III

RESULTS AND DISCUSSION

~~~~~~

The term 'mangroves' is applied to woody halophytes, which are shrubs or trees. In such type of plants there are two alternatives of exprimental set up, one is the mature leaves are to be studied for ecophysiological functions or second if entire body of the plant is to be analysed, then seedlings are to be studied. Because uprooting a shrub/tree does not serve the purpose. Therefore, second alternative is prefered. Nevertheless, there can be lot of difference between the species behaviour at seedling stage and at maturity. However, when alternative study is conducted species can be studied at any perticular stage and compared. Hence in present investigation mangrove seedlings become the subject of analysis. The results of analysis are presented in 20 Tables and 8 Figure and are discussed in following pages.

I) Leaf anatomy -

Mangrove leaves have been reported to possess a special structure similar to xerophytic leaves (Shimper, 1891). Mullan(1931,and 1933) described glandular hairs fro
~~~~~~

mangrove leaves and called those structures as salt glands. The structures were assigned a function of salt secretion. Haberlandt (1894, 1918) introduced the term hydathode for the structures secreting water in the liquid state. The epidermal hydathodes secrete, together with water, ions and minerals. They are refered to as salt glands and chalk glands depending on major constituents of secreted solute (Metcalf and chalk, 1950). Considerable literature has accumulated on structure and function of salt glands from time to time (Haberlandt 1914, Ruhland 1915, Skelding and Winterbothum 1949, Campbel and Strong 1964, Osmound, etal, 1969, Fahn, 1979 etc).

Later on the mangroves were classified based on presence of salt gland as excreting type of mangroves. In recent years leaves were studied for the ultrastructure of salt gland and ion transport through the salt glands. Chapman (1976) and Tomlinson (1986) have given good account of leaf anatomy. Mangroves have also been investigated for their Kranz anatomy (Bhosale, 1981, Dongre, 1982). Mulik and Bhosale (1983) and Mulik (1987) studied other aspects of mangrove leaves such as starch distribution patterns.
In all these works one aspect is missing for which present attempt is made.

In the present study transverse sections of leaves of salt exreting mangroves were found to contain oil globules, especially, in *Avicennia* and *Acanthus*. Therefore, other plants were also obeserved for prsence of oil globules. The photographs of some of the species are present in plates 1 and 2. *Acanthus ilicifolius* is known to contain oil in the

Plate - 3

Microphotographs of some transverse sections of leaves of -

a. *A. officinalis* - 10 x 10

b. *A. corniculatum* - 10 x 10

c. *A. ilicifolius* - x450

leaves , which has medicinal value (Chapman, 1976 and percival and Womersley, 1978). However, other mangroves have not been reported so.

It is evident from the plates that the mangrove leaves contain lot of oil. The photographs show that even at seedling stage (T.S.of young leaf of *Sonneratia* , *Lumnitzera* and *Avicennia* plate2(i)) oil is accumulated in the leaves. It is to be noted that the globules are seen only in photosynthetic tissue and not in storage tissue (*Lumnitzera* and *Sonneratia*) which seems to be obvious.

So as to confirm the high levels of oil the leaves were extracted with petrolium ether using Souxhelet apparatus.

Thus the pilot expreiments have shown that the leaves of mangroves contain extractable oil as shown below.

A. officinalis - 1.0 gm / 100 g freshwt.
A. ilicifolius - 1.6 gm / 100 g freshwt.
S. alba - 2.4 gm / 100 g freshwt.
C. tagal - 1.23 gm/ 100 g freshwt.

It seems that there is some correlation between mangrove and oil. It has been reported that mangroves indicate the presence of oil below the vegetation (Saenger et al 1983) as all the types of mangrove studied contain oil there seems to be co-relation between salinity and oil in these plants. However, at this stage enough data is not avialable to say anything conclusively.

II)Moisture percentage -

From Table 1 difference in moisture

Plate - 4

Microphotographs of some transverse sections of leaves of -

a. *L. racemosa* - 10 x 45

b. *S. alba* - 10 x 10

c. *C. tagal* - x450

Table - I

Moisture percentage and dry matter content from mangrove seedlings

		YL	ML	S	R	High - Low
1	SALT EXCRETING *Avicennia officinalis*	74.6 (25.4)	72.50 (27.5)	72.39 (27.4)	81.13 (18.87)	8.74 8.63
2	*Aegiceras corniculatum*	77.26 (22.74)	73.56 (26.44)	77.63 (22.37)	72.80 (27.20)	4.83 4.83
3	*Acanthus ilicifolius*	84.81 (15.19)	85.46 (14.54)	80.35 (19.65)	83.52 (16.48)	5.11 5.11
4	SALT ACCUMULATING *Sonneratia alba*	91.70 (8.3)	92.34 (7.66)	83.48 (16.52)	87.89 (12.11)	8.86 8.86
5	*Lumnitzera racemosa*	84.18 (15.82)	87.28 (12.72)	68.72 (31.28)	68.51 (31.49)	18.77 18.77
6	SALT EXCLUDING *Ceriops tagal*	69.44 (30.56)	68.84 (31.16)	59.59 (40.41)	73.81 (20.19)	14.22 20.22
7	*Rhizophora mucronata*	66.40 (33.60)	70.09 (29.91)	* 66.64 (33.36)* 64.98 (35.02)	80.82 (19.18)	14.42 14.42

Values expressed in g /100 g dwt.
Values in parenthesis are organic matter content.
YL - Young leaves S - Stem
ML - Mature leaves R - Root
* Original hypocotyl region

percentage of three different groups of mangrove seedlings is clearly observed. In salt excreting (secreting) type young leaves show higher levels of moisture content than mature leaves except in A. ilicifolius where mature leaves show slightly higher moisture percentage. In A. corniculatum and A. ilicifolius roots contain low levels of moisture than leaves. While in A. officinalis roots show higher moisture percentage than othr plant parts. Moisture percentage of stem remains in between young and mature leaves. Mature leaves of A. ilicifolius show highest moisture percentage (85.46%) and stem of A. officinalis shows low level of moisture percentage (72.39 %).

In a salt accumulating type, in both plants, mauture leaves show greater levels of moisture percentage than any other part. Where as low levels of moisture percentage are seen in roots (68.51) and stem (83.48) of L. racemosa and S. alba respectively.

Salt excluding type shows elevating levels of moisture percentage in roots of seedlings representing this group. While young leaves of C. tagal and mature leaves of R. mucronata show higher levels of moisture percentage when only leaves are compared. The trend in Rhizophora is similar to the report of Atkinson et al. (1967) where they have shown that in R. mucronata young leaves contain less water which increases with age. As compared to leaves and roots, stem shows low moisture percentage in both the plants.

It can be seen from Table 1 that there is a trend in each of the group where the difference between highest and lowest levels of moisture in the seedling is similar, except Avicennia and Lumitzera (Table 1). Amongest all the seedlings Sonneratia maintains high amount of water in the leaves. Similarly, Lumnitzera also has comparitively higher amount of water content in the leaves. Moisture content from leaves of mature tree has been reported several times in the past (Bhosale,1974; Shinde, 1981 ;Kotmire and Bhosale 1979, 1980 ; Karmarkar, 1986 ; Kotmire and Bhosale, 1986 ; and Sathe, 1981). It has been reported that generally mangrove leaves contain high amount of moisture, however, very little data is avialable on moisture content at the seedling stage. It is to be noted here that water economy is one of the problems that mangroves face. Table 1 depicts the fact that in case of salt excreting (secreting) type of mangroves different organs of the seedlings contain more or less similar amount of water oviwing to small difference between highest and lowest values. In case of salt accumulating type there is considerable difference between water levels of stem and leaves. But the variations in stem and leaves in two salt accumulating species is different. As compared to Lumnitzera , Sonneratia has less difference. It is interesting to note that Ceriops and Rhizophora have almost same difference between lowest and highest values of moisture percentage. This clearly indicates that three groups behave differently to accumulate water in different organs.

III)Dry matter content

Dry matter represents organic matter accumulated as well as minerals in the concerned organ. When water is removed from the organ, dry matter remains which is a measure of phytomass productivity. In present study Table 1 also records the values for dry matter content in different organs of mangrove seedlings. It can be said that in A. officinalis mature leaves and stem attain peak position of dry matter content while young leaves and roots remain at trough position. But in case of A. corniculatum troughs and peaks alternate with each other starting from young leaves ending with roots. Dry matter content of young and mature leaves of A. ilicifolius has lower levels with an elevation in stem and again decrease in roots. Stem of S. alba and stem and roots of L. racemosa show greater dry matter content (accumulation). In both plants mature leaves show low dry matter content. Higher levels of dry matter content in salt excluding type are observed in stem of both species. The mature and young leaves of C. tagal and R. mucronata have more dry matter than roots. Sathe (1991) has reported very high values of organic matter in different species of Avicennia according to him A. officinalis (leaves of mature tree) contain 59.8% organic matter. The maximum value he has reported is about 63% . However, in the present study highest value does not exceed 41% with a minimum of less then 8% . This shows that at seedling stage there is lot of moisture accumulated in the plant body as compared to mature trees or plants.

