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Salinity Induced Changes in the Leaf Characters of Avicennia Officinalis L. along the Wetlands of Kannur, Kerala, India

Jain James[1], Sreeja. P[2], Chandramohanan. K. T[3]
[1]*PG Student, Department of Botony, Sir Syed College, Kannur, India*
[2,3]*Assistant Professor, Department of Botony, Govt. Brennen College, Kannur, India*

***Abstract*—*Avicennia officinalis* is a dominant mangrove species found growing along the west coast of Kannur district. Leaf character of the mangrove was studied along the wetlands of Kannur district, in relation to station wise variations in salinity. There are variations shown in leaf morphology which indicate the role of abiotic stresses in controlling the growth of the plant. It was noticed that under the conditions of higher salinity, *Avicennia officinalis* showed increased thickness of hypodermal water storage tissue in the leaf (for conservation of water) and produced taller salt extruding glands at the lower epidermis to eliminate more salt on the other hand at lower salinity contrary to above occurred. These changes probably explain the stunted growth of *Avicennia officinalis* in high salinity environment and its vigorous growth at lower salinity.**

Index Terms*—*Avicennia officinalis

Abbreviations

KKCS : Kunhimangalam Kandal Conservation Site
U.E : Upper Epidermis
W.S.T : Water Storage Tissue
S.E.G : Salt Extruding Glands

I. Introduction

Mangroves are salt tolerant angiosperm plants, which are commonly present along the banks of coastal water bodies. They are highly adapted to the saline environment and exhibit a number of unique morphological and eco-physiological adaptations to the coastal environment [1], [2]. Mangroves are one of the world's most threatened ecosystems by mankind.

Mangroves are distributed circum tropically, occurring in 112 countries and territories. Global coverage has been variously estimated at 10 million hectares [3]. In India mangroves forests covers an area of 4,740 sq. km. [4]. Mangroves in Kerala are highly fragmented and are estimated to have less than 50sq.km, existing in discrete and isolated patches [5]. Kannur district of Kerala state, exhibits luxuriant mangrove forests which cover almost 80 % of the total mangrove forests of the state [6].

Avicennia officinalis belongs to family Acanthaceae and is commonly known as white mangrove. This is an evergreen perennial tree; generally attain a height between 15m and 20m; Leaves are simple, cauline, lamina elliptic obovate, broadly ovate or obovate-oblong, entire, lamina length 8cm-12cm and 4.5cm-5.5cm broad,leaves turning black on drying [7].

The mangrove *Avicennia officinalis* has salt storing glands, salt extruding glands, water storage tissue, ability to synthesize and store tannin etc. [9]. The present study aims to evaluate changes in the leaf morphology and anatomy of the mangrove along the anthropogenically stressed wetlands of Kannur in relation to station wise variations in salinity.

A. Study Area

Based on variations in salinity, tidal action, sources of pollution, diversity and distribution of mangroves, five sampling sites were selected.

Station-1 (S1): Kunhimangalam Kandal Conservation Site, KKCS: This is a well conserved site, so the degree of pollution is less. It has relatively more influence of fresh water.

Station-2 (S2): Valapattanam: This station has high anthropogenic activity, as it is close to a fish-landing site. The well-established industries and other developmental activities are a major threat to mangrove diversity in this area.

Station-3 (S3): Cherukunnu: It is a small village; the mangrove diversity is relatively high. The major threat here is non-degradable waste from factories and other domestic wastes directly discharged to the immediate environment.

Station-4 (S4): Koduvally: Fishing is intensively carried out in this region. A portion of the mangrove area was partly destroyed and reclaimed for the construction of a hospital.

Station-5 (S5): Melur: This is a freshwater site predominating with typical freshwater vegetation.

II. Materials and Methods

Quadrat of size 10m x 10m were sampled at different location from the above mentioned site randomly. Three plots are taken to study from a single station. Trees with similar girth at breast height (GBH) are selected to elucidate errors related to difference in age of the plants. Further, 3rd leaves from the each branch tip were sampled. Leaves of each tree are separately collected and labeled in separate polythene bags. Water and soil samples were also collected in small bottles from each site.

