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Variation in Seedling Characteristics of Five Populations of *Acacia tortilis* From the United Arab Emirates in Response to Increasing Sodium Chloride Concentrations

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التباين في خواص البادرات في نمط استجابة خمس عشائر من نبات أكاسيا تورتيليس من الإمارات العربية المتحدة لتراكيز مختلفة من كلوريد الصوديوم

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خلاصـة : تـم جمع بذور أشجار أكاسيا تورتيليس من خمسة مواقع في مدينة العين بدولة الإمارات العربية المتحدة وبعد إجراء المعاملة الأولية بحامض الكبريتيك المركز نبتت تحت أربعة تراكيز من محلول كلوريد الصوديوم وهي صفر و 20 و 90 و 150 مليمول . ولقد كان لتركيز الملح تأثيرا معنويا على كل من نسبة إنبات البذور وسرعة الإنبات والمحتوى المائي للبادرات و لطول المجموع الجذري وللمجموع الخضري للبادرات ، كما أظهرت الدراسة أن التباين في نمط استجابة مجموعات البذور التي جمعت مـن مواقع مختلفة للمعاملة بالمحاليل الملحية يشير إلى وجود اختلافات وراثية في تكيف النباتات على البيئات المحلية والذي يمكن أن يـؤدي إلى انعزالها إلى عشائر متميزة نتيجة تأثرها بدرجات متفاوتة في انخفاض منسوب المياه الجوفية والتوسع العمراني في المنطقة.

ABSTRACT: Seeds of *Acacia tortilis* collected from 5 sites around the city of Al Ain in the United Arab Emirates were germinated in 4 concentrations of sodium chloride (0, 20, 90 and 150 mM of NaCl). Percent of germination, rate of germination, seedling moisture content, root and shoot lengths and seedling lengths were all significantly affected by salt stress. Seeds collected from the different sites were significantly different in their response to salinity conditions. Variations in the response of seedlings from different sites to the different salt treatments suggest an underlying genetic variability within the *A. tortilis* populations, possibly resulting from variations in the prevailing local conditions. Urbanization in the area and the changing water table may have divided *A. tortilis* into distinct subpopulations that are significantly different in seedling characteristics and their response to saline conditions.

KEYWORDS: *Acacia tortilis*, Seed Germination, Variability, Salt Stress.

1. Introduction

Acacia tortilis (Forssk.) Hayne is a medium flat-topped tropical tree legume that belongs to the family leguminosae, subfamily Mimosoidae. It is known to predominate in areas of prolonged dry season such as those prevailing in the eastern plains of the United Arab Emirates (Western, 1989). In this semi-arid region, vegetation cover has shown considerable fluctuations. This is attributed to the scarcity of natural resources in the region, the frequent short term fluctuations in the climate and the increasing human interference. The city of Al-Ain of the United Arab Emirates (UAE) (latitude 24^{15}, Longitude 55^{45} and altitude 301.6 m above sea level) was established 160 km east of the Gulf Coast near Al Buraimi Oasis. The area is characterized by a relatively high water table, semi-stable sand dunes with frequent outcrops of limestone. Scattered stands of *Acacia sp*. And *prosopis sp*. are common with high incidence of annuals after a rainy winter (Western, 1989).

Ground water constituted the major source of water for domestic and agricultural uses. Ground water depletion during the last three decades may have resulted in the lowering of the water table and increased soil salinity, especially around Al Ain. It may have also contributed to the decline in stands of *Acacia* and *Prosopis* in the region (Western, 1989).

