I. INTRODUCTION

PLATE 1

Salt excretion by leaves of A. *ilicifolius* in natural habitat.

The term 'Mangrove' has been defined by Davis (1940) as a general term for the plants living in muddy, loose, wet soils in tropical tide waters. However, the term is applied to the trees or shrubs that grow in the region between high spring tide mark and neap low tide mark (Macnae, 1968; Chapman (1970)) has given world distribution of mangroves where he has mentioned that India has more than 20 species of mangroves. Mangroves and associate species found along the western coast of Maharashtra have been enumerated by Kotmire and Bhosale (1979). According to them the total number of mangroves species along western coast are 21 including associate species. Joshi and Bhosale (1982) have recorded 28 species of mangroves including mangrove grass, brackish water fern and sand binders along western coast of Maharashtra.

The history of study of mangroves can be traced as far back as 1893 when Haberlandt first drew attention to vivipary in these plants. Even before that Schimper (1891) had reported in one of the earlier comprehensive publications that the leaves of mangroves show a special structure which corresponds to that of the Xerophyte leaves. Schimper (1903) has stated that mangroves face 'physiological dryness'. The soils in which mangroves grow are physiologically dry. So Schimper (1903) concluded that problem of halophytes is water balance. Because of this postulation the mangroves were studied for transpiration by Drabble and Hilda (1905), Hill (1908), Halket (1911), Faber (1913, 1923), Johnsen and York (1915), Ursprung and Blum (1916), Harris and Lawrence (1917), Delf (1921) and Braun-Blanquet _et. al_. (1931). Indian mangroves received attention with Blatter (1905) who gave account of mangroves of Bombay. Mullan (1931, 1933) observed some plants with some anatomical features and stated that mangroves possess glands on leaves which were similar to glands observed by Ruhland (1915) in _Statice_. Mullan (1931,1933) has recorded few plants like _Avicennia_, _Aegiceras_, _Acanthus_ and _Clerodendrum_ with salt glands and _Rhizophora_, _Ceriops_ and _Bruguiera_ without salt glands. He has also observed glandular hairs on the stem of halophytes. He further recorded that under glykic condition thickness of leaves is less. Iljin (1932) has recorded salt accumulation in mangroves and concluded that mangroves are physiologically adapted. He has also shown that these plants have more resistance to sodium.

Steiner (1934) has studied halophytes from the aspect of osmotic pressure of cell sap and found that

a) osmotic pressure of cell sap fluctuates with rain fall, a rise in dry weather and fall in wet weather;

b) alternations in osmotic pressure of cell sap in general were an expression of displacement of water content, the changes reflected those of all the osmotic pressure components and were not that of chloride alone;

c) it could not be correlated with external conditions; osmotic pressure showed a relation with Na and Cl ions and salts taken in, formed a controlling mechanism and

d) the osmotic pressure in the cell sap depended on soluble salt contents.

Steiner (1934) also suggested that the sodium component of the cell sap might be greater than could be accounted for by chlorides.

Keller (1925) has noticed succulence and for the first time he suggested that NaCl causes succulence. Early work on mangroves by several investigators has shown that with low salt in substratum rate of transpiration is more, and more salt decreases it (Van Ruhland, 1915; Keller, 1925; Benecke, 1930; Bickenbach, 1932; Schratz, 1934; Adriani, 1937 and Van Eijk,1939). Adriani (1934) has stated that increase in osmotic pressure of soil solution increases osmotic pressure in cell sap. He (1958) has reported ion accumulation is a better adaptation for growth of halophytes. Chapman (1954) has correlated chloride to exchangable Na. Henckel (1950) has proposed that chloride ions are attached to proteins in cells. He (1963) has also stated that property of salt tolerance has been acquired by these plants during process of their own development and mangroves have originated from terrestrial plants.

Walter (1961) has reported that when chloride concentration in soil is higher, permeability of root gets affected and more salts enter into the tissue causing injury. So there is burst of salt. But if chloride concentration in soil is less, salt concentration in cell sap remains higher. Obviously, osmotic pressure is more in cell-sap and water uptake becomes easy. He has classified these plants in mainly three groups as :

1) Excretion type :: Very few halophytes can excrete salts. This salt excretion takes place by certain glandular hairs and it is seen in many mangroves like *Avicennia*, *Aegiceras*, *Acanthus ilicifolius* etc.

2) Regulation type :: The extreme halophytes like *Salicornia*, *Arthrocnemum* and others lack the ability to excrete salts. They are succulent and survive the rising of the salt concentration by a permanent increase of their water content. Hence they become more and more succulent during their development. On the other hand mangroves not having salt excretion do not show such increase of leaf volume with age but the salt concentration in the cell sap remains more or less constant. The method of regulation is not known.

3) Cumulation type :: Here the plants are devoid of any regulatory mechanism. The salt concentration therefore rises more and more during their development and the plant dies when a certain level is reached.

Scholander (1968) has suggested that plants like *Rhizophora* have special ultrafilters due to which they do not absorb salt but exclude it. By this an additional class of mangroves has been considered as Excluding type. Recently Joshi <u>et. al</u>. (1975) also have classified mangroves as

a. <u>Excreting type</u> - <u>Avicennia</u>, <u>Aegiceras</u>, <u>Acanthus</u>.

b. <u>Accumulating type</u> - <u>Sonneratia</u>, <u>Lumnitzera</u>, <u>Salvadors</u>.

c. <u>Excluding type</u> - <u>Rhizophora</u>, <u>Ceriops</u>, <u>Bruguiera</u>.

