

**NUTRIENT AND WATER RELATIONS
OF *ATRIPLEX LEUCOCLADA* GROWING
IN DIFFERENT HABITATS OF THE
MEDITERRANEAN COASTAL REGION OF EGYPT**

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Atriplex leuoclada (Chenopodiaceae) is a shrub growing in many different habitats in sand dunes. The sand dune system is characterised by its small-scale heterogeneity. *Atriplex* occurs in different habitats varying from sand to playas where has high accumulation of salts. Ion accumulation and water relations of *Atriplex leuoclada* growing in different habitats were compared. *Atriplex leuoclada* showed a genetic fixed ion pattern independently of soil type.

Key words: biomass, nutrient, sand dunes, water potential, water relations

INTRODUCTION

Plants growing at coastal dune plants receive wind-borne salt water spray. In the high shore dunes the maximum amount of spray is precipitated on the top of the slope facing the sea. Some species and ecotypes of the spray zone have been shown to be more resistant to salt than others. These differences correlate with the differences in wettability, which has been suggested to be related to differences in some morphological features (Ahmed and Wainwright 1976, Rozema *et al.* 1983). The acquisition of water and nutrients is one of the major functions of roots and is especially suited for a demonstration of the close interrelation between morphology and function. If agricultural soils are considered, the ability of plants to influence the solubility or mobility of macronutrients in the rhizosphere is of minor importance (Hoffland *et al.* 1990). Hence, the size of the absorbing surface, as well as the ability to the ab-

sorbing surface, as well as the ability to explore undepleted soil horizons (Shaverbush and Barber 1983) are important factors for the acquisition of mineral nutrient. It has been demonstrated both theoretically and experimentally that such factors are of special importance when explaining genotypic differences in the growth and yield under conditions of low soil fertility (Sattelmacher and Thomas 1990).

Mineral nutrient supply has a pronounced influence on size and morphology of the root system (Drew and Saker 1978). This effect depends mainly on the nutrient, the concentration range considered, the means of application, and on environmental conditions.

The objective of the present paper is to compare the mineral contents and water relations of *Atriplex leuoclada* in different habitats.

MATERIAL AND METHODS

Study area. North area includes the sand dunes and playa areas located on Mediterranean region, where the yearly rainfall exceeds 200 mm (Fig. 1).

The plant materials were collected from different habitats for both water potential and mineral content measurements, where the water potentials were measured by using a Scholander type pressure bomb (Soil moisture, Santa Barbara, USA). The different elements were measured as follows. N was measured by a C/N analyser model Na-1500 (Carlo Erba, Goettingen, Germany). Samples were combusted with supplemental of oxygen at 1020 °C. NO_x is then reduced to N_2 and analysed by gas chromatography (2–3 mg of the re-dried samples was weighed in zinc containers). Atropine samples were used as calibration standards. Empty zinc containers were run as blanks. The analysis was carried out twice for each sample, P after Gericke and Kurmies (1952), Ca, Mg, K, Na were analysed by atomic absorption spectrophotometer. Chloride was

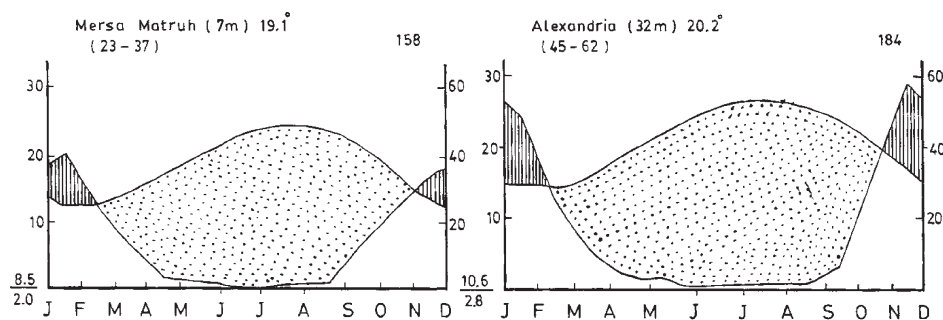


Fig. 1. Climatic diagrams of the two stations inhabited by *Atriplex leuoclada*

Table 1

Woody biomass and assimilating shoot system of the individual plants along a soil catena in summer and winter in the different habitat (mean $\pm$ S.E.)

Habitat	Summer		Winter	
	Woody (g/plant)	Green (g/plant)	Woody (g/plant)	Green (g/plant)
Dune	1,224 $\pm$ 58	360 $\pm$ 18	1,336 $\pm$ 61	392 $\pm$ 19
Interdunes	1,584 $\pm$ 66	528 $\pm$ 25	1,656 $\pm$ 81	568 $\pm$ 26
Playa	1,930 $\pm$ 93	1,080 $\pm$ 49	2,140 $\pm$ 103	107 $\pm$ 51

determined by titration method after Bassett *et al.* (1985). Organic acids were determined by means of gas chromatography. SO_4 was analysed by turbidimetric method after Bassett *et al.* (1985).

RESULTS AND DISCUSSION

Biomass

Atriplex dominating the playa areas has higher biomass if compared with that grown on the sand dunes (Table 1). The woody part represent about 82% of the total plant in the playa areas, 73% of the whole plant in the interdune areas and only 64% of the whole plant in the dune areas, respectively. There was no significant difference between the summer results and winter results (Table 1).

Ion content

Atriplex leucoclada shows like all Chenopodiaceae (Breckle 1976, Blume *et al.* 1995) a genetically fixed ion accumulation, mainly N , Na^+ , K^+ , Ca^{2+} , Mg^{2+} and little Cl^- . Organic acids compositions for the plant under study were affected by salt stress conditions. Data shows an increase of the different organic acids (Table 2). The large increase in oxalic acids, citric acids and succinic acids. The accumulation of organic acids may be due to the deviations of the

Table 2

Organic acid content (%) in the shoot juice of *Atriplex leucoclada*, in the different habitats on dry weight basis (mean $\pm$ S.E.)

