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Salinity, Osmotic Pressure and Transpiration Relationships of *Salicornia herbacea* in its Natural Habitat

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With 2 Figures

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Summary

In the present study, the inter-relationships between the salinity and osmotic pressure values of the soil and *Salicornia herbacea* L. plants at three localities at different distances from the sea-shore were investigated. The effects of salinity and osmotic pressure values of the plant and the medium on the total water lost by transpiration were also studied. The results obtained indicate that the plant salinity and osmotic pressure values changed linearly with changes of the salinity and osmotic pressure of the soil. On the other hand, the loss of water by the transpiration of the plant decreased with an increase in the salinity and osmotic pressure of the medium and plant.

Zusammenfassung

Die Beziehungen zwischen dem Salzgehalt und dem osmotischen Druck des Bodens und von *Salicornia herbacea* L. wurden an drei von der Küste des Ägäischen Meeres verschieden weit entfernten Stellen verfolgt. Ferner wurde die Wirkung dieser Größen auf die Transpiration der Pflanze studiert. Die Ergebnisse zeigen, daß sich Salzgehalt und osmotischer Druck der Pflanze parallel zu den Bodenwerten ändern. Hingegen sinkt die Wasserabgabe der Pflanze mit ansteigendem Salzgehalt und osmotischem Wert von Boden und Pflanze.

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1. Introduction

The specific eco-physiological importance of halophytes was first stressed by SCHIMPER 1898 and even today there are many problems in this subject which need elucidation. The factors having the most important role in the eco-physiology of these plants are concerned with the salinity and the osmotic pressure of the medium along with the salinity, osmotic pressure and transpiration relations of the plants occurring in this medium. Many works have been done to investigate one or more of these factors and their interrelations. ÖNAL 1966 reported that the sodium chloride content of the cell sap of halophytes did not increase according to the level of this salt in the soil. Later some evidence was obtained implying that the ion concentration in the various parts of halophytic plant species differs (CHATTERTON *et al.* 1970; WALLACE & ROMNEY 1972).

Controversial results have been reported on the salinity and osmotic pressure relationships of halophytes. REPP 1939 reported that in halophytes growing in the habitats with low salt content the osmotic pressure was high and this was not related to the salt accumulating in the plant, whereas JACKSON, TAYLOR & HENDRICKS 1970 stated that the osmotic pressure increase in the cell sap was directly related to the salt content of the plant. At the same time, it was reported that the osmotic potentials of the plant and medium solution was in equilibrium whether the osmotically active substance in the growth medium was a permeating or a nonpermeating one (RUFELT 1963, JARVIS & JARVIS 1963, MEIRI & POLJAKOFF-MAYBER 1969). WAISEL 1972 concerning the relations between the osmotic pressure increases of the medium and osmotic pressure values of the root, has reported that the osmotic pressure difference between roots of halophytes and their medium could be —30 bars or higher.

As far as we know there are previous investigations concerning the salinity and transpiration relationships of halophytes in their natural habitat.

There are a few laboratory studies on the salinity gradients and transpiration relations of halophytes and the results obtained are controversial. ÖNAL 1971 reported a decrease in the transpiration coefficients of halophytic plants when grown in increasing sodium chloride concentrations. On the other hand, WAISEL 1972 has reported that the transpiration rates of halophytes are dependent on the plant structure and their own water supplies rather than on the salt content of the medium. WAISEL 1972 referring to these controversies, claimed that this may be due to the different methods employed in the transpiration measurements.

We have performed the present investigation in order to study the salinity, osmotic pressure and transpiration relations of *Salicornia herbacea* L. a typical coastal halophyte of Turkey to the increasing salinity gradients of the medium and thus to understand these important aspects of it's eco-physiology.

2. Materials and Methods

Salicornia herbacea L. has been used as an experimental plant throughout this work. It occurs abundantly along our coast and is a typical example of coastal halophytes of Turkey.

The investigations reported here were made at three sites situated at different distances from the Aegean sea (A: 10 m, B: 1000 m, C: 3400 m). *S. herbacea* was the dominant species. The osmotic pressure and salinity of the medium, and osmotic pressure, salinity, and transpiration of *S. herbacea* were measured simultaneously at different times of the year June, July and August, 1974.

The sap from the experimental plant was extracted according to ZEYBEK 1969 and the saturation extract from the soil sample was obtained according to JACKSON 1958. Their electrical conductivity was measured with a Wheatstone Bridge Conductivity meter (U.S. Salinity Lab. Staff. 1954). The osmotic pressure measurements of the soil samples and materials were made with Knauer Osmometer.