IV)Biomass content

Attempt has been made to record the per seedling biomass of each species under investigation. It can

Plant		Freshwt/Plant	Dry matter/Plant	Ash/organ
SALT EXCRETING	YL	0.764	0.194	27.16
	ML	0.773	0.213	33.23
Avicennia	S	0.773	0.214	20.12
	R	0.773	0.146	11.70
officinalis	Total	3.083	0.767	92.21
	YL	0.246	0.056	5.15
	ML	0.092	0.024	2.5
Aegiceras	S	0.522	0.117	9.8
	R	0.265	0.072	6.5
corniculatum	Total	1.125	0.269	23.95
	YL	0.102	0.015	1.6
	ML	0.155	0.023	2.5
Acanthus	S	0.368	0.096	9.2
	R	0.232	0.038	3.95
ilicifolius	Total	0.857	0.148	14.95
SALT ACCMULATING	YL	0.248	0.021	2.52
	ML	0.220	0.017	2.4
Sonneratia	S	0.219	0.036	4.3
	R	0.153	0.019	2.58
alba	Total	0.84	0.93	11.8
	YL	0.083	0.013	2.0
	ML	0.076	0.010	1.7
Lumnitzera	S	0.056	0.017	1.9
racemosa	R	0.061	0.019	2.3
	Total	0.276	0.059	7.9
SALT EXCLUDING	YL	0.364	0.111	10.00
	ML	0.292	0.091	8.2
Ceriops	S	10.62	4.29	514.8
	R	0.804	0.211	29.5
tagal	Total	12.08	4.70	562.5
	YL	1.23	0.41	41.0
	ML	2.15	0.64	64.0
	S'	14.83	4.95	485.1
Rhizophora	S	31.46	11.02	881.6
mucronata	R	2.51	0.48	77.8
	Total	50.03	17.5	1549.6

be seen from Table 2 that in case of A. officinalis contribution of different organs to the seedling biomass is equal but in case of rest of the two species in the group, stem has major contribution. In case of A. officinalis mature leaves have higher ash percentage indicating more minerals whereas in case of A. corniculatum and A. ilicifolius higher ash percentage is of the stem, (Figure 2 & 3).

In salt accumulating type again there is more or less equal share to the biomass by different organs. In case of Sonneratia stem shows higher percentage of ash, however, in Lumnitzera it is the root. In case of salt excluding type of mangrove seedlings major contribution to the seedling biomass is due to stem. The ash content per seedling also has major contributon from stem in these two species (Table 2)

It can be said that biomass production by the species at seedling stage depends much upon what type of species it is. Further, the contribution of different organs is also specific to the mode of reproduction. (vivipary, cryptovivipary or no vivipary). In viviparous seedlings original hypocotyl has highest mass which continues further.

A) Macro elements

Sodium (Na)

Amongst the essential nutrient elements sodium was not included initially. But later on ample literature has accumulated indicating essetiality of sodium for certain plants. The classic example of Atriplex vesicaria (Adriani,1958) can be given. Not only this species but other species of Atriplex and many other halophytes depend upon Na for their full growth. As the mangroves grow in the intertidal zone along estuaries and creeks, and as the soil and water flooding the plants have Na as major constituent, determination of sodium becomes necessery. As a matter of fact, mangroves are said to face problems to avoid sodium and take up potassium (Joshi et al. 1972).

From Table 3 it is clearly observed that sodium values estimated from dry matter by wet digestion and from ash estimation closely match. The table indecates that roots and mature leaves of all plants show high levels of sodium content, in case of salt secreting type; where as low levels of soduim are observed in stem and young leaves except in A. officnalis where young leaves show highest level of sodium. Roots of A. ilicifolius show elevated levels of sodium content than any other part as well as remaining seedlings. The values for sodium in the leaves of maturre plants have been reported from time to time (Joshi, 1975; Joshi and Shinde, 1978 ; Bhosale, 1978 ; Joshi and Bhosale, 1982; Karmarkar, 1986; Mulik and Bhosle, 1986). There is very wide

Table - III

* Sodium from different parts of mangrove seedlings

		YL	ML	S	R	High-Low
1	SALT EXCRETING Avicennia officinalis	2.7 (2.06)	2.4 (1.85)	2.0 (2.06)	2.6 (2.69)	0.7 (0.8)
2	Aegiceras corniculatum	1.7 (1.85)	2.6 (2.70)	1.7 (1.85)	2.9 (2.9)	1.2 (1.1)
3	Acanthus ilicifolius	3.8 (3.97)	5.0 (5.45)	4.1 (4.18)	5.24 (5.03)	1.4 (1.4)
4	SALT ACCUMULATING Sonneratia alba	6.5 (6.51)	7.56 (7.57)	3.13 (3.12)	2.88 (2.70)	4.68 (4.88)
5	Lumnitzera racemosa	0.69 (0.15)	2.4 (2.48)	1.44 (1.42)	1.25 (1.00)	1.71 (2.33)
6	SALT EXCLUDING Ceriops tagal	2.0 (2.06)	2.6 (2.07)	1.4 (1.42)	2.6 (2.70)	1.2 (1.3)
7	Rhizophora mucronata	1.1 (1.42)	1.1 (1.42)	* 2.0 (1.64)* 1.4 (1.21)	4.7 (3.97)	3.6 (2.76)

Values expressed in g /100 g dwt.
Values in parenthesis are from ash, expressed as g /100 g dwt.
YL - Young leaves S - Stem
ML - Mature leaves R - Root
* Original hypocotyl region

range of sodium values from 00.2 % to 3.3 % on dry weight basis depending on the location and the season. Mulik and Bhosale (1986) found in A. ilicifolius that sodium values of mature leaves and seeds are very close in case of samples collected from Bankhind and Ganapatipule; however , there is more difference in two values for the samples collected from Bhateye estuary. Higher levels of sodium in the seeds as compared to leaves may play some role in seed germination directly on the ground (no vivipary). After the development of seedling from such a type of seed it shows tendeney of further accumulation of sodium. That is why in the present study, very high levels of sodium are found.

It may be noticed that in a salt excreting type of mangrove seedlings sodium remains highest in the roots. Mature leves of S. alba and L. racemosa seedlings have highest sodium content. S. alba mature leaves show high level than not only other part but also other mangroves. The lower levels are recorded for roots except the young leaves of L. racemosa. The values reported by Joshi and Bhosale (1982) in the mature leaves of these two species are more than 5 %. Those reported by Bhosale (1982) are 2.8 and 3.24 for S. alba and L. racemosa, respectively. In this comparison present, values are very high in case of S. alba and low in L. racemosa as they are 7.56 and 2.4 for S. alba and L. racemosa, respectively.

Roots of R. mucronata have greater sodium content. In C. tagal higher sodium is found in mature leaves and roots (same level). In case of young and mature leaves of

R. mucronata sodium content is very low as compared to other parts of seedling and other seedlings, possibly, indicating its nature.

So far as sodium is concerned there seems to be some kind of check or barrier between the roots and other organs, especially, in case of *R. mucronata*. In case of *Ceriops* though there is a drop in the level of sodium from roots to stem the leaves contain high amount of the element. It seems possible that for the uptake and translocation of sodium these two species have different mechanism. Surprisingly very high level is observed in roots of *R. mucronata* which is in contradiction with presence of ultrafilter in the roots of *Rhizophora* proposed by scholander (1968). Field (1986) has doubted the presence of this kind of tissue filter located in the roots.

A report from Popp (1984) states that leaf age did not appear to affect Na and Cl storage much ; but concetrations of So_4 and Mg increases in old leaves of salt secreting species and members of Rhizophoraceae. Nevertheless, in present study salt secreting, salt accumulating and other mangroves except *R. mucronata* show elevated levels of Na in old leaves than young ones. According to Flowers et al.(1977) atleast 80 % of the Na is present in the leaves of excluding type of halophytes. Karkar (1984) and Karkar and Bhosale (1986) have reported Na from different parts of the seedlings of *R. mucronata* and *Kandelia candel*. According to them leaves of seedlings contain higher levels of Na than the leaves of mature tree. Similar observation was due to Chapman (1944). He showed, in case of Avicennia germinans that sodium chloride concentration in the leaves of mature plant is low (5 %) than that of seedling leaf (30.5%) . Their study shows that at seedling stage higher amount of sodium is absorbed ; may be either it is required or there is no check, at seedling stage, on the absorption of sodium. The latter case seems to be not possible as unchecked sodium uptake may harm the seedling. Higher levels of sodium in the leaves rather than stem or root (except R. mucronata) recorded in present study support this view.

Table 11 represents distribution of different elements in a single seedling of A. officinalis. Similarly Table 12-17 represents the same for different species. It is evident from all these Tables that the total sodium present in a single seedling of A. officinalis (Table 11) is 18.43 mg which is 26.8 % of the total minerals investigated and about 20 % of ash. This value for A. corniculatum is 30 % when compared to other elements studied, however, in relation to ash content it is only 23.7 %. Though A. ilicifolius is classified as salt secreting type it seems that the species accumulates Na. In this species sodium represents 44.4 % of ash and 43 % of the minerals studied. Joshi and Bhosale (1982) have classified A. ilicifolius as salt accumulating type of mangrove which seems to be reasonable. On these grounds. In case of S. alba sodium is 36.8 % of ash and 40.2 % of the minerals studied. These values are very close to A. ilicifolius. Another succulent mangrove L. racemosa shows only 13 % of the minerals studied and about 10 % of ash. In

C. tagal and R. mucronata soduim contributes to about 26 % of elements recorded. However, they differ with respect to percentage on the basis of ash. On the basis of sodium content Sidhu (1963) considered three catogories of mangroves

(i) Species with more than 5 % Na - *A. marina* and *Salvadora persica*.

(ii) Species containing 3 to 5 % Na - *A. alba*, *L. racemosa*, *C. tagal*, and *A. ilicifolius*

(iii) Species with 1 to 3 % Na - *A. officinalis*, *R. mucronata*, *A. corniculatum*, *E. agallocha*, and *Derris* etc.

If the mangrove seedlings are to be classified on above lines it can be seen that *A. ilicifolius* falls in the catogory of 3 to 5 % Na, where as *S. alba* falls in different catogory not mentioned by Sidhu, i.e. above 5 % (for this only leaves are considered). The rest of the mangrove seedlings show less than 3 % sodium. Thus the catogories are considered as follows, for the seedlings.

a) less than 3 % ,

b) 3 to 5 % and

c) above 5 % .

