% sea water (34.73 $\pm$2 dS·m^{-1}). They were designated as control, 12, 24 and 36 dS·m^{-1} respectively. The level of salinity was maintained by a periodical check and adjusted as required. Seedlings were transferred after three weeks to Jiffy-7 peat pellets which were soaked in water for 20 minutes and arranged in trays (50 each).

After one month each peat pellet was transferred into a fiberglass pot (33 cm diameter by 29 cm deep). The pots were filled with a mixture of peat-moss, sand and organic matter at a ratio of 3:2:1, respectively, and watered with the same saline solution. Germination was measured at two, three and four weeks from planting while chemical analysis of leaves was carried out four months later. The data was subjected to statistical differences (LSD) and Duncan's Multiple Range (DMR) at 5% probability.

Results

Table 1 illustrates the germination of *Atriplex* spp. irrigated with different salt concentrations. Generally germination range from (9.9% to 49.1%). The highest germination was obtained with *Atriplex canescens* at 12 dS·m^{-1} while the lowest was for *Atriplex polycarpa* L at 36 dS·m^{-1}. The germination of all species showed no differences between the controls. However, there were differences in germination as a function of salt concentration (Table 1). High salt concentration resulted in a significantly reduced germination in all species.

Atriplex canescens had a higher germination than other species at 12 dS·m^{-1} while *lentiformis* L had a higher germination than the others at 24 dS·m^{-1} (Table 1). *Polycarpa* L and *nummularia* had the lowest germination percentage at 36 dS·m^{-1}, while the *lentiformis* L showed no significant differences between 12 dS·m^{-1} and 24 dS·m^{-1} salt concentration.

The mineral composition of all *Atriplex* species tested showed a gradual increase with increasing salt concentration (Table 2). *Atriplex canescens* had a higher Ca concentration than others followed by *lentiformis* L.

Magnesium showed no differences between control treatments but for other treatments *Atriplex semibaccata* had a higher Mg content than other species. Table 2 also revealed no significant

TABLE 1

Effect of salt concentration in irrigation water germination of Atriplex species

Atriplex Species	Germination (%)				
		Concentration dS ·m^{-1}			
	control	12	24	36	mean
lentiformis	47.2^{aA}	25.2^{bB}	23.8^{bA}	14.3^{cA}	27.6
canescens	45.3^{bA}	49.1^{aA}	17.2^{cB}	13.5^{dA}	31.3
semibaccata	41.4^{aA}	21.7^{bB}	14.9^{cB}	13.5^{dA}	22.9
nummularia	43.8^{aA}	22.5^{bB}	16.2^{cB}	10.1^{dB}	23.1
polycarpa	45.7^{aA}	23.6^{bB}	15.2^{cB}	9.9^{dB}	23.6
mean	44.7	28.4	17.5	12.3	26.7

^{A,B} Means followed by the same capital letter for each concentration for the different species are not significantly different at 5% level of probability according to DMR method.

^{a,b,c,d} Means followed by the same lower case letter within each species are not significantly different at 5% level of probability according to DMR method.

differences between Mg levels at 24 dS·m^{-1} and 36 dS·m^{-1}. As far as sodium, Na, is concerned, the results showed no differences between species at different salt concentrations, except for *Atriplex canescens* which had a lower percentage than others in the control and at 12 dS·m^{-1}. *Atriplex semibaccata* had the lowest Na levels and showed no significant differences at different salt concentrations.

Potassium levels increased remarkedly with an increase in salt concentration for all species, reaching a maximum of 6.8% for *Atriplex canescens* at 36 dS·m^{-1}. At the two lowest treatments (control and 12 dS·m^{-1}), *canescens* and *nummularia* had a higher K level than other species (Table 2). However, at 36 dS·m^{-1} salt concentration, *lentiformis* L and *canescens* had the highest K content. There were no significant differences between the species at any particular salt concentration but there were significant differences between differences salt concentrations.