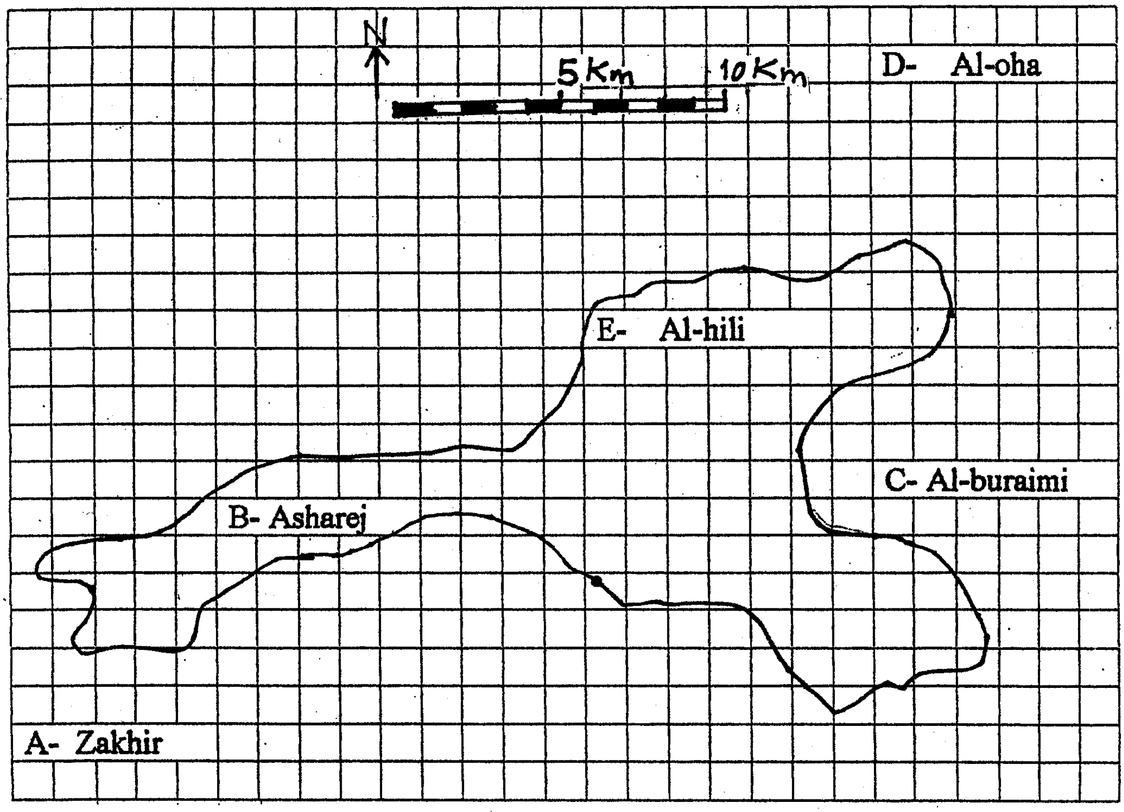

Figure 1. Relative location of the different seed collection sites around the city of Al Ain, UAE.

Increasing soil salinity is a common problem that is affecting more lands in semi-arid areas. Plant adaptation due to prevailing conditions demands their ability to grow at sodium chloride concentrations that are lethal to unadapted plants. Plant species that are adapted to saline soils may become a valuable genetic resource. It has been suggested that a great deal of variability exists for adaptation to drought and salinity in arid and semi-arid conditions (Amzallag *et al*., 1995). Stability in the expression of such trails has been shown to correlate with coefficient of variation under uniform conditions.

Table 1: Analysis variance summaries (mean squares) of the data for germination percentage, rate of germination and lengths of shoots, roots and seedlings of five populations of *A. tortilis* under saline conditions.

Source of Variance	Germination percentage	Germination rate	Seedling length	Shoot length	Root length
Population (P)	414.79***	5.88**	1454.8*	2552.75**	1359.96**
Salinity (S)	273.77***	2.06*	10067.7***	470.14**	1272.24**
P× S interaction	20.0***	1.65*	2091.1*	1134.28**	199.49 N S

*, ** and *** = significant at .05, .01 and .001 levels respectively; NS = non-significant.