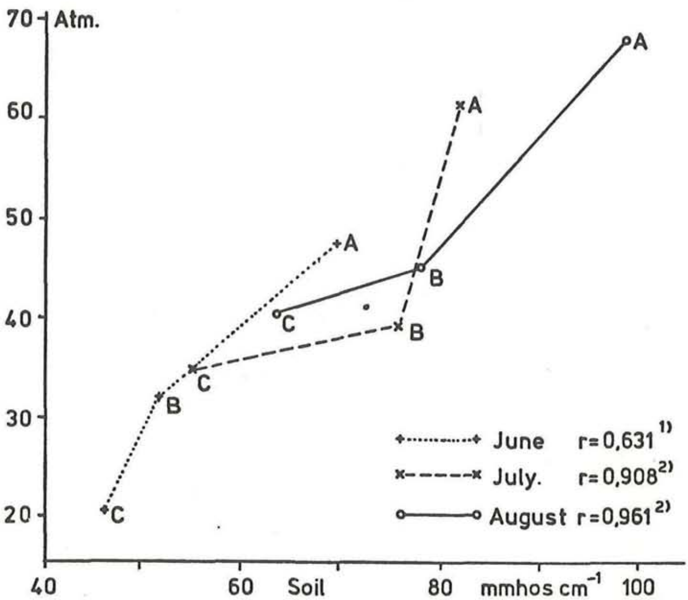

Fig. 1. The relation between the soil salinity and plant osmotic pressure values at different sites. (1) = significant at 5% level, 2) = significant at 1% level)

For all transpiration measurements gravimetric method was used. Individual plants were brought to the laboratory alongwith soil blocks in polyethylene bags. The soil particles were then washed and each plant placed in a 50 ml container full of water. Cotton was used to hold the plants and the container then sealed with liquid paraffin to prevent loss by evaporation. The container was weighed every 90 minutes from 7.30 A.M. till 7.30 P.M. Evaporation from the medium was measured with PICHE Evaporometer and the relative humidity was determined with a LAMBRECHT aspirated psychrometer. All measurements were done in the laboratory under identical conditions.

The statistical correlation analyses of the values recorded were performed according to STEEL & TORRIE 1960.

3. Results

3.1 Inter-relationship between salinity and osmotic pressure values

The salinity and osmotic pressure values of both the soil and the plant gradually increased at subsequent months in all the sites (Table 1).

Table 1

Salinity, osmotic pressure and transpiration values of soil and plant samples taken from various sites (A, B, C). The distance from sea-shore is given next to the site, standard errors of means are given

Site	Month	Salinity [1]) mmhos.cm^{-1}		Osmotic pressure [1]) Atm.		Transpiration[2]) mg.g^{-1} water content (90 min)
		Soil	Plant	Soil	Plant	
A	June	70,6±1,5	113,6±1,1	35,4±0,3	47,2±0,7	33,2±1,3
10 m	July	83,9±0,7	138,6±0,7	43,6±0,7	62,0±0,3	40,6±1,1
	August	100,6±0,8	145,4±1,6	58,0±0,4	68,4±1,1	47,7±1,1
	Mean	*85,0*	*132,5*	*45.7*	*59,2*	*40,5*
B	June	52,2±2,0	86,8±2,0	23,0±0,2	32,2±0,5	43,1±1,6
1 km	July	73,4±0,4	99,0±1,2	27,1±0,5	39,6±0,4	55,0±1,3
	August	78,3±1,3	105,8±0,8	39,7±0,8	45,0±0,3	61,0±1,6
	Mean	*68,0*	*97,0*	*29,9*	*38,9*	*53,1*
C	June	46,5±1,3	68,6±1,3	15,3±0,5	20,8±0,2	53,6±1,5
3,4 km	July	55,7±0,7	89,0±0,4	21,2±0,5	34,6±0,3	61,5±1,2
	August	64,7±0,4	98,8±1,8	26,9±0,2	40,6±0,4	75,3±2,0
	Mean	*55,6*	*85,5*	*21,1*	*32,0*	*63,1*

[1]) Means of 5 values; [2]) Means of 50 values

Fig. 1 shows a significant positive correlation between osmotic pressure of plant and salt content of soil, throughout the period of investigation.