The mechanism of salt absorption in mangroves has been studied by number of investigators. Pioneer work in this line is due to Epstein (1966), Rains and Epstein (1967) and Rains (1972). It has been reported that there exist two mechanisms, I and II. Here absorption of K depends on concentration of sodium present in the soil. Mechanism I operates below 1mM sodium concentration of soil while mechanism II operates when soil concentration is from 1mM to 10mM Na. Joshi <u>et. al</u>. (1975) reported that mechanism II is operative in mangroves.

All this information indicates that mangroves have special mechanisms for salt regulation like excretion, accumulation and exclusion which permit them to face successfully their natural habitat of salt-stress, though they seem to differ in efficiency for resisting substrate salt content (Mizrachi et. al. 1980). This approach is evident from the growth and survival of mangroves such as Rhizophora mangle, Avicennia nitida and others, grown in an artificial salt concentration gradient (Pannier 1959, Anno 1972, Mizrachi 1978). It has been observed that all species suffered growth reduction and finally death which indicates, that these mechanisms have an appreciable influence on the location and zonal distribution of the same species in the mangrove community.

In addition to adaptations to regulate salts from substrate, mangroves also have some more adaptations. Some mangroves show the presence of vivipary or cryptovivipary to induce salt tolerance in young developing seedlings (Henckel 1963; Bhosale and Shinde 1982). However, some of the representatives like Acanthus ilicifolius do not have viviparous germination. It was observed that in A. ilicifolius there is peculiar mode of vegetative propagation. The adventitious roots are given out from the nodes on the stems which run parallel to the ground. They touch the soil and produce new root system.

It is interesting to note that while other mangroves require crypto or typical vivipary to overcome salinity problems in germination of seeds, the seeds of some mangroves like A. ilicifolius germinate on saline soil in the month of June/July when salinity has been considerably lowered due to onset of monsoon (Joshi et. al. 1975).

During last decade Sidhu (1975) has studied structure of epidermis and stomatal apparatus of some mangrove species. According to him the variations in stomatal and epidermal patterns of fully expanded leaves are functions of genetic differences among species as well as variations in environmental factors such as temperature, humidity and light intensity. In dorsiventral leaves of mangroves, cuticle on the lower leaf surface was invariably thicker than that on the upper surface. Wax coatings were present on both surfaces of leaves of most of the tree species. The upper epidermis cells were larger than lower epidermis. The stomata were restricted to the lower epidermis. A. ilicifolius shows caryophyllaceous type of stomata. Epidermal cells of both, upper and lower epidermis are polygonal, thin walled and without tannins.

Stomatal frequency is 150-175/mm^2 and stomatal index is 22.0. Joshi et. al. (1975) have studied stomatal behaviour in mangroves including Acanthus and have shown that the stomata remain open in early morning. Joshi et. al. (1981) have shown that higher salinity does not alter structure of stomata but reduces their number in case of Salicornia brachiata and Suaeda nudiflora.

Scope of present investigation :

Based on this background present study has been undertaken. A non-viviparous plant, Acanthus ilicifolius, L, belonging to family Acanthaceae has been selected. The results are compared with another salt excreting plant Avicennia marina. Both were grown under laboratory conditions to study the salt tolerance and excretion of salts.

Acanthus ilicifolius a dicot plant is common along the coast in tidal swamps and along the banks of creeks and tidal rivers. It is often called the Sea Holly. Its vernacular name is Marandi. It is distributed along sea coast of India, Ceylon, Malaya, Philippines, Australia, Tropical and South Africa.

The plant, A. ilicifolius Linn. has several stems which are erect, scarcely branched, cylindric, stout and glabrous. Leaves are opposite, deccussate. Leaves like those of the holly, 3-6 by 2-2½ inches; oblong or elliptic, usually pinnatifid or toothed, rigid, acute or truncate at the apex, with sharp spinous teeth on the margin terminating the lateral nerves and the midrib. Nerves are strong conspicuous, petioles 1/4 in long each with two stipules like spines at the base. Flowers are sessile, in opposite pairs, in terminal crowded or interrupted spikes varying much in length (4-15 inches). Flowering takes place in the month of April-May. Flowers are with bracts, which are ½ - 2/3 in. long, ovate, acute, glabrous, bracteoles similar 1/4 - 1/3 in. long. Calyx is glabrous, outer segments 5/8 in. long, elliptic-oblong, obtuse, mucronulate, inner segments 1/2 in. long, oblong, rounded and ciliate at appex., slightly apiculate. Corolla is 1¼ - 1¾ in. long, blue, bilobed with lower lip obovate, nearly 1 in. broad, hairy on the upper surface, very shortly 3 lobed, the lobes rounded, the middle one much narrower than the lateral. Filaments are thick, glabrous, slightly striate. Anthers are densely bearded. Style — glabrous. Capsules — 1 in. long oblong, obtuse, apiculate, brown smooth and shining. Seeds 1/4 in. in diameter broadly avoid or sub-oricular much compressed, testa very lax.

Salt glands, a special feature for adaptation to saline soil, are observed on upper epidermis of the leaf. These salt glands excrete excess salt, present in plant body.

As the plants under investigation are excreting type of mangroves, a review of salt glands is taken into consideration. It is followed by the study of salt gland in _A_. _ilicifolius_. Further the excretion is studied by testing the salt excreted from the leaves under Hoagland solution culture and soil culture conditions. This study is further extended to know the excretion under different salt levels in the substratum.

The plants are treated with different sodium chloride concentrations and the effect of salt on dry matter production is included as the productivity of the plant. This piece of work ends with summary and conclusions followed by a list of references cited in the Results and Discussion. The methods employed alongwith the material selection, have been described earlier to Results and Discussion.

This piece of work is original and it has been mentioned in the statements.