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The Effects of Some Soil Factors on the Phenotypic Plasticity of *Senecio glaucus* L. in the Eastern Region of Saudi Arabia

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Abstract: The effects of some soil factors on the phenotypic plasticity of *Senecio glaucus* L. in three selected sites at the coastal part of the Arabian Gulf near Ad Dammam city in the eastern region of Saudi Arabia was investigated. The investigation was conducted by mechanical analysis of soil and chemical analyses of soil and plant samples. It was found that soil salinity stress represents the major factor affecting the morphological and physiological characteristics of the investigated species. The morphological traits of the investigated species mostly affected by salinity are: length of shoot, length of root, number of leaves per plants and the number of ray florets per capitulum. It was also found that the investigated plant growing under high salt stress is characterized by low water content, low content of chlorophyll *a* and high content of proline. The decrease of chlorophyll *a* content could be related to the decrease of water content of plant leaves under salt stress, whereas, the high content of proline in the plant tissues could be explained as an osmotic adjustment mechanism for the investigated species growing under high salinity stress.

Key words: *Senecio glaucus* L., phenotypic plasticity, salinity, Saudi Arabia.

INTRODUCTION

During the last few decades the study of plants, especially the adventive taxa, growing under different environmental conditions had gained much interest. Such studies would reveal the phenotypic plasticity of plants which describes the capacity of a genotype to exhibit a range of phenotypes in response to variations in the environment. The phenotypic plasticity affects the strength and direction of natural selection, in other words, plants showing plasticity are likely to acquire new traits by evolutionary changes. Such insight indicates why some plants are more liable to evolutionary changes than others. Some of these studies assessed the phenotypic plasticity of some plants under experimental conditions (Bell and Sultan, 1999; Ryser and Eek, 2000; Wu *et al*., 2004; Peperkorn *et al*., 2005); whereas others assessed this plasticity in natural populations (Chang *et al*.,2004; Mal and Lovett –Doust, 2005).

Chapman and Abbott (2005) reported that *Senecio* sect. *Senecio* is complex owing to recent species radiation, high morphological plasticity and occasional interspecific hyperidization. Working on *cpDNA* they concluded that *Senecio* restricted to sand dunes in southern Sicily is a variant from North African *S. glaucus* subsp. *coronopiflius*.

S.glaucus subsp. *coronopifolius* (Maire) Alexander is synonymous to *S. glaucus* and it is a member of family Asteraceae.The morphological characteristic of the investigated *Senecio glaucus* L. fits the morphological description given by Migahid (1988). However this species shows some variations in different habitats. This species commonly known as Zamluq, Rejel El-ghurab or Gregar and it covers large areas especially after the rainy season. It grows among other forbs in many parts of the Eastern province of Saudi Arabia particularly along the Gulf shore and in disturbed areas in urban places. Many volatile oils have been extracted from its flowers and leaves , some of which have the scent of apricot (De Pooter *et al*., 2006).

It has been noticed that the investigated species shows some morphological variations in the shoot systems especially the height of the plants and the number of leaves in different localities, in which it grows, at Ad Dammam city, Saudi Arabia. These differences are most probably related to edaphic (soil) factors rather than climatic ones. Therefore, this study was conducted to reveal the effects of soil factors on characters of this native species.

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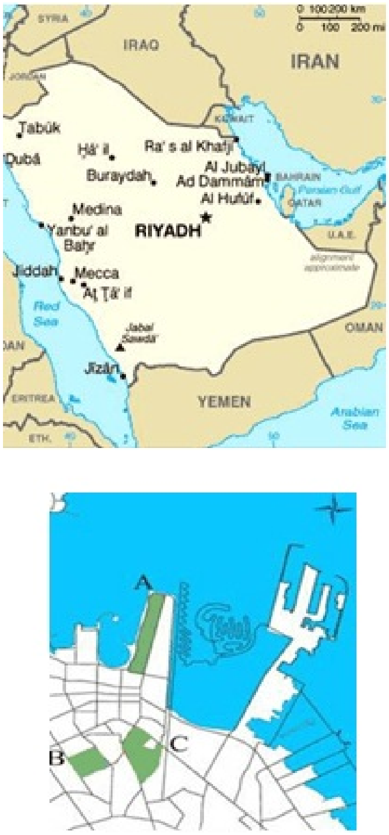
MATERIALS AND METHODS