Based on Sodium three categories of mangrove seedlings are considerd as less than 3 % , 3-5 % and above 5 % .

Thus it is found in the present study that mangrove seedlings absorb large amounts of Na. It is obvious because Na is the major cation present in mangrove environment, i.e. the soil and flooding water.

Potassium (K)

In the biological world potassium has unique place it is the only monovalent cation recognized as essential for metabolic processes except a few micro-organisms (Epstein, 1972). According to Larsen (1967) the problem of salt tolerance is linked with potassium uptake. Even though mangroves depend on sodium, potassium is equally essential. Joshi et al. (1972) have stated that real problem of mangroves is to absorb more potassium in presence of higher levels of sodium in the external environment.

In the present investigation potassium distribution in different organs of the mangrove seedlings is studied. Table 4 records the values of potassium on the basis of dry weight (wet digestion method). It also shows potassium content estimated from ash. In case of A. officinalis these values are very close. These two values give the range of variation for remaining seedlings.

It is seen from the table that young leaves in comparison with mature ones contain higher amounts of potassium except in L. racemosa. In case of A. corniculatum and R. mucronata K levels of young and mature leaves of seedlings are same. When comparison is made between all organs it is seen that potassium values are highest either in

Table - IV

Potassium from different parts of mangrove seedlings

		YL	ML	S	R	High - Low
1	SALT EXCRETING *Avicennia officinalis*	2.0 (2.24)	1.75 (1.82)	2.25 (2.24)	1.25 (1.21)	1·00 (1·03)
2	*Aegiceras corniculatum*	0.5 (0.38)	0.5 (0.38)	1.0 (1.21)	1.0 (1.21)	0·5 (0·8)
3	*Acanthus ilicifolius*	1.75 (2.44)	1.25 (1.41)	2.0 (2.24)	2.55 (2.85)	1·3 (1·4)
4	SALT ACCUMULATING *Sonneratia alba*	1.25 (1.41)	.75 (0.59)	1.25 (1.41)	2.00 (0.79)	1·25 (0·82)
5	*Lumnitzera racemosa*	0.25 (0.38)	0.75 (0.79)	1.00 (1.21)	0.75 (0.79)	0·75 (0·83)
6	SALT EXCLUDING *Ceriops tagal*	1.0 (1.21)	0.5 (0.38)	0.25 (0.18)	0.5 (0.38)	0·75 (1·03)
7	*Rhizophora mucronata*	0.5 (0.59)	0.5 (0.59)	* 0.25 (0.38)* 0.5 (0.38)	0.5 (0.59)	0·25 (0·21)

Values expressed in g /100 g dwt.
Values in parenthesis are from ash, expressed as g /100 g dwt.
YL - Young leaves S - Stem
ML - Mature leaves R - Root
* Original hypocotyl region

stem or root except *Ceriops* where they are highest for young leaves. *R. mucronata* shows same levels in the all the parts. Bhosle(1978) has recorded potassium values from the leaves of mangroves from two places Deogad and Mumbra. *A. officinalis* has 1.07 % and 1.8 % potassium which is very close to the present values recorded for the mature leaves. *S. alba* has been shown to contain 0.8 % and 0.72 % K. In that comparison present value of 0.72 is very close. Similarly, for the rest of the plants also the present values are close to the ones recorded by Joshi(1976) and Bhosale (1978). However, present values differ from the ones reported by Joshi and Shinde (1978) for the mangroves leaves from Terekhot and Chiplun. This indiciates that the location of mangrove occurrence is important .

As seen from Table 18 potassium does not show perticular trend with respect to its distribution in different organs. This may be because of existance of K-mechanism in these plants which has been indicated by Black (1960). Only observation which can be made is the highest value is not recorded for mature leaf in any of the seedlings. It is believed that more potassium is required by and / or translocated to the young growing parts (Joshi et al., 1972 ; 1975, and Joshi, 1976). Nevertheless, in present study highest values for potassium are recorded in majority cases for roots and stems. Similar observation is due to Kulkarni and Bhosale (1989) where two species of *Rhizophora* were analysed and compared with mature leaves.

In the present observations, on the basis of entire seedling, *A. officinalis* shows 15.6 % K of total ash of the seedling. This forms 20.7 % of total minerals investigated (Table 11). These values for seedling of A. coriculatum are low (Table 12). The total K per seedling of A. coriculatum is 2.29 mg. The third salt excreting mangrove Acanthus has silghtly higher value than Aegiceras. The total K content of the seedling is 2.96 mg. In case of Sonneratia and Lumnitzera very low levels of K are observed, that is, 1.23 mg /seedling and 0.42 mg/seedling, respectively . In Sonneratia this level is about 10% which is approximatly 6% of total minerals(Tables 14 & 15). Rhizophora and Ceriops have large amount of K as compared to other seedlings. Nevertheless, the percentage contribution of potassium to the ash is 2.4 and 4.8% in C. tagal and R. mucronata , respectively , (Tables 16 & 17).

This study shows that even at seedling stage luxury uptake of K is not visible. However, Na might not have affected K absorbtion and it may be true that there exists a seperate mechanism for K uptake which is independant of Na . This can be further clearified by taking into consideration relative values of K and Na.

Sodium / Potassium (Na/K)

The values of Na/K ratio are recorded in Table 5. It is interesting to note that in almost all seedlings this ratio is dropped in young leaves than mature ones . As compared to other organs mature leaves to be store houses for Na or it can also be said that very less potassium is accumulated in these organs , owing to high Na/K ratio. The drop in value of the ratio in case of S. alba is by about

Table - V

Sodium to Potassium ratio from different parts of mangrove seedlings

		YL	ML	S	R	High-Low
1	SALT EXCRETING *Avicennia officinalis*	1.35	1.37	0.89	2.08	1.19
2	*Aegiceras corniculatum*	3.4	5.2	1.7	2.9	3.5
3	*Acanthus ilicifolius*	2.17	4.0	2.05	2.05	1.95
4	SALT ACCUMULATING *Sonneratia alba*	5.2	10.08	2.50	1.44	8.64
5	*Lumnitzera racemosa*	2.76	3.2	1.44	1.67	1.76
6	SALT EXCLUDING *Ceriops tagal*	2.0	5.2	5.6	5.2	3.6
7	*Rhizophora mucronata*	2.2	2.2	* 8 2.8	9.4	7.2

Values expressed in g /100 g dwt.

YL - Young leaves
ML - Mature leaves
S - Stem
R - Root

* Original hypocotyl region

50% . Similar is the observation with *A. ilicifolius*. According to Rains and Epistein(1972) K : Na ratio in sea water is 1:40 this is reduced to 1 : 7 in plants. According to Joshi et al. (1972) this ratio is 1:0.98 in Ceriops for hypocotyl.

In present study the seedling of *C. tagal* shows higher value for this ratio. This indicates the tolerence to sodium. Eventhough the works of Ayers (1951) and Sutcliffe(1962) have shown efficient mechanism of potassium uptake, in present study the ratio seems to be high, especially because the study material is seedling (Supposed to be sensetive to salts). According to Joshi et al.(1975) mangroves acquire salt tolerance by increasing K uptake. Shinde and Bhosale (1986) have shown that *A. corniculatum* seedlings grown under cultural conditions and treated with NaCl and Na_2SO_4 have decreased levels of K with increasing salt concentration. But the Na levels go on increasing resulting in lower Na/K ratio. This indicates that seedlings of *Aegiceras* are not capable of acquiring salt tolerance *in vitro* by increasing K uptake. Thus K mechanism in mangrove seedlings remains unclear. But it can be seen that it is not only Na or K that is important from the point of view of metabolic process, it is the relative amount of these two monovalent cations, which is more important. Therefore Na/K ratio is considerably droped in young leaves of mangrove seedlings.

Calcium

Calcium is an important divalent cation. According to Epstein (1972) the adequate value for Ca is 0.5

% on dry weight basis. However, it has been found that in many plants values of 3.5 % exist (Ferry and Ward, 1959.) Table 6 depicts the values for Ca in different mangrove seedlings by acid digestion method. While Table 8 records the values for Ca extracted from ash of different parts of mangrove seedlings. From Table 6 it is observed that lowest values are from roots of the seedlings of salt excreting group, while highest values are reported from stem, mature leaf and young leaf of A. officinalis, A. corniculatum and A. ilicifolius, respectively. The mature leaf of S. alba and stem of L. racemosa show presence of high levels of calcium. The stem and young leaf of S. alba and L. racemosa respectively, are with low levels. Ca level in stem of L. racemosa are higher than other seedlings. C. tagal and R. mucronata from salt excluding group follow similar trend in case of highest and lowest Ca levels. Highest Ca levels in both plants are from mature leaves while low levels are present in stem of both seedlings.

Ca is thought to be immobile element (Epstein ; 1972). Calcium fluxes or calcium transport mechanisms across the plasma memberane have been known to be affected by various primary signals including light, growth substances, and gravity (Allan and Trewavas 1987). However, little is known about movement of clacium between organells and cytoplasm in responce to these signals (Allan and Hepler 1989). Calcium is a second messenger for a varity of fundamental and specilized cellular activities in biological cell. Activation of plant cell by primary signals elivate the intracellular free calcium. The response to this higher level

Table - VI

Calcium from different parts of mangrove seedlings

		YL	ML	S	R	High-Low
1	SALT EXCRETING *Avicennia officinalis*	0.90	0.87	1.00	0.61	0·396
2	*Aegiceras corniculatum*	0.472	0.476	0.448	0.388	0·088
3	*Acanthus ilicifolius*	0.708	0.704	0.612	0.372	0·336
4	SALT ACCUMULATING *Sonneratia alba*	1.02	1.476	0.812	1.136	0·664
5	*Lumnitzera racemosa*	1.00	2.056	2.736	1.6	1·736
6	SALT EXCLUDING *Ceriops tagal*	0.512	0.608	0.452	0.54	0·156
7	*Rhizophora mucronata*	0.892	0.932	* 0.64 0.504	0.628	0·428

Values expressed in g /100 g dwt.