Stress conditions may expose unrecognized variability within and between plant populations. Limited reports dealt with tree legumes of the region in relation to drought adaptations. We carried out the study on the population biology and adaptation of one of the key species (*Acacia tortilis*) in the changing environments of the region. The primary objective of the present study was to assess the extent of variation for salt tolerance in different populations of *Acacia tortilis*, particularly at the initial growth stages.

2. Materials and Methods

Mature pods and seeds of *A. tortilis* were collected from five sites around the City of Al-Ain in the UAE: site A, south west (Zakhir); site B, west (Asharej); site C, east (Al-Buraimi); site D, north east (Al-Oha); and site E, north of Al-Ain (Al-Hili). See Figure 1.The urban collection sites are undisturbed areas that are at least 5 km apart, separated by major structures such as the University Campus, a highway, residential areas and the city center. Within each site seven to thirteen trees were sampled. Seed and pod collections were made towards the end of the spring of 1996. Seed moisture content was determined by weight difference before and after oven drying at 105 C for 24 h. Seeds were pretreated with concentrated sulfuric acid for 30 min, thoroughly washed with distilled water, placed in 9 cm Petri-dishes on "seed test thick" 9 cm filter papers (Whatman's No. 1) and kept moistened with 0, 20, 90 or 150 mM of NaCl solutions. Fifty seeds were placed in each Petri dish with three replicates for each treatment combination. Seeds were germinated at 25° C ± 1° C. The germination was assessed as the percentage of seeds with radicles emerging each day for 10 days. The mean rate of germination of each population was determined as Maguire Index where MI equals the sum N_i /T_i , where N_i = the number of seeds that germinated in each time, T_i from the beginning of the experiment. Root and shoot lengths for each treatment were measured after 10 days of germination. Data were analyzed statistically using two-way analysis of variance.

Table 2: The effect of NaCl concentration in germination medium on seedlings root, on shoot length germination percentage and an germination rate of five populations of *Acacia tortilis* from UAE.

	NaCl concentration (mM)							
	0	20	90	150	0	20	90	150
Population	Root length (MM)				Germination percentage			
A Zakhir	34.4 a*	42.9 ab	41.0 ab	29.7 ab	35.0 b	35.3 b	31.7 b	20.3 b
B Asharej	33.7 a	36.7 ab	48.9 a	40.6 a	42.3 ab	42.7 ab	41.7 ab	29.0 ab
C Al Buraimi	41.8 a	49.3 a	46.3 ab	35.7 ab	41.0 ab	39.7 ab	36.7 ab	34.7 ab
D Al Oha	41.4 a	39.8 ab	35.2 ab	21.5 b	48.7 a	48.7 a	44.0 a	42.7 a
E Al hili	40.9 a	34.3 b	32.2 b	28.5 ab	34.0 b	36.7 b	33.0 ab	30.3 ab
	Shoot length (mm)				Germination rate (number/day)			
A Zakhir	59.0 a	56.7 a	47.0 a	37.8 a	23.4 b	23.4 b	23.6 b	22.3 b
B Asharej	52.1 ab	52.4 ab	38.7 b	29.8 ab	24.3 ab	24.0 ab	23.5 b	22..0 b
C Al Buraimi	46.8 bc	41.5 bc	38.0 bc	28.3 ab	24.7 a	24.5 a	24.6 a	26.0 a
D Al Oha	52.8 ab	56.3 ab	40.6 ab	32.6 ab	25.1 a	24.7 a	23.9 ab	22.8 ab
E Al hili	47.5 b	45.9 ab	37.7 bc	25.4 b	24.3 ab	24.2 ab	24.2 ab	23.8 ab
	Change in root length:shoot length ratio as % of control				Change in seedling water content as % of control			
A Zakhir	0.0	+31	+53	+36	0.0	-0.44	-4.01	-5.68
B Asharej	0.0	+8	+94	+109	0.0	-1.90	-4.25	-5.82
C Al Buraimi	0.0	+34	+37	+42	0.0	+0.68	-4.29	-5.76
D Al Oha	0.0	-9	+12	-15	0.0	-0.78	-4.36	-6.59
E Al hili	0.0	-13	-1	+30	0.0	-2.94	-4.53	-4.52

* Along each column means followed by the same letter are not significantly different (α = 0.05) according to Duncan Multiple Range test.