Description of the Study Area:

The study area chosen for this study was the coastal part of the Arabian Gulf near Ad Dammam city (Figure 1). Three sites have been chosen for this study, these are: site A, is about 70 m from the Gulf shore, site B is about 8 km to the south west of site A and site C is about 4 km to the south east of site A. In association with *Senecio glaucus* the three sites share the following two species: *Heliotropium bacciferum* and *Salsola baryosma*. In site A *Zygophyllum qatarense* grows in association with the other 3 spp. While in site B *Brassia tournefertii* was also recorded. However in site C many spp. occur such as: *Malva parviflora*, *Zygophyllum album*, *Brassica tournefortii*, *Chenopodium murale*, *Lasiurus scindicus* and *Brassia tournefertii*.



Ad Dammam city

Fig. 1: The study area at the coastal part of the Arabian Gulf near Ad Dammam city, Saudi Arabia. The three selected sites: A, B and C are shown on the magnified map below.

Chemical and Mechanical Analyses of Soil Samples:

Soil samples were collected from the three sites at the following depths near the investigated species: 0-5 cm, 5-25 cm and 25-50 cm. Three soil replicates for each depth were collected in plastic bags. The bags containing the soil samples were kept tightly closed and stored in the laboratory at 25º C.

The soil samples were air dried, thoroughly mixed and passed through 2mm sieve to remove gravels and debris. Mechanical analyses were made using serial sieves. Determination of pH was made using a pH- meter. The electrical conductivity (EC) was measured using electric conductivity meter at 25º C.

Analytical procedures for soil chemical analysis followed those of Allen *et al.* (1974). K and Na were estimated by flame emission; whereas, Ca and Mg were measured by atomic absorption spectrophotometer. Sodium adsorption ratio (SAR) was calculated according to the following equation (Alperovitch *et al.,* 1986).

$$SAR = \frac{[Na^{+}]}{\sqrt{1/2\ ([Ca^{+}] + [Mg^{+}])}}$$

Chemical Analyses of Plant Samples:

Ten samples of the investigated species were collected randomly from each of the three study sites. Chlorophyll *a* and *b* and carotenoid pigments were determined by the spectrophotometer method as recommended by Smith and Benitez (1955). Proline was estimated calorimetrically following the method of Bates *et al*. (1973).

The results obtained from plant analysis were statically analyzed using the SPSS program version 10 according to Snedecor and Cockran (1969).

RESULTS AND DISCUSSIONS

It is evident from Table (1) that the soils sustaining S*enecio glaucus* in the three investigated sites fall within two categories, namely: coarse and fine sand. The soils of the three sites are more or less homogenous mechanically to the depth of 50 cm; however, site B showed considerable decrease in fine sand with depth followed by considerable increase in coarse sand. Due to mechanical homogeneity of the soil in the three investigated sites, soil texture would not have effect on the phenotypic plasticity of the investigated species.

The pH measurements (Table 2) showed that the soil in the three sites are moderately alkaline, and the alkalinity is more evident in site A being the most close to the Gulf shore.

It is of prime importance, in order to evaluate the effects of soil factors on the morphological and physiological traits of *S. glaucus* to determine the soil salinity which represents the concentration of inorganic

Table 1: Mechanical analysis of soil samples collected from the study area using sieves method. The samples were collected randomly from three sites at three different depths.

Samples collected from site A				
Fine sand		Coarse sand		
Wt. in gm	%	Wt. in gm	%	Depth in cm
75.314	75.4	24.536	24.6	0 – 5
79.235	79.6	20.367	20.4	5 - 25
71.185	71.2	28.762	28.8	25 - 50
Samples collected from from site B				
Fine sand		Coarse sand		
Wt. in gm	%	Wt. in gm	%	Depth in cm
73.028	72.7	27.485	27.3	0 – 5
66.263	66.9	32.824	33.1	5 - 25
58.168	58.7	40.969	41.3	25 - 50
Samples collected from site C				
Fine sand		Coarse sand		
Wt. in gm	%	Wt. in gm	%	Depth in cm
72.117	72.6	27.242	27.4	0 – 5
69.692	69.9	29.96	30.1	5 - 25
72.147	72.7	27.1	27.3	25 - 50

Table 2: Chemical analyses of the soil sustaining *S. glaucus* in the three investigate sites. Ions were determined as meq/ l; EC as ds/m; Organic mater, Organic carbon and Saturation in percentages.