YL - Young leaves S - Stem
ML - Mature leaves R - Root

* Original hypocotyl region

calcium possibley function through calcium binding proteins ; one of such being Cal-modulin the most ubiquitos (Allan and Hepler 1989) at this juncture of study it is not possible to know about Cal-modulin in mangroves. However, in case of mangroves clacium uptake seems to be efficient. Joshi and Bhosale (1982) have reported Ca values as high as 5.88 % in Salvadora persica. In case of L. racemosa Ca percentage was shown to be 2.17. In almost all mangrove species they have reported Ca above 1 % except for Acanthus and Aegiceras. This indicates that none of the mangrove species is defficient in Ca. In the present study Lumnitzera seedlings seem to be efficient in Ca uptake (Table 6). There is lot of difference (Table 6 and 8) between the Ca values obtained by wet digestion method and ash extraction. That means for Ca the method of extraction may have significance (which is not so for Na and K).

It has been reported by Joshi and Bhosale (1982) that salt tolerance of saline plants is developed by the capacity to increase uptake of Ca and K from Na rich environment. According to them seasonal variation in Ca has shown higher levels for some of the mangroves in summer. Which is indicative of role of Ca in salt tolerance. In present study higher levels of calcium are found in Sonneratia and Lumnitzera may be due to their accumulative nature. It may be noted that except A. corniculatum all seedlings show more than 0.5 % Ca, the amount supposed to be adequate. It is observed from Table 18 that it is only A. ilicifolius where highest level of Ca is found in young leaf and it is only L. racemosa where young leaves show lowest Ca.

In none of the seedlings mature leave show lowest levels.

On the basis of single seedling (Tables 11 to 17) high level of Ca is found in Ceriops and Rhizophora but the percentage contribution either to ash or total elements is less than salt accumulating type, especially, L. racemosa. In salt excluding mangroves per seedling values indicate that Ca is second highest cation however, in Lumnitzera it is the highest element , where Na is very close to it. But in rest of the plants it is the third highest element except Acanthus where Ca value is slightly less than mangnesium. Thus the study indicates that the seedlings have different perference for different elements, especially, K and Ca. It is quite interesting to note that in Ceriops and Rhizophora Ca is prefered over K. For salt excreting type and Sonneratia K is the second highest cation. All these observations lead to the conclussion that though Ca is divalent, immobile element it plays important role in ion regulation of mangroves, at least at seedling stage.

Magnesium (Mg)

Another macroelement and a divalent cation is magnesium. In glycophytes 0.2 % Mg is supposed to be sufficient for normal growth (Epstein, 1972). In mangroves Mg values are recorded higher than this. Kotmire and Bhosale (1979) have recorded a range for Mg values from leaves of mangrove plants as 0.31 to 1.66 %. The present observations are on similar lines (Table 7). Magnesium determined from ash shows very high levels and differs much from the values obtained by wet digestion method (Table 8). It is evident

Table - VII

Magnesium from different parts of mangrove seedlings

		YL	ML	S	R	High -Low
1	SALT EXCRETING *Avicennia officinalis*	0.84	0.64	0.52	0.72	0.32
2	*Aegiceras corniculatum*	0.56	0.60	0.32	0.36	0.28
3	*Acanthus ilicifolius*	0.88	1.04	0.32	0.74	0.72
4	SALT ACCUMULATING *Sonneratia alba*	0.88	1.08	1.28	0.64	0.64
5	*Lumnitzera racemosa*	0.36	0.8	0.48	0.44	0.44
6	SALT EXCLUDING *Ceriops tagal*	0.52	0.44	0.24	0.52	0.28
7	*Rhizophora mucronata*	0.88	1.12	* 0.32 0.44	0.56	0.56

Values expressed in g /100 g dwt.

YL - Young leaves
ML - Mature leaves
S - Stem
R - Root

* Original hypocotyl region

Table - VIII

Calcium and Magnesium extracted from ash of different parts of mangrove seedlings

		YL	ML	S	R	
1	SALT EXCRETING *Avicennia officinalis*	0.296	0.14	1.94	0.25	Ca
		1.52	1.04	0.56	1.24	Mg
2	*Aegiceras corniculatum*	0.186	0.272	0.172	0.09	Ca
		0.62	1.16	0.38	0.52	Mg
3	*Acanthus ilicifolius*	0.172	0.158	0.49	0.256	Ca
		0.84	2.92	1.58	0.82	Mg
4	SALT ACCUMULATING *Sonneratia alba*	1.89	0.84	0.69	0.97	Ca
		0.74	0.68	2.22	0.56	Mg
5	*Lumnitzera racemosa*	2.82	0.786	0.368	0.164	Ca
		1.46	1.06	1.02	1.22	Mg
6	SALT EXCLUDING *Ceriops tagal*	0.418	0.314	4.82	3.52	Ca
		1.14	1.26	2.82	1.22	Mg
7	*Rhizophora mucronata*	0.102	0.104	* 0.11 0.096	0.104	Ca
		0.78	0.64	* 1.86 1.72	0.36	Mg

Values expressed in g /100 g dwt.

YL - Young leaves S - Stem

ML - Mature leaves R - Root

* Original hypocotyl region

from Table 18 that highest value for Mg is in the leaves, either mature or young. However, in Sonneratia highest value is for the stem. It is quite interesting to record lowest values for stem. This indicates translocation of the element to the leaves and further its accumulation in the leaf. In Sonneratia, perhaps the translocation is slow and therefore, accumulation appears in stem.

On the per seedling basis (Table 11 to 17). Mg content of Avicennia seedling is 5.15 mg whereas it is 1.03 and 0.88 for Aegiceras and Acanthus, respectively. Mg stands fourth in the descending order of mineral elements investigated. However , in Acanthus it is third, differing marginaly from Ca, which is the fourth element. Interestingly enough, the difference between values for the third and the fourth element is very less for all seedlings except Lumnitzera. For salt excreting type of mangroves and Sonneratia it is the difference between Ca and Mg. In Ceriops and Rhizophora K is third and Mg is fourth and difference between these two values is very less. From this one thing is seen that Rhizophor and Ceriops form a distinct group.

Closeness of the values for third and fourth rank elements (values in desending order) indicates that uptake and /or distribution of these two elements is interlined. Thus, for the regulation of third order element the fourth order one, namely, Mg is directly or indirectly responsible it can be vice versa. Moreover, though there is a slightly higher accumulation or absorption of third order element. It can be said that more or less equal preference is given to both the elements.

B) Microelement (Trace-element)

Iron (Fe)

Amoungest trace metals Fe is important and many a times shows considerable quantities in plant tissues. Its role in plant metabolism is well known but its role in salt tolerance of plant is occure. So for as Indian mangroves are concerned some data is avialable on mineral composition due to the reports of Sidhu (as sited by Walsh, 1974). Joshi (1973),Bhosale (1979) Kotmire and Bhosale (1979 and 1980), Untawale et al. (1980), Bhosale et al. (1983), Subramanian and Venugopalan (1983), Kulkarni and Bhosale (1989), Kulkarni (1990), and Bhosale (1990).

In present study Fe values are high as compared to earlier reports. However, Untawale et al. (1980) could record similarly high values for Bruguiera gymnorrhiza as 2.2 % . It is evident from Table 9 that the lowest value amongst all seedlings is for the root of A. coriculatum (0.218). The highest value has been recorded in S. alba for roots only (2.90). When different organs are compared highest values are recorded either for the stem or root. For salt excreting type stem shows maximum value whereas , rest of the two groups have highest value for root except C. tagal where stem and roots have almost the same level of Fe. Values recorded in the present study and also by Untawale et al. (1980) indicate that for mangroves Fe is not a trace metal but they can absorb enough quantities of it without any toxicity symptoms. The present study has observed 2.9 % Fe in roots of S. alba as the highest level. Kotmire and Bhosale

Table - IX

Iron from different parts of mangrove seedlings

		YL	ML	S	R	High-Low
1	SALT EXCRETING *Avicennia officinalis*	0.428	1.204	2.15	0.518	1·722
2	*Aegiceras corniculatum*	0.234	0.378	0.780	0.218	0·562
3	*Acanthus ilicifolius*	0.232	0.234	1.05	0.66	0·818
4	SALT ACCUMULATING *Sonneratia alba*	0.782	0.698	1.810	2.90	2·202
5	*Lumnitzera racemosa*	0.29	0.644	0.366	0.974	0·634
6	SALT EXCLUDING *Ceriops tagal*	0.286	0.562	0.734	0.730	0·448
7	*Rhizophora mucronata*	0.344	0.330	* 0.458 0.389	0.690	0·360

Values expressed in g /100 gdwt.

YL - Young leaves
ML - Mature leaves
S - Stem
R - Root

* Original hypocotyl region

(1979) have reported maximum value of 2.8 % for Halophila becarii and 2 % for Lumnitzera racemosa. It is to be mentioned that the values compared with present observations are for leaves of mature trees whereas in present study different parts of seedlings are analysed.

