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Growth, Ionic and Water Relations in *Atriplex amnicola* under Saline and Hypoxic Conditions

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ABSTRACT

Growth of *Atriplex amnicola* and its ionic and water relations were studied under saline and hypoxic conditions in an experiment conducted in nutrient culture. Salinity levels (50 and 400 mol m^{-3} NaCl) were developed stepwise and hypoxia was induced by disconnecting the aeration of nutrient solution. Shoot fresh and dry weights were negatively affected by salinity and hypoxia. Na^+ and Cl^- concentrations in the leaf increased while that of K^+ decreased at high salinity. Leaf water potential was reduced under high salinity and hypoxia. Turgor pressure variation and regulation in leaf epidermal cells in relation to stress tolerance is discussed.

Key Words: *Atriplex amnicola*; Salinity; Hypoxia; Water relations; Growth

INTRODUCTION

Salinity and hypoxia are known to affect adversely the growth and water relations of *Atriplex amnicola,* particularly during longer periods of exposure (Galloway & Davidson, 1993). An increase in the uptake of Na^+ and Cl^- may result in their accumulation to toxic levels in the plant leaves (Barrett Lennard, 1986; Munns & Passioura, 1984). Increased resistance to water movement from root to shoot under hypoxic conditions may cause water deficient to develop in the shoot (Drew, 1983). In the present study, the growth and ionic and water relations of *Atriplex amnicola* were investigated under salinity and hypoxic conditions.

MATERIALS AND METHODS

Two months old seedlings (Parveen *et al.,* 2002, in this issue for details) of *Atriplex amnicola* were transplanted in plastic pots containing aerated ½ strength Hoagland nutrient solution. After two weeks of transplanting, plants were exposed to incremental salinity stress (50 and 400 mol m^{-3} NaCl). On completion of salinity stress, hypoxia was imposed by disconnecting the aeration. After 15 days the growth period under stress, plants were harvested and shoot fresh and day weights were recorded.

One day before harvesting, leaf water potentials (Ψ) were measured on small shoots enclosed in a pressure chamber. The leaves were excised, the trichomes were removed with a soft artist's brush. The leaves were then frozen, crushed and centrifuged to extract the sap. Osmotic pressure (π) of the leaf sap was measured by freezing-point depression osmometery. Turgor pressure (P) was estimated by the simplified equation (Ψ = P-π). Turgor pressure of leaf epidermal cells (control plant only) were also measured directly with cell pressure probe (Hüsken *et al.,* 1978). Na^+ and K^+ in the leaf sap were determined by flame photometer and Cl^- by chloride meter.

RESULTS AND DISCUSSION

Shoot fresh weight of *Atriplex amnicola* was adversely affected by high salinity level (Table I). Hypoxia also decreased the shoot fresh weight at both salinity levels. This reduction in shoot fresh weight was 45% at low salinity level as compared to 17% at highly salinity level. Response of shoot dry weight to salinity and hypoxia was similar to that observed in case of fresh weight. However, FW:DW

Table I. Shoot growth of *Atriplex amnicola* as affected by salinity and hypoxia

	Salinity (mol m^{-3})			
	50		400	
	Aeration	Hypoxia	Aeration	Hypoxia
FW (g/plant)	10.5 ± 0.70	5.79 ± 0.10	6.5 ± 0.71	5.4 ± 0.01
DW (g/plant)	1.64 ± 0.02	1.08 ± 0.07	1.04 ± 0.05	0.87 ± 0.08
FW: DW ratio	6.40	5.37	6.25	6.21

FW = Fresh weight; DW = Dry weight

Table II. Leaf ionic concentrations of *Atriplex amnicola* as affected by salinity and hypoxia

	Salinity (mol m^{-3})			
	50		400	
	Aeration	Hypoxia	Aeration	Hypoxia
Na^+ (mol m^{-3})	128 ± 13	110 ± 13	232 ± 30	186 ± 18
K^+ (mol m^{-3})	81 ± 1.4	72 ± 5.6	58 ± 5.6	60 ± 9.2
Cl^- (mol m^{-3})	201 ± 4	208 ± 13	514 ± 41	560 ± 46

Table III. Leaf water relations of *Atriplex amnicola* as affected by salinity and hypoxia

	Salinity (mol m^{-3})			
	50		400	
	Aeration	Hypoxia	Aeration	Hypoxia
Ψ (bar)	-10.2 ± 2.1	-17.4 ± 1.8	-22.6 ± 1.6	-25.6 ± 2.0
π (bar)	-14.2 ± 2.2	-21.0 ± 2.3	-25.8 ± 1.5	-28.6 ± 2.2
P (bar)	4.0	3.6	3.2	3.0

ratio of shoot was affected negatively by hypoxia at low salinity level where as at high salinity level it was not influenced by oxygen deficiency in the root medium.