Criteria	Site A			Site B			Site C		
	Depth in cm			Depth in cm			Depth in cm		
	0-5	5-25	25-50	0-5	5-25	25-50	0-5	5-25	25-50
PH	8.11	8.07	7.95	7.95	7.83	7.67	7.89	7.8	7.5
EC (ds/m)	5.63	5.19	5	1.17	1.36	1.71	1.05	0.94	1.01
Organic mater (%)	0.27	0.35	0.27	0.19	0.11	0.07	0.1	0.07	0.06
Organic carbon (%)	0.16	0.2	0.16	0.11	0.04	0.03	0.03	0.06	0.06
Moisture content (%)	1.37	1.838	2.11	0.418	1.647	2.767	0.816	2.276	2.815
Saturation (%)	20.8	23.5	24.8	23.1	23.5	23.6	23.4	24.2	25.7
SAR	2.85	2.7	2.67	0.25	0.31	0.43	0.19	0.21	0.14
$CaCO_3$	26.3	24.2	25.3	14.7	20	15.8	15.8	14.7	15.8
HCO_3^-	11.25	9.02	9.27	7.78	7.81	8.12	7.36	7.19	6.34
Cl^-	9.87	18.61	25.77	1.92	1.62	1.69	1.4	1.74	1.37
SO_4^{-2}	29.18	25.18	37.4	7.7	9.13	11.71	2.6	4.09	4.27
Na^+	17.9	15.9	26.3	1.44	1.57	2.14	1.01	1.24	0.94
K^+	3.98	3.42	7.83	0.86	1.23	1.01	1.09	0.95	0.6
Ca^{+2}	42.4	29.4	33.8	13.2	14.8	18.8	9.62	8.51	9.6
Mg^{+2}	3.85	3.4	2.42	1.73	1.73	3.3	1.56	1.24	0.85

Table 3: The variations in the recorded traits of *S. glaucus* in the three investigated sites.

Recorded Characters	The sites		
	A	B	C
Length of shoot.	12.5 cm	16 cm	21.5 cm
Length of root	16 cm	13.5 cm	14
No. 0f branches / plant	5	4	7
No. of leaves / plant	38	31	60
Plant indumentum	dense	sparce	rare*
Lower leaves :			
Leaf length	5 cm	6 cm	6.5 cm
Leaf width	0.35 cm	0.4 cm	0.5 cm
No. of lobes	6	5	7
Upper leaves:			
Leaf length	2 cm	2 cm	0.3 cm
Leaf width	0.2 cm	0.25 cm	0.3 cm
No. of lobes	2	2	3
No. of inflorescence / plant.	3	3	3
Length of peduncle	3.5 cm	3.5 cm	4cm
Inflorescence diameter	2 cm	2cm	2cm
No. of ray florets / Inflorescence.	14	17	21

*not seen by nacked eye.

Table 4: The variations in the content of water, chlorophyll a & b and proline of *S. glaucus* in the three investigated sites.

% analyses	Sites of study		
	A	B	C
water contenteee	59.54± 3.19	72.77± 2.36	81.1± 3.78
Chlorophyll content:			
Chlorophyll *a*	6.264± 0.821	11.733± 1.62	10.822± 2.448e
Chlorophyll *b*	2.639± 0.651	1.150± 0.215	1.262± 0.409e
Carotenoids	3.752± 0.609	3.355± 0.568	3.152± 0.930e
Proline content. (Umole)	0.0152± 0.00042	0.0137± 0.00112	0.0061± 0.00040

salts in the soil. The total salt content can be easily estimated by the electrical conductivity EC of the water extracts of the soil. The EC in site B and C in the range from 0 – 2 ds/m which is safe for all plants (Ryan *et al*., 2001). The EC in site A, however, ranges from 5 - 5.63 ds/m. This range is considered by Ryan *et al*., (2001) as highly saline, and the presence of *S. glaucus* in such salinity range indicates that this species is not much sensitive to saline environments.