Kulkarni (1990) has analysed R. mucronata propagules for distribution of Fe along the length. He has reported highest values for middle part of the hypocotyl and moderate values for proximal and distal parts. His observations on R. apiculata show similar trend. It seems that when Rhizophora propagule is released from the mother plant and establishes itself into a seedling its iron strategy changes. It is possible that distribution of Fe, after its absorption, in the plant body depends upon the need for the organ and the state of translocation. Thus it is very likely that at seedling stage translocation of Fe is slow or the stem and root can accumulate it for some time (Table 18). Slow translocation of Fe in glycophytes has already been reported. Subramanian and Venugopalan (1983) have reported that roots have very high levels of Fe as compared to leaf in A. marina and R.mucronata ; this is coinsiding with present observations.

Iron on per seedling basis is depicated in Tables 11 to 17. It is found that Fe values can be considered at three levels as upto 5 ; 5-10 and ; above 10 percent of ash. Though Fe is supposed to be microelement its level in mangrove seedlings is pretty high, even more than some of the major element. It can be seen from Tables 11 to 17 that in R.

mucronata Fe value is very close to K value, a very vital element. In case of *C. tagal* Fe is considerably in more quantity than K. In case of salt accumulating type *Lumnitzera* both elements show values near to each other while *Sonneratia* has slightly higher level of Fe. The salt excreting groups shows that the level of K is higher than that of Fe.

As it has been discussed earlier the elements of position three and four possibly compite with one another whereas Fe seems to compete with K though the valancies of elements are different. Thus for mangroves Fe can be identified as a macroelement.

C) Chloride (Cl)

Mangrove habitat is rich in sodium chloride, obviously, because flooding water has sodium chloride as the major salt. Therefore, amongst the anions, chloride becomes important contributor. The requirement of chloride for the growth of higher plants was reported by Broyer et al. (1954). According to Woolley and Broyer defficiency symptoms first appear in mature leaves and, then on old and young leaves. Beadle et al. (1957) reported that in case of salt rich plants Cl always dominates amoung the anions. Therefore, in present study Cl concentration in the different parts of mangrove seedlings has been determined.

Table 10 records the values for Cl. In salt accumlating type mature leaves show higher levels of Cl as compared to the same organ of other seedlings. Walter (1955) suggested that the succulence in halopytes is due to Cl ions.

Table - X

Chloride content (from ash) of mangrove seedlings

		YL	ML	S	R	High-Low
1	SALT EXCRETING *Avicennia officinalis*	3.19	3.16	3.13	3.1	0.09
2	*Aegiceras corniculatum*	2.81	2.88	2.81	2.79	0.09
3	*Acanthus ilicifolius*	2.85	2.91	2.79	2.85	0.12
4	SALT ACCUMULATING *Sonneratia alba*	2.54	3.7	2.57	2.88	1.16
5	*Lumnitzera racemosa*	10.47	8.05	3.08	6.29	7.39
6	SALT EXCLUDING *Ceriops tagal*	3.21	3.19	3.16	3.13	0.08
7	*Rhizophora mucronata*	3.17	3.19	* 3.21 3.17	3.19	0.04

Values expressed in g /100 g dwt.

YL - Young leaves S - Stem
ML - Mature leaves R - Root

* Original hypocotyl region

Hence in the present observation Sonneratia and Lumnitzera which are sucuclent species show higher chlorides. Lumnitzera has very high chloride content in young leaves (10.47 %). Similar observations have been reported for R. apiculata by Karkar and Bhosale (1986). Woolley et al. (1958) reported that chloride is translocated from older to younger leaves and from high concentrations to lowest ones. This explains higher values for Cl in young leaves of Lumnitzera. In other seedlings there is marginal difference between chloride values of young and mature leaves. It is evident from Table 10 that there is no major difference between the levels of chloride in different organs of a seedling except salt accumulating mangroves.

Tables 11 to 17 indicate that major weight of the seedling ash is contributed by Cl which can be as high as 49.24 % (L. racemosa). When Cl is compared with other elements investigated its percentage goes very high except A. illcifolius and S. alba where it is similar to its percentage contribution to ash. The table further indicate that there cannot be any other anion, the level of which could be more than Cl except exduding type of mangroves. In Rhizophora and Ceriops there is a large gap in the ash per seedling and the total of the elements studied. So it is possible that in these two plants there can be other anions or elements which have higher leavels than Cl.

Table - XI

Distribution of ash and some mineral elements in the seedlings of *A. officinalis*

		YL	ML	S	R	Total	% Contr. to ash	% Contr. to el. total
1.	Ash	27	33	20	11.70	91.7		
2.	Sodium	5.24	5.11	4.28	3.80	18.43	20.10	23.82
3.	Potassium	3.88	3.73	4.82	1.83	14.26	15.55	18.43
4.	Calcium	1.75	1.86	2.15	0.89	6.65	7.25	8.60
5.	Magnesium	1.63	1.36	1.11	1.05	5.15	5.62	6.66
6.	Iron	0.8	2.6	4.6	0.75	8.75	9.54	11.31
7.	Chloride	6.19	6.73	6.69	4.52	24.13	26.3	31.19

Value expressed in mg /100 g dwt

YL - Young leaves
ML - Mautre leaves
S - Stem
R - Root

Table - XII

Distribution of ash and some mineral elements in the seedling of *A. corniulatum*

		YL	ML	S	R	Total	% Contr. to ash	% Contr. to el. total
1.	Ash	5.1	2.5	9.8	6.5	23.9		
2.	Sodium	0.95	0.62	1.99	2.09	5.66	23.7	29.8
3.	Potassium	0.28	0.12	1.17	0.72	2.29	9.58	12.06
4.	Calcium	0.26	0.11	0.52	0.28	1.17	4.90	6.16
5.	Magnesium	0.31	0.14	0.32	0.26	1.03	4.31	5.42
6.	Iron	0.13	0.091	0.91	0.16	1.29	5.40	6.79
7.	Chloride	1.57	0.69	3.28	2.01	7.55	31.6	39.76

Values expressed in mg /100 g dwt

YL - Young leaves
ML - Mautre leaves

S - Stem
R - Root

Table - XIII

Distribution of ash and some mineral elements in the seedlings of *A. ilicifolius*

		YL	ML	S	R	Total	% Contr. to ash	% Contr. to el. total
1.	Ash	1.6	2.5	9.2	4.0	17.3		
2.	Sodium	0.57	1.15	2.95	1.99	6.66	38.50	39.76
3.	Potassium	0.26	0.29	1.44	0.97	2.96	17.11	17.67
4.	Calcium	0.11	0.16	0.44	0.14	0.85	4.9	5.08
5.	Magnesium	0.13	0.24	0.23	0.28	0.88	5.09	5.25
6.	Iron	0.035	0.054	0.88	0.25	1.22	7.05	7.28
7.	Chloride	0.42	0.67	2.0	1.10	4.18	24.16	24.96

Values expressed in mg / 100 g dwt.

YL - Young leaves
ML - Mautre leaves
S - Stem
R - Root

Table - XIV

Distribution of ash and some mineral elements in the seedlings of *S. alba*

		YL	ML	S	R	Total	% Contr. to ash	% Contr. to el. total
1.	Ash	2.52	2.4	4.3	2.58	11.80		
2.	Sodium	1.37	1.29	1.13	0.55	4.34	36.78	37.4
3.	Potassium	0.26	0.13	0.46	0.38	1.23	10.42	10.59
4.	Calcium	0.21	0.25	0.29	0.22	0.97	8.2	8.36
5.	Magnesium	0.19	0.18	0.46	0.12	0.95	8.05	8.18
6.	Iron	0.16	0.12	0.65	0.55	1.48	12.54	12.75
7.	Chloride	0.53	0.63	0.93	0.55	2.64	22.37	22.74

Values expressed in mg/100 g dwt

YL - Young leaves
ML - Mautre leaves
S - Stem
R - Root

Table - XV

Distribution of ash and some mineral elements in the seedlings of *L. racemosa*

		YL	ML	S	R	Total	% Contr. to ash	% Contr. to el. total
1.	Ash	2.0	1.7	1.9	2.3	7.9		--
2.	Sodium	0.09	0.24	0.25	0.24	0.82	10.38	12.42
3.	Potassium	0.033	0.075	0.17	0.14	0.42	5.32	6.36
4.	Calcium	0.13	0.21	0.47	0.030	0.84	10.6	12.72
5.	Magnesium	0.047	0.08	0.081	0.83	0.29	3.7	4.39
6.	Iron	0.038	0.064	0.062	0.180	0.344	4.35	5.21
7.	Chloride	1.36	0.81	0.52	1.2	3.89	49.24	58.90

Value expressed in mg /100 g dwt

YL - Young leaves
ML - Mautre leaves
S - Stem
R - Root

Table - XVI

Distribution of ash and some mineral elements in the seedlings of C. tagal

		YL	ML	S	R	Total	% Contr. to ash	% Contr. to el. total
1.	Ash	10.0	8.2	514.8	29.5	562.5		
2.	Sodium	2.22	2.37	60.06	5.49	70.14	12.5	23.43
3.	Potassium	1.11	0.46	10.73	1.06	13.36	2.4	4.46
4.	Calcium	0.57	0.55	19.31	1.14	21.57	3.8	7.20
5.	Magnesium	0.58	0.40	10.30	1.10	12.38	2.2	4.13
6.	Iron	0.32	0.51	31.0	1.5	33.33	5.9	11.13
7.	Chloride	3.6	2.9	135.6	6.6	148.7	26.4	49.65

Value expressed in mg /100 g dwt

YL - Young leaves
ML - Mautre leaves
S - Stem
R - Root

Table - XVII

Distribution of ash and some mineral elements in the seedlings of *R. mucronata*

		YL	ML	S	R	Total	% Contr. to ash	% Contr. to el. total
1.	Ash	41.0	64.0	485.1 ^881.6	77.8	1549.5		
2.	Sodium	4.51	7.04	99.0 ^154.3	22.56	287.41	18.55	24.75
3.	Potassium	2.05	3.2	12.38 ^55.1	2.4	75.13	4.85	6.47
4.	Calcium	3.65	5.95	31.68 ^55.5	3.02	99.8	6.44	8.59
5.	Magnesium	3.60	7.17	21.78 ^35.26	2.67	70.48	4.55	6.07
6.	Iron	1.4	2.1	22.6 ^42.9	3.3	72.3	4.67	6.23
7.	Chloride	13.00	20.0	159.0 ^349.0	15.3	556.3	35.90	47.90