Discussion

The results presented in Table 1 revealed a highly variable range of germination among the *Atriplex* species studied. This is due to the fact that *Atriplex* spp. usually loses viability very quickly when the harvested seeds are not dry. The reduction in germination with an incease in salt concentration was reported by Ibrahim *et al,*(1991) for non-halophytes. Generally, under salt stress, plant growth is reduced due to a reduced ability of the plant to adjust osmotically. Regulation of tissue solute concentration

TABLE 2

Effect of salt concentration in irrigation water on mineral composition of Atriplex species

Atriplex Species	Salt Concen-tration	Mineral Composition[a] %					
	$dS{\cdot}m^{-1}$	Ca	Mg	Na	K	Ash	Mean
Lenti formis	Control	0.4	1.3	1.7	2.9	16.7	4.6
	12	0.7	1.6	1.7	4.2	22.9	6.2
	24	1.0	2.1	2.6	5.4	32.6	8.7
	36	2.3	2.2	2.8	6.3	36.8	10.1
	Mean	1.1	1.8	2.2	4.7	27.3	7.4
Cane-scens	Control	0.4	1.4	0.3	4.4	14.2	4.1
	12	0.8	1.6	0.5	5.5	22.8	6.2
	24	1.8	2.2	2.3	6.7	25.9	7.8
	36	2.5	2.3	2.4	6.8	31.4	9.1
	Mean	1.4	1.9	1.4	5.9	23.6	6.8
Semi baccata	Control	0.5	1.1	1.0	3.3	13.6	3.9
	12	0.6	2.2	1.9	3.5	26.6	7.0
	24	0.9	3.3	1.5	4.2	28.4	7.7
	36	1.8	3.4	2.0	5.3	30.1	8.5
	Mean	1.0	2.5	1.6	4.1	24.7	6.8
Nummu-laria	Control	0.7	1.3	1.9	4.0	17.2	5.0
	12	0.8	1.9	1.9	4.8	23.1	6.5
	24	0.9	2.0	2.2	5.0	29.7	8.0
	36	1.9	2.3	2.4	5.9	32.3	8.9
	Mean	1.1	1.9	2.1	4.9	25.6	7.1
Poly carpa	Control	0.5	1.1	1.0	2.9	14.6	4.0
	12	0.5	1.2	1.3	3.3	22.4	5.7
	24	0.9	2.1	1.9	4.1	26.6	7.1
	36	1.9	2.3	2.0	5.2	30.9	8.5
	Mean	1.0	1.7	1.5	3.8	23.6	6.3
	LSD (5%)	0.3	0.5	1.4	1.3	8.6	-

[a]dry weight basis

(i.e. osmotic adjustment) has been considered an important mechanism by which *Atriplex* can adapt to increasing salinity.

A previous study has shown that the plant species has a protein content of 1.7 to 14.9% (Ibrahim, 1997). This is considered to be satisfactory compared to many known forage crops. In the same study it was also demonstrated that the species had an average fiber and fat content of 13.7% and 1.3%, respectively which is reasonable. However, the high salt content is a disadvantage if foliage is to be used as feed or food.

A significant increase in plant mineral content was observed with an increase in the salt concentration of irrigation water, but it was still within the range of salt concentration described by (Epstein, 1983). This high salt content is considered a disadvantage for feed or food if sodium is the dominant salt. Our study showed that *Atriplex canescens*, which is the best performing species, had a high Na level at high salt concentrations. The same results were obtained by McFarland *et al,* (1992), who found Na, Ca and Cl as the dominant mobile ions in *Atriplex canescens*. However, Ibrahim *et al,* (1991), noted that the sensitivity of forage crops towards Cl or Na was higher for non-halophytes.

Osmotic adjustment in *Atriplex* and most halophytic chenopodes is the main mechanism that regulates the absorption of salt (Charnock, 1988). Most of these halophytes have the ability of compartmentation of different salts between the vacuoles and the cytoplasm. This mechanism was demonstrated clearly in our study (Table 2) by the increase in ash level due to salt absorption by *Atriplex*. The increase in mineral content between low and high salt concentration was 538% for Ca by *lentiformis* L, 868% for Na by *canescens*, 217% for Mg by *semibaccata*, and 120% for K by *lentiformis* L. In conclusion, *Atriplex* spp. can be grown successfully under high salt conditions. The recommended species are *Atriplex lentiformis* L and *Atriplex canescens*. These two species can produce more than five kilos of dry matter every three months.

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