Table 1 shows mean square, F values and probability for the different parameters as affected by population, salinity. The five populations were significantly different in all parameters. The different populations were also significantly affected by the different salt concentrations.

The data for on root lengths, shoot lengths, germination percentage and germination rate of the 5 populations of *A. tortilis* are presented in Table 2. The five populations were significantly different in seed germination percentage (Table 1). The increasing concentrations of the saline solutions decreased the germination medium was also did different NaCl concentrations. The populations showed a slight but significant reduction in the rate of germination that was more pronounced at the higher salt concentrations.

Although the five populations of seeds were significantly different in their initial seed moisture content, their respective seedlings lost 4-4.5 % and 4.5-6.6 % of their moisture content when geminated at 90 mM and 150 mM of NaCl solutions, respectively, as compared to germination in distilled water (Table 2).

Root length of seedlings from populations D and E were markedly reduced by the higher salt concentrations. Seedlings of populations A, B, C had longer roots at the 20 and 90 mM salt levels but reduced length when germinated in distilled water and 150 mM NaCl. Shoot length of populations A, B, D and E were not significantly reduced by the 20 mM treatment compared to the control. However, in all populations the increase in salt from 20 mM to 90 mM and then to 150 mM resulted in a significant reduction in shoot length. Both root and shoot lengths as well as the overall seedling length showed significant population times salt concentration interaction. In all populations, seedling length was significantly reduced at 150-mM NaCl. The effect of the higher salt concentrations was more pronounced on the shoot than on the root elongation. The is reflected in the increase in root: shoot ratio for populations A, B and C. Populations D and E both showed increases and decreases in root: shoot length ratio compared to the control.

3. Discussion

Analysis of the germination characteristics of five seed populations of *A. tortilis*, collected from five sites around Al Ain, suggests that the recently urbanized semi-arid plains of eastern U.A.E. have been under the influence of both biotic and abiotic factors. This may have started the noticeable changes in the local plant communities observed by Western, (1989). The low germination percentage observed in this study at different salt levels, despite seed pretreatment with sulfuric acid suggests that the hard seed coat of the species has developed as an adaptation to permit a few seeds to germinate in the harsh conditions of the semi-arid climate. Populations A and B had a very low rate of germination at the higher salt levels. Seedling length was the highest at the 20 mM salt concentration for all populations except E where the control produced the longer seedlings. However, 20 and 90 mM levels of NaCl seemed to have promoted root growth of population B. It has been previously suggested (Saab *et al* 1990) that higher NaCl concentrations increased root growth and decreased shoot growth. This was reflected in the increased root length : shoot length ratio with the increasing salt concentration. This was true for all the populations except D which showed a slight decline in root to shoot ratio at the 150 mM concentration. The populations were also different in their response. Koehl (1996) suggested that reduced shoot : root ratio has a selective advantage in delaying the onset of critical water saturation deficit and thereby the plants ability to take up additional water from deeper soil levels.

Coleoptile and root growth has also been reported to be involved in seedling response to dehydration (Guidera, *et al,* 1997). Salinity is reported to cause a reduction of water uptake in many species of Acacia seeds (Rehman, *et al,* 1996). In this study this was reflected in reduced seedling water content. The variation between the population may point to possible adaptation to changing local environments. The high heritability estimates for the rate of germination in rice, chickpea and lentil reported by Rao, *et al* (1997) and Mamo, *et al,* (1996) may explain the high genetic variability observed variation between populations in their seedling characteristics. Studies are underway to quantify the genetic variability within this species and to correlate such adaptations with environmental attributes specific to the region.

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