Value expressed in mg /100 g dwt

YL - Young leaves
ML - Mautre leaves
S - Stem
R - Root

^ Original hypocotyl region

Table - XVIII

Organs Showing Highest and Lowest values for different elements and % difference between the two

		Av. off.	Ag. c.	Ac. ili.	S. alba	L. rac.	C. tagal	R. m.
1.	Moisture Cot.							
	* High	R	S/YL	ML/YL	ML/YL	ML/YL	R	R
	* Low	S	R	S	S	R	S	S/YL
	* Diff.	8.74	4.83	5.11	8.86	18.77	14.22	14.42
2.	Organic Cont.							
	* High	ML/S	R/ML	S	S/R	R/S	S	S
	* Low	R	S	ML	ML	ML	R	R
	* Diff.	8.63	4.83	5.11	8.86	18.77	20.22	14.42
3.	Sodium							
	* High	YL/R	R	R	ML	ML	ML/R	R
	* Low	S	YL/S	YL	R	YL	S	YL/ML
	* Diff.	0.7	1.2	1.4	4.68	1.71	1.2	3.6
4.	Potassium							
	* High	S/YL	S+R	R	R	S	YL	--
	* Low	R	YL+ML	ML	ML	YL	S	--
	* Diff.	1.0	0.5	1.3	1.25	0.75	0.75	--
5.	Sodium to Potassium							
	* High	R	ML	ML	ML	ML	S	R
	* Low	S	S	S+R	R	S	YL	YL+ML
	* Diff.	1.19	3.5	1.95	8.64	1.76	3.6	7.2
6.	Calcium							/
	* High	S	ML	S	YL	YL	S	S
	* Low	ML	R	ML	S	R	ML	S
	* Diff.	0.396	0.088	0.336	0.664	1.736	0.156	0.428
7.	Magnesium							
	* High	YL	ML	ML	S	ML	YL+R	ML
	* Low	S	S	S	R	YL	S	S
	* Diff.	0.32	0.28	0.72	0.64	0.44	0.28	0.56
8.	Iron							
	* High	S	S	S	R	R	S/R	R
	* Low	YL	R/YL	YL	ML	YL	YL	ML
	* Diff.	0.012	0.052	0.126	0.068	0.03	0.062	0.044
9.	Cho.* High	YL/ML	ML	ML	ML	YL	YL/ML	S`
	* Low	R	R	S	YL/S	S	R	S+YL
	* Diff.	0.09	0.09	0.12	1.16	7.39	0.08	0.04

VI) COMPARATIVE STRATEGY OF DIFFERENT ELEMENTS

Figures 1 to 7 give a comparative account of different elements and ash percentage on the basis of dry weight. All the seedlings show percentage of ash below 17 or near 15. The lowest value for ash percentage is 8 seen in root of A. officinalis and stem of R. mucronata. According to Walter and Stadelmann (1974) halophytes have very high ash content in their levels varying between 15 and 30 % on dry weight basis. A classification of halophytes has been considered by them as follows-

1) Cloride halophytes - more than 30 % ash

2) Alkaline halophytes - usualy more than 20 % ash.

3) Sulphate halophytes }
4) Desalting halophytes } ash content usually 15 %

In this comparison mangrove seedlings show very low ash percentage almost all values falling bellow 17 % . This indicates that these seedlings contain comparatively less amount of minerals and more amount of organic matter. Ambike (1986) have reported that young leaves of A. ilicifolius and S. apetala contain low values for ash than mature and senescent ones . Their reports indicate that mature leaves have 15.9 and 13.1% ash for A.ilicifolius and S. apetala respectively. Present observations are on similar lines .

It can be noted from the Figures that ash percentage in the seedlings of salt excreting type of mangroves is higher in leaves as compared to roots. In case of salt accumulating type leaves and roots show higher ash than stem whereas for salt excluding type root has highest ash percentage . This trend indicates that more ash in leaves of excreting type of mangroves is because of higher minerals which are translocated to the leaves possibley for excretion. In case of C. tagal and R. mucronata more minerals in the roots are indicative of their retension in the organ . In case of succulents there is no such distinction. The works of Downton (1982) Burchett et al. (1984) and Clough (1984) on A. marina and R. stylosa suggest that the behaviour of these two species in responce to salinity of external medium is different.

The regulation of salt concentration in salt excreting type of mangroves is at least partially achived due to salt glands (Atkinson et al. 1967,Downton ;1982,Burchett et al;1984,Clough;1984). In case of Rhizophora the situation is different with increase in salt concentration of external medium after a certain level the leaves show approximetly constant ionic strain (Clough 1984). According to Field (1986) root mass and, root surface area restrict the amount of ion transport that can occur through the roots.

~~~~~~
~~~~~~

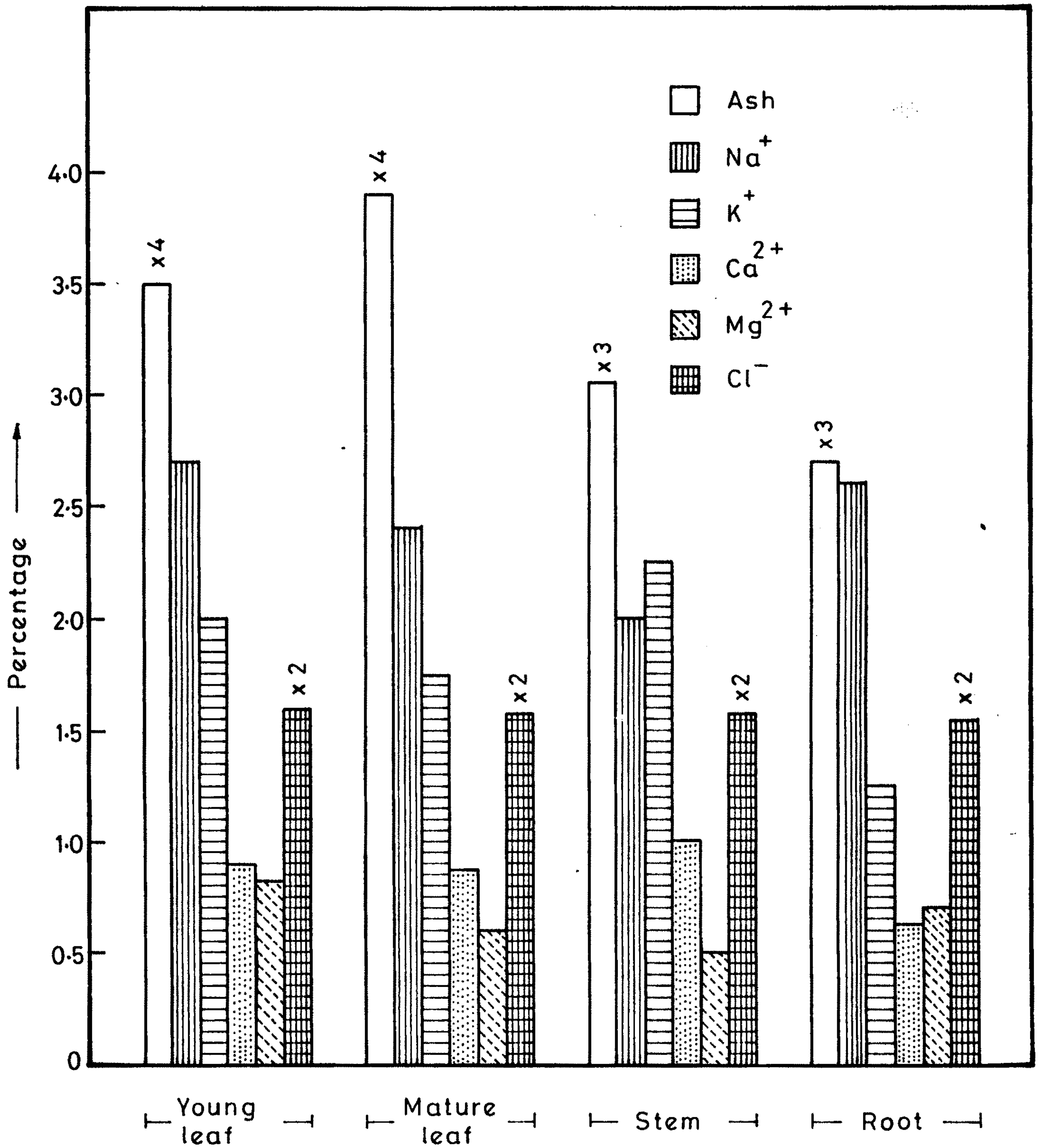


FIG. 1: MINERAL ELEMENTS AND ASH PERCENTAGE FROM THE SEEDLINGS OF *Avicennia officinalis*