3.2 Inter-relationship between salinity and transpiration rates

Table 1 also shows the soil and plant salinity values and plant transpiration rates. A negative correlation can be shown between these variables. For example, in site A, which is closest to the sea shore, the mean of plant salinity values was 132.5 mmhos.cm^{-1} for the period of investigation, whereas the amount of water lost by transpiration by the plant within

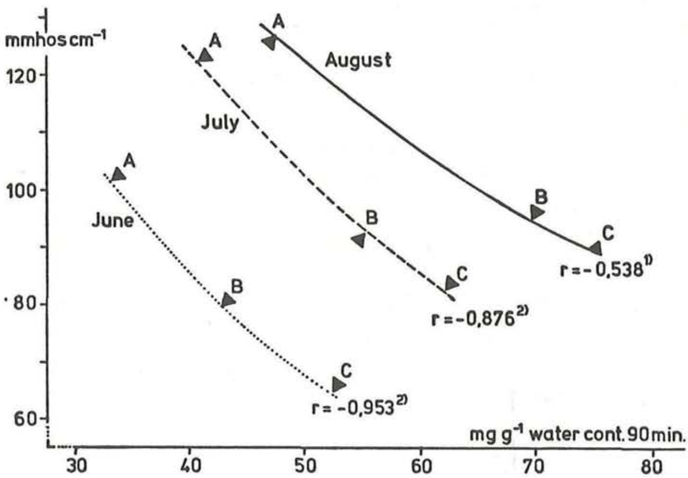

Fig. 2. The relation between salinity and transpiration values of plant samples taken from different sites. ([1]), [2]) see fig. 1)

the same period was 40.5 mg.g^{-1} water Cont in 90 Min. However, in site C, which is the farthest from the sea shore, the former value was 85.5 mmhos.cm^{-1} and the latter was 63.1 mg.g^{-1} water Cont. in 90 Min., respectively. The data of Table 1 also shows that, within the same period of study, the plant salinity value of site A was 55.1% more than that of site C. On the other hand, at site A, the water lost by transpiration is 35.8% less than that at site C. In Fig. 2 the negative linearity of the correlation between salinity of plant and the transpiration rate is shown.

3.3 Inter-relationship between transpiration and plant osmotic pressure values

At site A, the mean plant osmotic pressure was 59.20 Atm. whereas the mean transpiration was 40.5 mg.g^{-1} water Cont. in 90 Min. At site C, on the other hand, the former value was 32.0 Atm. and the latter was 63.1 $mg.g^{-1}$ water Cont. in 90 Min. (Table 1). This shows a negative correlation between the plant osmotic pressure values and the amount of water lost by transpiration, viz., with a decrease in plant osmotic pressure value there was a increase in transpiration.

4. Discussion

The commonly accepted view is that the salt affects the transpiration, but whether it is stimulatory or inhibitory has been controversial. BRAG 1972, on the basis of his investigations on the effect of medium salinity on the transpirational water loss, reported a 50% increase in transpiration by the addition of Na^+ and KCl to the growth medium of wheat and pea. On the other hand, ASHBY & BEADLE 1957 and ÖNAL 1971 have reported that the increased salinity of the medium reduced the transpiration rate and this is in agreement with our results reported here. The accumulation of minerals taken from the medium dissolved in water can be detrimental to plant life. To prevent this plant mobilizes such minerals by dissolution in the sap. For this reason the protoplasm of halophytes has higher viscosity and lower elasticity than glycophytes (GENKEL 1954). Such alterations taking place in halophytic cells cause electorlysis and hence colloidal alterations (SCHRATZ 1934, cf: CHAPMAN 1960). As a result of this a resistance is likely to be exerted to the passage of water through plasma and cell wall. We may explain the decrease in water loss in halophytes as being due to the result of such physiological events.

Many workers working on the relations between salinity of the medium and plant osmotic pressure have reported that plants growing in saline media have high osmotic values (BERNSTEIN 1961, JACKSON, TAYLOR & HENDRICKS 1970). Our results also revealed a positive linearity of these two values (Fig. 1). The plant and medium salinity directly effected the osmotic pressure and there was a negative correlation between transpiration and osmotic pressure (Table 1).

REPP 1958 has reported that the halophyte problem must be dealt with taking the salt regulation and not the water regulation, as the main issue. In contrast to this, WAISEL 1972 has asserted that in dealing with this problem, the plant structure and water resources, rather than salt regulation, must be taken into consideration. Halophytes, such as *Salicornia herbacea*, by increasing their osmotic potential absorb much water in order to nullify the detrimental effects of mineral salts accumulation. They bind the salt in vacuoles with water in order to prevent the enzyme activation and other metabolic events resulting from salt accumulation (ADRIANI 1956, WEIMBERG 1967, FLOWER & HANSON 1969). In this way, the loss of water by transpiration is prevented to a large degree. In the light of this, we believe that, aside from REPPS 1958 claim that the problem of halophytes is related to the plant structure and water resources, the relation of this problem to water regulation to nullify the detrimental effects of the salts must also be recognized. We conclude from our results that in dealing with the eco-physiology of halophytes, both water and salt regulations must be taken into consideration.

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