Habitat	Glycolic acid	Oxalic acid	Fumaric acid	Tartaric acid	Citric acid	Succinic acid
Dunes	0.0	9.8 $\pm$ 0.92	0.56 $\pm$ 0.02	0.0	6.71 $\pm$ 0.32	3.11 $\pm$ 0.19
Interdunes	0.32 $\pm$ 0.01	16 $\pm$ 1.21	0.93 $\pm$ 0.05	0.23 $\pm$ 0.01	8.53 $\pm$ 0.77	4.75 $\pm$ 0.29
Playa	0.36 $\pm$ 0.02	26.3 $\pm$ 1.83	1.12 $\pm$ 0.07	0.48 $\pm$ 0.02	12.24 $\pm$ 0.93	6.24 $\pm$ 0.36

Table 3
Ions content (mmol Kg⁻¹ d.w.) of *Atriplex leucoclada* along different habitat

Habitat	N	P	Ca	Mg	K	Na	Cl	SO ₄
Dunes	362 ±21.07	54 ±8.02	174 ±19.7	66 ±11.72	354 ±19.76	286 ±16.44	109 ±18.03	208 ±16.62
Interdunes	408 ±20.3	69 ±8.0	158 ±13.53	72 ±5.86	412 ±14.64	418 ±21.38	160 ±15.39	254 ±5.86
Playa	584 ±21.39	109 ±13.58	166 ±35.09	51 ±4.16	523 ±9.87	977 ±16.82	336 ±23.35	416 ±13.65

main cycles or glycolysis pentosphosphate and glycolate cycles in order to increase the level of organic acids and for sugar alcohols for osmoregulation of the stressed plants. These compounds are responsible for raising the osmotic pressure inside the cells. Sugar alcohols are known as compatible solutes and act as osmoregulators (Brown 1978). It can be suggested that the increase in organic acids in *Atriplex* could be on the expece of anabolism (biomass gain) and used as compatible solutes beside proline (Batanouny and Ebeid 1981, Batanouny *et al.* 1985, Wyn Jones and Gorham 1983). The ions contents are very variable and show no clear relations with the adaptation conditions. Also on the poor salt sands habitats have a high concentrations of Na⁺ and K⁺ and low concentrations of Cl⁻ in its shoot systems (Table 3).

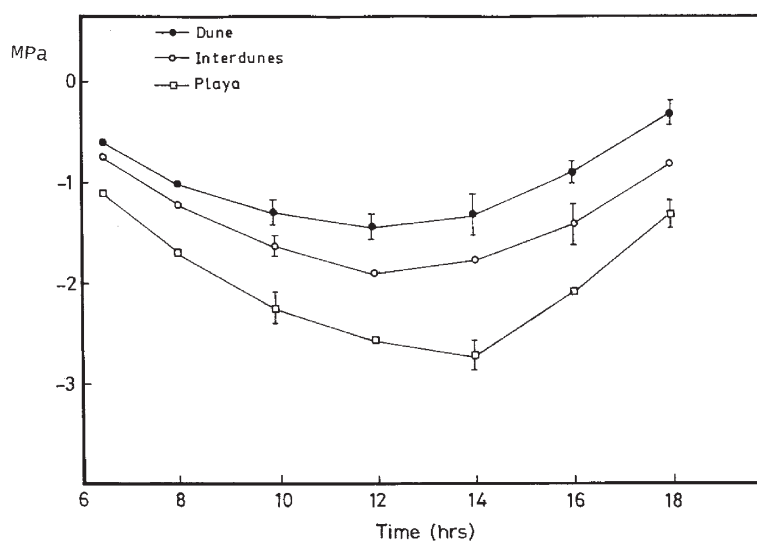


Fig. 2. Diurnal course of water potential in *Atriplex leucoclada* in sand dunes, interdunes and on a playa in July 2003

Water relations

The water content of sand dunes in comparison with that of the playa areas is much lower, where the infiltration in the upper 30–60 cm is much limited (Yair *et al.* 1997, Littmann and Kalek 1998) in spite of heavy rainfall in playa area, which leads to high water content of the playa areas. *Atriplex leucoclada* grows on the playa dry mudflats are characterised by a low water potential and significantly reduced CO₂ and water vapour exchange (Fig. 2) (Veste 1995, Veste and Breckle 1995). Ion accumulation contributes mostly to the low osmotic potential, which enables water uptake at these unfavourable soil conditions.

Atriplex leucoclada forms a bipartite root system with roots closely to the surface (0–50 cm) and one taproot down to 5 m deep (Veste and Breckle 1996a). Water seeps out to 3–5 m in sand dunes and floats in part laterally along dune body (Veste and Breckle 1996b, Yair *et al.* 1997). The surface soil dries out completely within a few weeks after the end of winter rain season, so that water is only available from soil at 3–5 m deep until the next winter rainy season. For this reason the water supply in deep layers after the rainfall could be used by *Atriplex leucoclada* like the other species for example *Retama raetam* and *Thymelaea hirsuta* (Veste and Breckle 1996a).

The available water limit the water content and the productivity of this ecosystem. The ecophysiological adaptation ability and the accumulation of ions enable *Atriplex leucoclada* to grow on the playa areas, in spite of the low water availability of these habitats and of the high salt content. The genetic ability to accumulate of ions and to synthesise organic acids lead to build up a negative osmotic potential in *Atriplex leucoclada* like other xerophytes of Chenopodiaceae (Breckle 1976, Albert *et al.* 1990) which improves the water content of this species under the desert conditions.

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