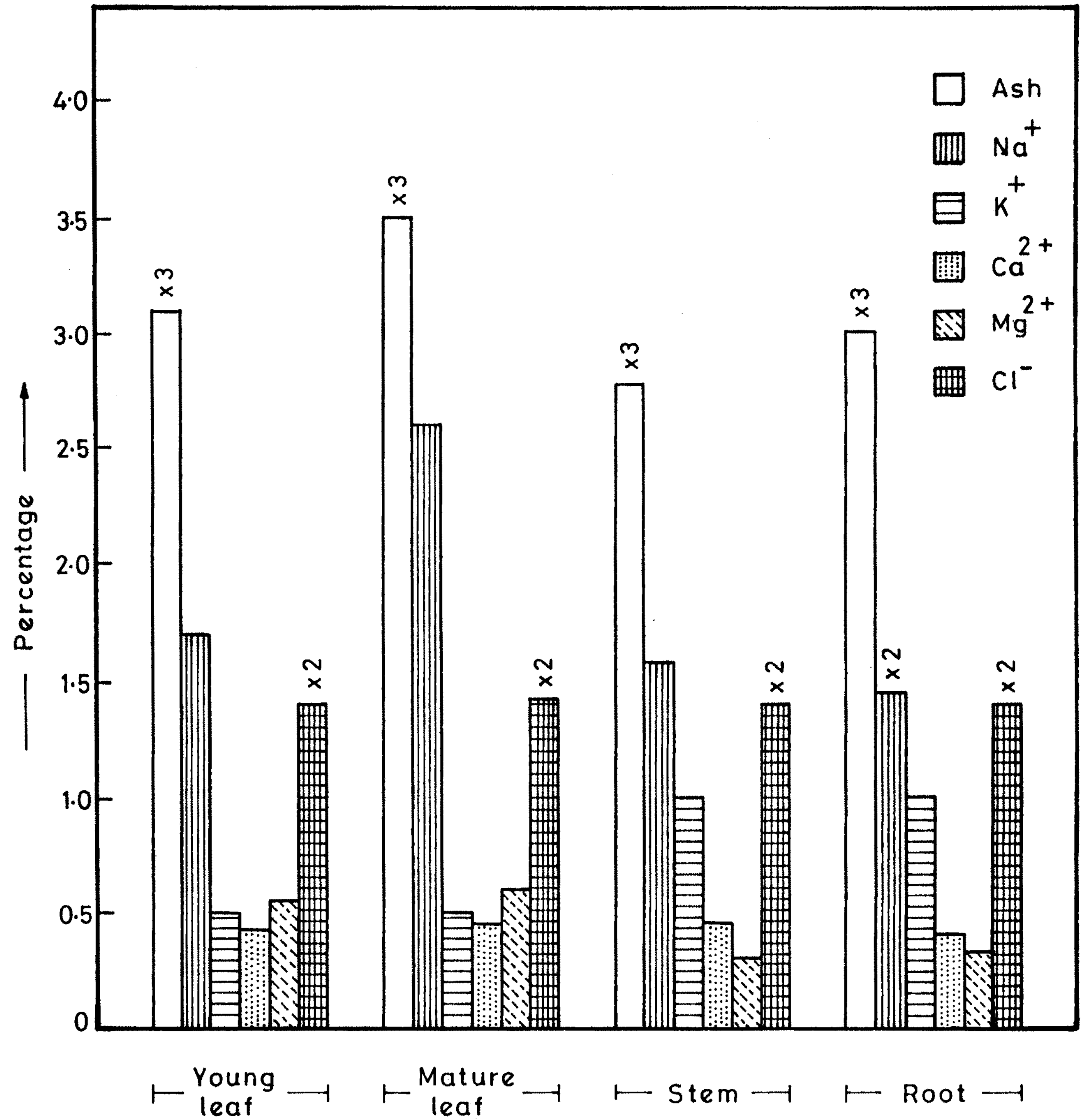


FIG. 2 : MINERAL ELEMENTS AND ASH PERCENTAGE FROM THE SEEDLINGS OF *Aegiceras corniculatum*

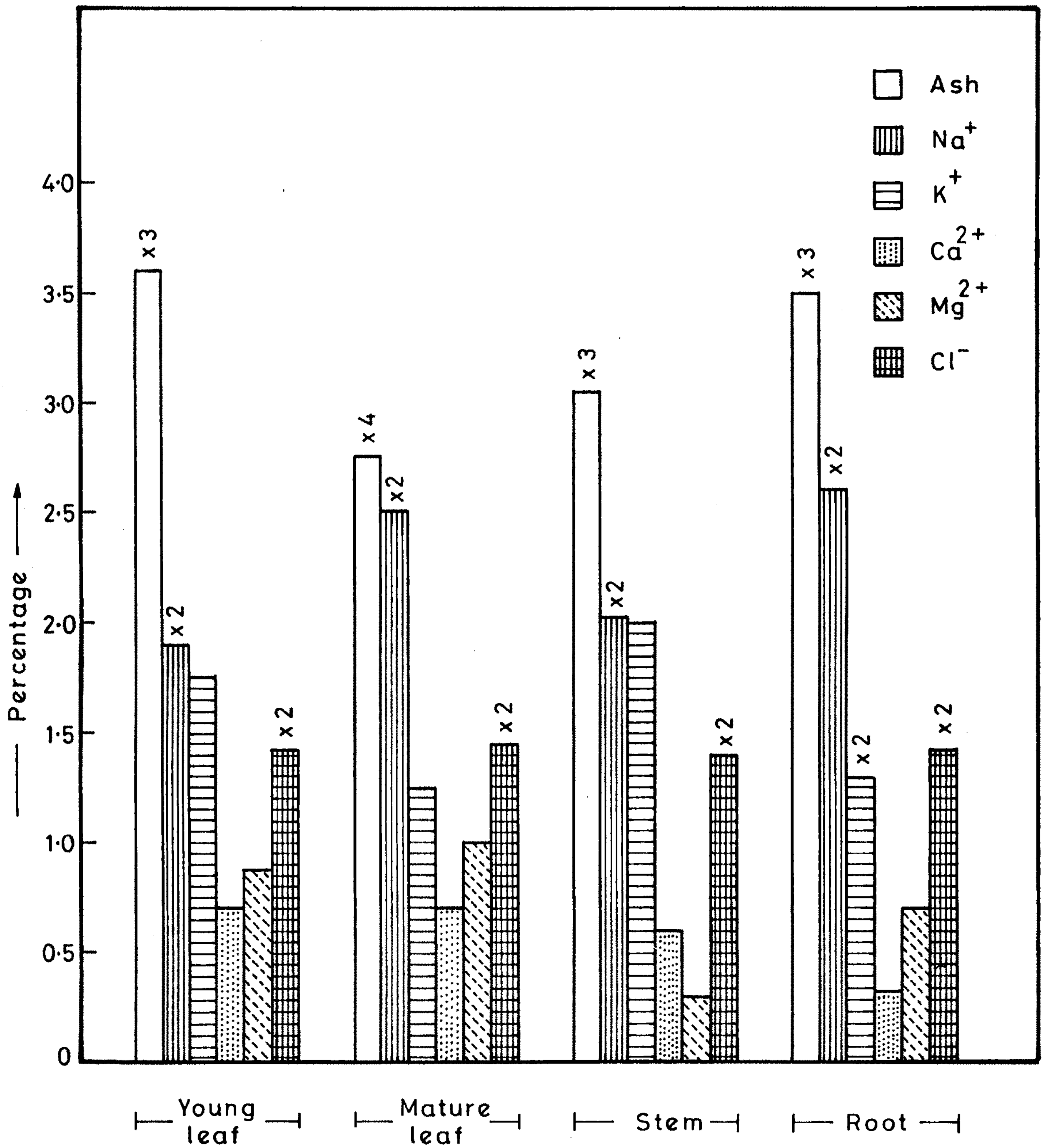


FIG. 3 : MINERAL ELEMENTS AND ASH PERCENTAGE FROM THE SEEDLINGS OF *Acanthus-ilicifolius*