Na^+ concentration in the leaf was enhanced at high salinity level (Table II). At low salinity level, hypoxia significantly decreased the Na^+ and K^+ concentration in the leaf while effect was non-significant at high salinity. Leaf Cl^- concentration was 2.5 times higher at high salinity but hypoxia did not affect Cl^- contents of the leaf at both levels of salinity.

Leaf water relations of *Atriplex amnicola* were adversely influenced by salinity and hypoxia (Table III). The leaf water potential was significantly lower at high salinity level. Hypoxia also negatively affected the leaf water potential. In spite of marked variation in leaf water and osmotic potentials under saline and hypoxic conditions, the turgor pressure was not much influenced by the external stress conditions. This might be due to the fact that turgor is regulated by the plant as suggested by Thomos and Wyn Jones (1982). They observed that plant growth at a range of NaCl concentrations did not affect the turgor pressure of epidermal cells. Since the turgor pressure is a prerequisite for cell expansion (and therefore plant growth), the regulation of turgor pressure may be important for stress tolerance in plants.

Direct measurement of turgor pressure of leaf epidermal cells revealed diurnal variations i.e. it declined during the light period and recovered by early morning (Fig. 1). Moreover, turgor pressure increased with distance from the apex of plant shoot (Fig. 2) indicating that turgor pressure increases with leaf age. Theoretically this increase could be due to an increase in the concentration of solutes present in the cells of older leaves, or an increase in the concentration of ions in the apoplast (cell wall) of younger leaves (Greenway & Munns, 1983; Thomos & Wyn Jones, 1982). These results suggest that direct measurement of turgor pressure be made at defined time of day (preferably morning) and on equivalent matured leaves for treatment comparisons.

Fig. 1. Variation in cellular turgor pressure with time of day. Measurements were performed in 4th leaf from apex

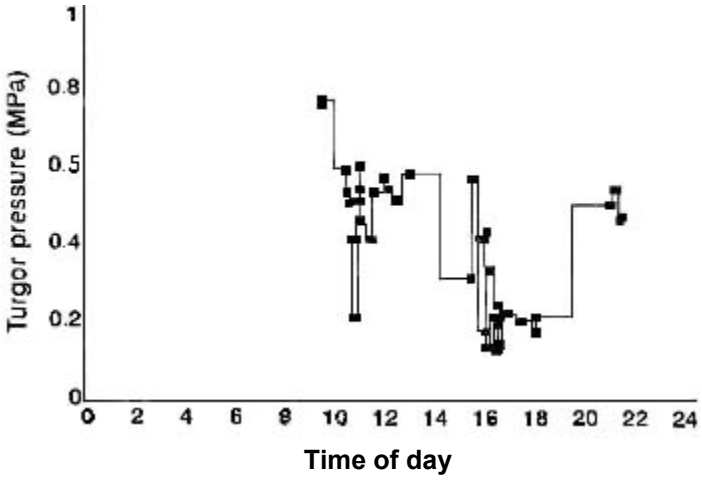
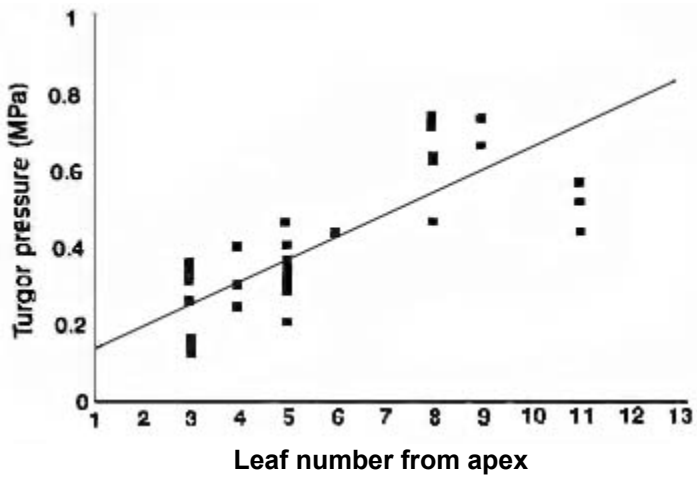


Fig. 2. Profile of cellular turgor pressure along the plant axis. Measurements were carried out between 9.00 to 11.00 a.m.



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