However, as seen from Table (3) the high salinity range in site A does affect most of the traits of the investigated species. The investigated species in site A showed relative reduction in shoot length associated with relative increase in root length.

Sodium adsorption ratio (SAR) is the proportion of sodium ions compared to the concentration of Ca and Mg. This ratio expresses the relative salinity of Na ions in the soil exchange reactions. Although SAR range in site A (the closest to Gulf shore) is higher than that in site B and C (Table 2), it still occurs in the safe range. According to Munshower (1994) SAR range above 12-15 represents serious physical problems to plants particularly the difficulty in absorbing water.

The organic matter content of the three investigated sites is very low (less than 1% for the three sites). Site A, however, shows slight increase in the organic matter content compared to site B and C (Table 2). In general soil organic matter content in semi arid areas is normally less than 1 % (Ryan *et al*., 2001), and this is probably due to the aridity coupled with constant wind's erosion of the surface layer of the soil which contains dried plant remains.

Soil moisture is one of the limiting growth factors in arid areas. The moisture percentages increase with depth in the three studied sites (Table 2); a feature of normal sandy soils in arid zones. However, the percentages of moisture in the surface layer (0-5 cm) in site A is not much less than at deeper soils (25-50 cm). This may be due to low evaporation rate, since this site is near the Gulf shore. The soil moisture at the range of *S. glaucus* roots in site C is relatively higher than in the other two sites, and this difference is reflected upon the growth of *S. glaucus* in the three sites. For instance, the roots are shorter and the number of leaves per each plant is much higher in site C than in the other two sites (Table 3) .The soil saturation percentages in this study coincide with the moisture content in the three sites and this may be due to the homogenous soil textures in the different studied depths.

Site A contains higher quantities of Na^{+}, K^{+}, Ca^{++} and Mg^{++} than the other two sites. In addition to that, site A is characterized with high levels of $CaCO_3$ and this may be due to the littoral deposits containing sea shells. According to Ryan *et al*. (2001) soils with high $CaCO_3$ tend to have lower availability of P and some micronutrient cations, and this may explain the reduction of the vegetative growth of the investigated species in site A compared to the other two sites (Table 2).

Site A, which is more saline than the other two sites, is characterized with low chlorophyll *a* content compared with the other two sites (Table 4). The decrease of chlorophyll *a* content under salinity stress had been reported by many workers (Seemann and Critchley,1984; Ashraf, 1989; Ortiz *et al.,* 1994; Popova *et al.,* 1995; Wang and Nii, 2000; and Netondo *et al.,* 2004). The decrease of chlorophyll *a* content in plants growing in site A may be associated with and most probably related to the decrease of plants water content. Gadallah (1991) and Wang & Nii (2000) stated that the decrease of chlorophyll *a* content is highly related to the decrease of water content of plant leaves under salt stress.

From the proline content (Table 4) one can assume that plants growing in site C are less subjected to salt stresses. This was clearly reflected in the studied growth traits (Table 3). In site C the plant length and the number of leaves per plant are much higher and than in site A and B. In addition to that, the roots are shorter and the hairs are less frequent in site C. It has also been noticed that the number of ray florets per capitulum are much higher in site C (21) than in site A and B (14-17), though the diameter of the inflorescence is the same in the three investigated sites.

The limited number of species growing in site A may be greatly due to the high salinity in this site. Mean while the growth of *Malva parviflora* in site C reflects the low concentration of salts in this site, because this species has been recorded to be sensitive to salinity (Chauhan *et al*., 2006*)*.

In conclusion, as it is evident from Table (3), that the morphological traits of the investigated species mostly affected by salinity are: length of shoot, density of hairs, length of root, number of leaves per plants and the number of ray florets per capitulum. It was also found that the investigated plant growing under high salt stress is characterized by low water content, low content of chlorophyll *a* and high content of proline.

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