Leaf length, width and area were calculated by laying the leaves to be measured on a 1-cm grid and tracing their outlines. The anatomical peculiarities were studied in suitably stained transverse sections, using compound microscope. Measurements of the tissue parts were taken with the help of ocular meter and stage micrometer.

III. Results and Discussion

In the present study ranges in numerical data overlap in all five stations. This is reflected in leaf form parameters of narrowness (L/W) and area (L x W). Station 1 leaves are generally longer whereas leaves from station 3 are generally more-obovate. Smallest leaves are recorded in Station 4. Larger leaves characterized Station 5. Considering the numbers of pneumatophores, highest number of pneumatophores are found in station 2 followed by station 3 and lowest number of pneumatophore are found in station 4 and 5. (Table-1).

The leaf of Avicennia is dorsiventral. Most of the characters show xeric adaptations for conservation of water [8]. A typical transverse section shows the following parts: 1) Upper epidermis, U.E 2) Water storage tissue, W.S.T 3) Mesophyll, 4) Lower epidermis with salt extruding glands, S.E.G.

It was observed that the length of the salt glands varied according to the salinity of the environment. At lower salinity the gland cells were shorter (Fig. 2) in height whereas at the higher salinity the gland cells were taller (Table 2). Water storage tissue also showed changes in thickness at the lower and higher salinities at different stations. At Station 4, when the average salinity was 3082 mg/ml, here the average thickness of water storage tissue was 0.156mm, whereas, in Station 1 and 5 the average salinity was 3040 mg/ml here the thickness of water storage tissue was 0.063mm.Thus it can be inferred that at lower salinity the thickness of the water storage tissue reduced significantly probably because plants do not require more succulence. The palisade tissue also showed slight changes in thickness. The change however was not very evident. The number of salt glands in the lower epidermis of the leaves also increased with the increase in salinity.

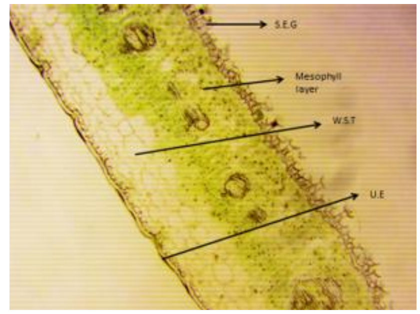

Fig. 1. A typical transverse section of leaf of *A. officinalis*

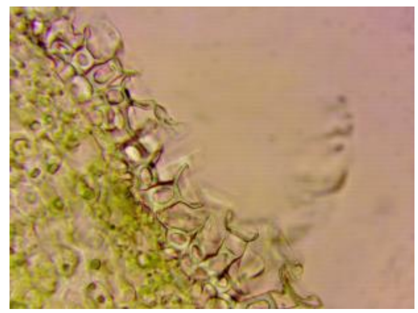

Fig. 2. At lower salinity salt extruding glands are shorter and broader

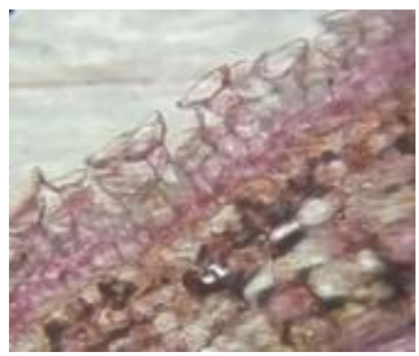

Fig. 3. At higher salinity salt extruding glands are taller and slender

TABLE I
Variations in the Leaf Area. Mean Measurements (cm) and Ranges (in parentheses)

S. No.	Attributes	S1	S2	S3	S4	S5
1	Leaf L (Length)	9.2 (8.5-9.6)	8.5 (8-8.7)	8.9 (7.7-10)	8.1 (7.2-9.5)	9.8 (7.5-10.5)
2	Leaf W (Width)	4.7 (4.3-5.1)	4.1 (3.5-4.6)	4.6 (3.5-5)	4.4 (3.8-4.9)	4.9 (3.8-6)
3	Pneumatophore N(Number)	150 (111-200)	433 (250-700)	433 (250-600)	183 (95-350)	223 (100-350)
4	Leaf L/W	1.95 (1.9-2)	2.1 (1.9-2.2)	2 (1.6-2.3)	1.8 (1.6-2)	2 (1.6-2.4)
5	Leaf L×W	27.5 (25-30.1)	33.5 (32.5-35.4)	30.3 (28-32.9)	26.1 (25.5-26.8)	36.4 (28.5-48.3)
6	Leaf apex	Rounded	Rounded	Rounded	Rounded	Rounded

TABLE II
Mean measurements (mm) and Ranges (in parentheses) of Major Regions in the Leaves of *Avicennia officinalis*

Station	Length of extruding gland cell	Thickness of W.S.T	Thickness of Mesophyll layer	Number of salt gland
S1	0.033 (0.032- 0.034)	0.063 (0.06- 0.064)	0.167 (0.159- 0.169)	26 (25-26)
S2	0.037 (0.036- 0.038)	0.066 (0.061- 0.066)	0.162 (0.151- 0.169)	31 (30-33)
S3	0.042 (0.041- 0.043)	0.071 (0.067- 0.078)	0.156 (0.154- 0.158)	31 (30-32)
S4	0.039 (0.035- 0.042)	0.156 (0.04- 0.58)	0.133 (0.13- 0.14)	22 (21- 23)
S5	0.034 0.034- 0.035	0.063 (0.06- 0.066)	0.164 (0.159- 0.169)	24 (23- 25)

TABLE III
MEAN MEASUREMENTS (MM) AND RANGES (IN PARENTHESES) OF MAJOR REGIONS IN THE LEAVES OF *AVICENNIA OFFICINALIS*

S. No.	Parameters	Result				
		S1	S2	S3	S4	S5
WATER ANALYSIS						
1	pH	6.67	7.14	6.81	6.89	6.67
2	Total dissolved solids, mg/ l	3040.0	3084.0	3079.0	3082.0	3042.0
3	Total Hardness, mg/ l	4726.0	4848.0	4785.0	4656.0	4756.0
4	Total alkinity, mg/ l	87.63	87.63	87.63	87.63	87.63
5	Chloride, mg/ l	14065.50	14296.0	14287.0	14099.0	14079.0
6	Sulphate, mg/ l	1540.0	1816.0	1810.0	1424.0	1424.0
SOIL ANALYSIS						
Macronutrients						
7	Nitrogen(Kg/ha) (kg/**ha)**	1.9	0.39	1.1	1.56	0.39
8	Phosphorous(kg/ha)	14.94	29.88	74.7	44.8	7.47
9	Potassium(kg/ha)	309.1	35.32	383.0	330.4	99.05
Micronutrients						
10	Boron(kg/ha)	2	0.5	0	0	0

On the basis of water and soil analysis it is found that higher salinity is found in S2 followed by S4 and lower salinity is found in S1. The increase and decrease in salinity is likely to cause some stresses in plants growing in that region. pH of water ranges from 6.67-7.14. Comparatively hardness of water is high in S2 (Table 1). Soil analysis results shows that large amount of macronutrients are present in Station 4 and Station 5 is characterized by low macronutrient content.

IV. CONCLUSION

In the present study it became apparent that the mangrove *Avicennia officinalis* showed certain variations in leaf characters with change in environmental factors. A station wise variation in leaf morphology was observed which indicate the role of abiotic stresses in controlling the growth of the plant. Further at higher salinity they showed increased length of the salt extruding glands on the lower epidermis of the leaf, more thickness of the leaf water storage tissue. At lower environmental salinity they showed shorter cells of salt extruding glands on lower epidermis of the leaf, as well as less thickness of leaf water storage tissue as succulence were not required due to availability of fresh water. The plants in high saline areas were observed to spend more energy on growth of salt extruding glands and water storage tissue which lead to their stunted growth. Opposite changes in these structures, at lower salinity stations occurred which favour growth of the mangroves.

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