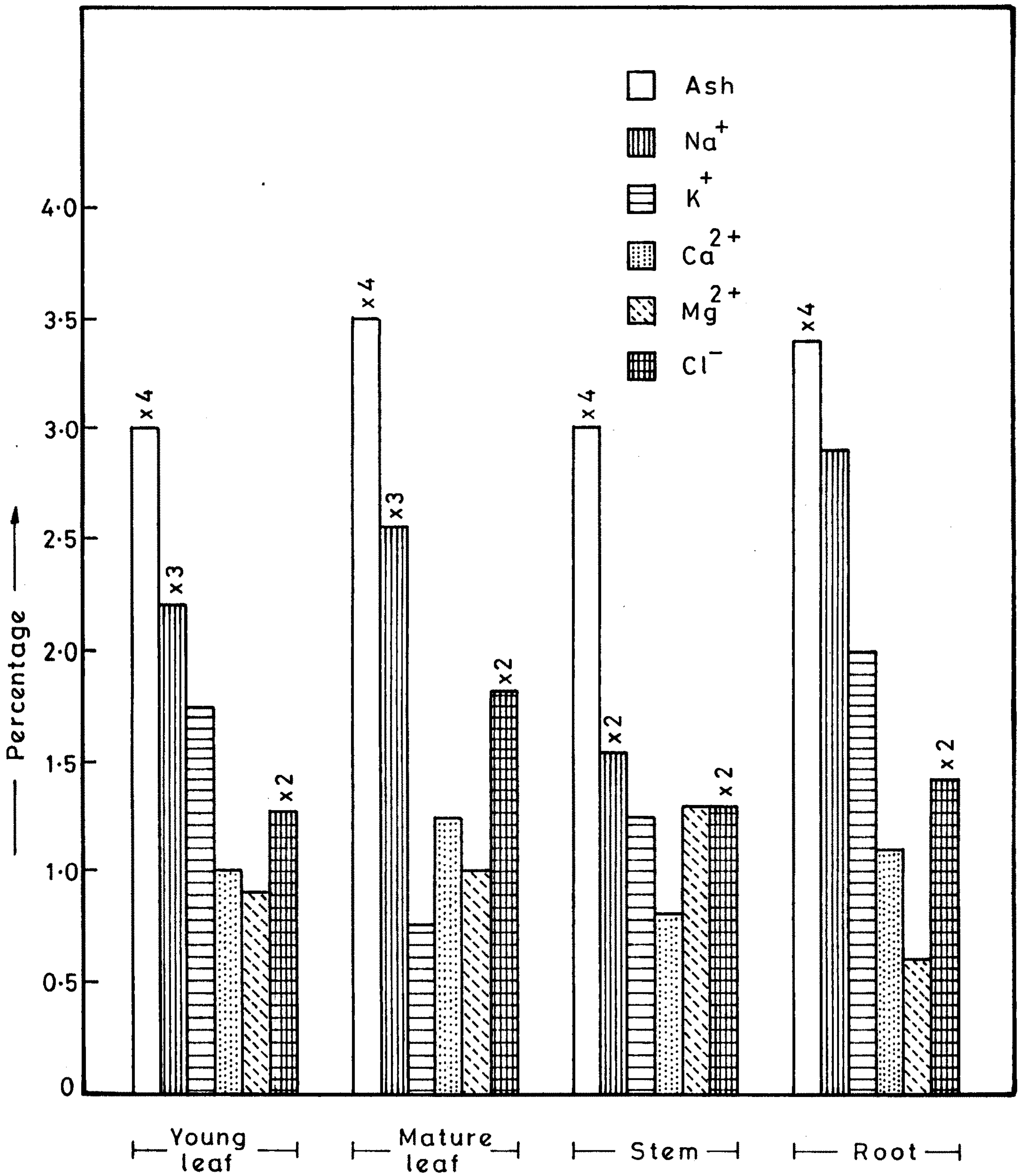


FIG. 4 : MINERAL ELEMENTS AND ASH PERCENTAGE FROM THE SEEDLINGS OF <u>Sonneratia alba</u>

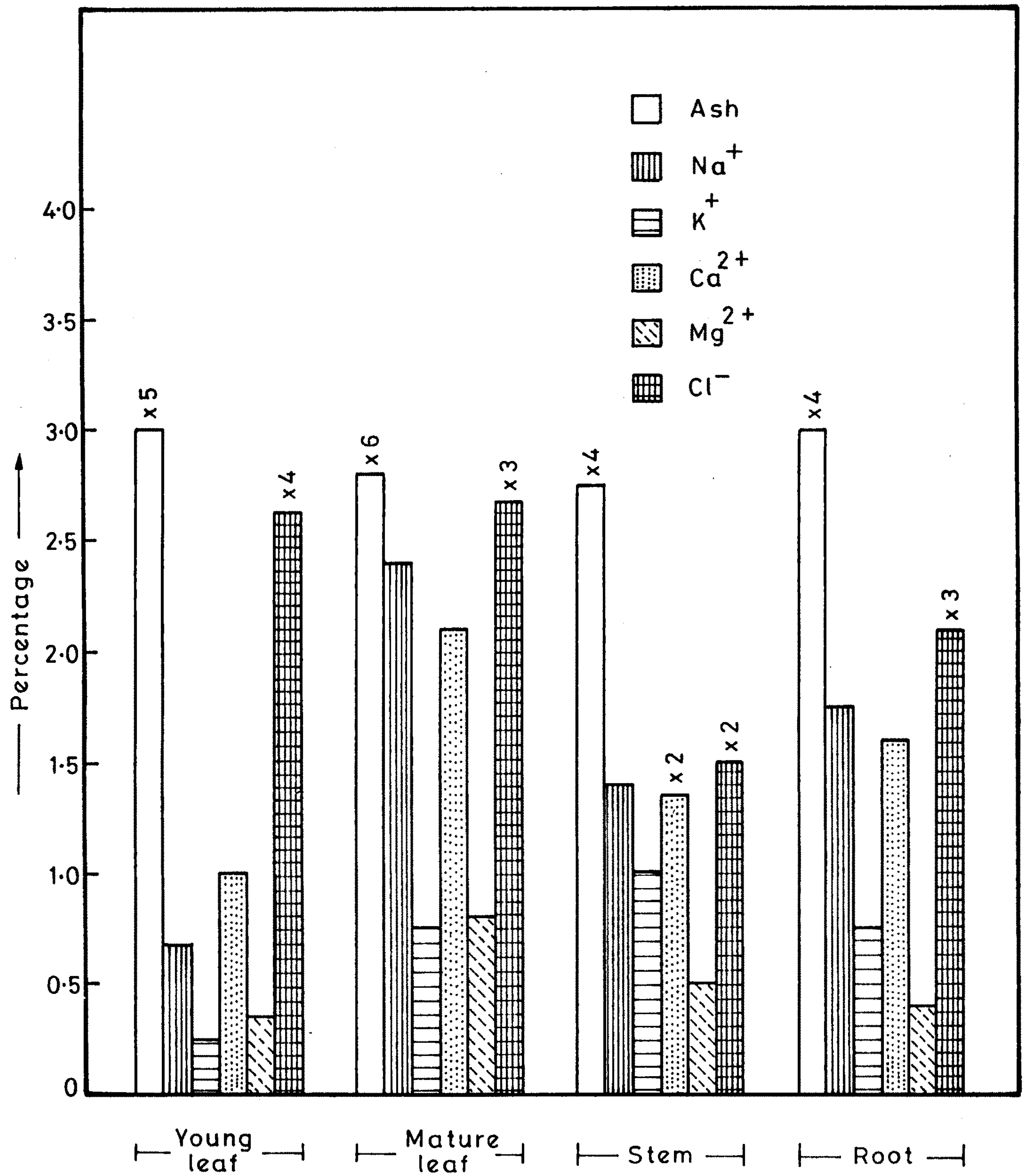


FIG. 5 : MINERAL ELEMENTS AND ASH PERCENTAGE FROM THE SEEDLINGS OF *Lumnitzera racemosa*

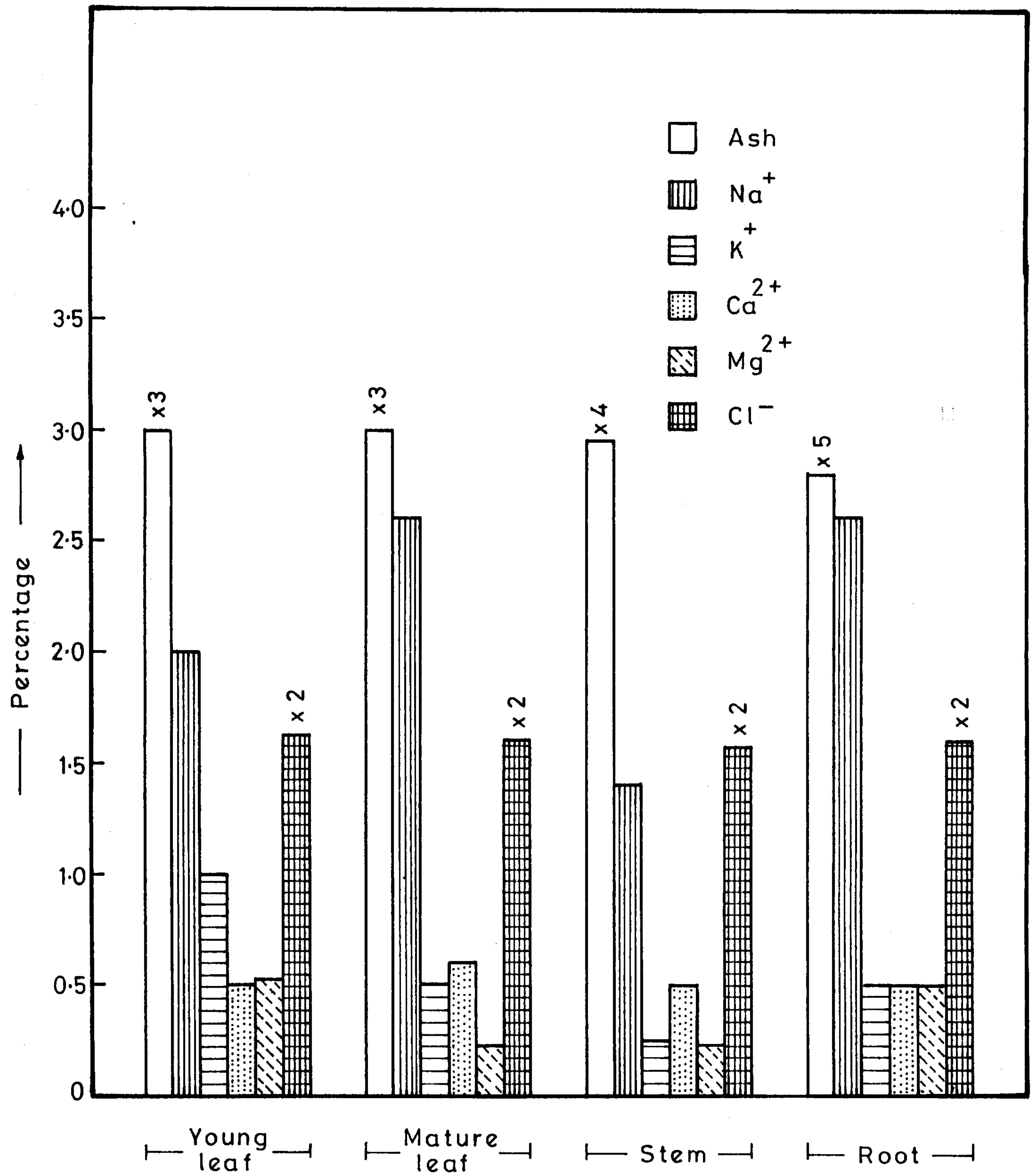


FIG. 6 : MINERAL ELEMENTS AND ASH PERCENTAGE FROM THE SEEDLINGS OF *Ceriops tagal*

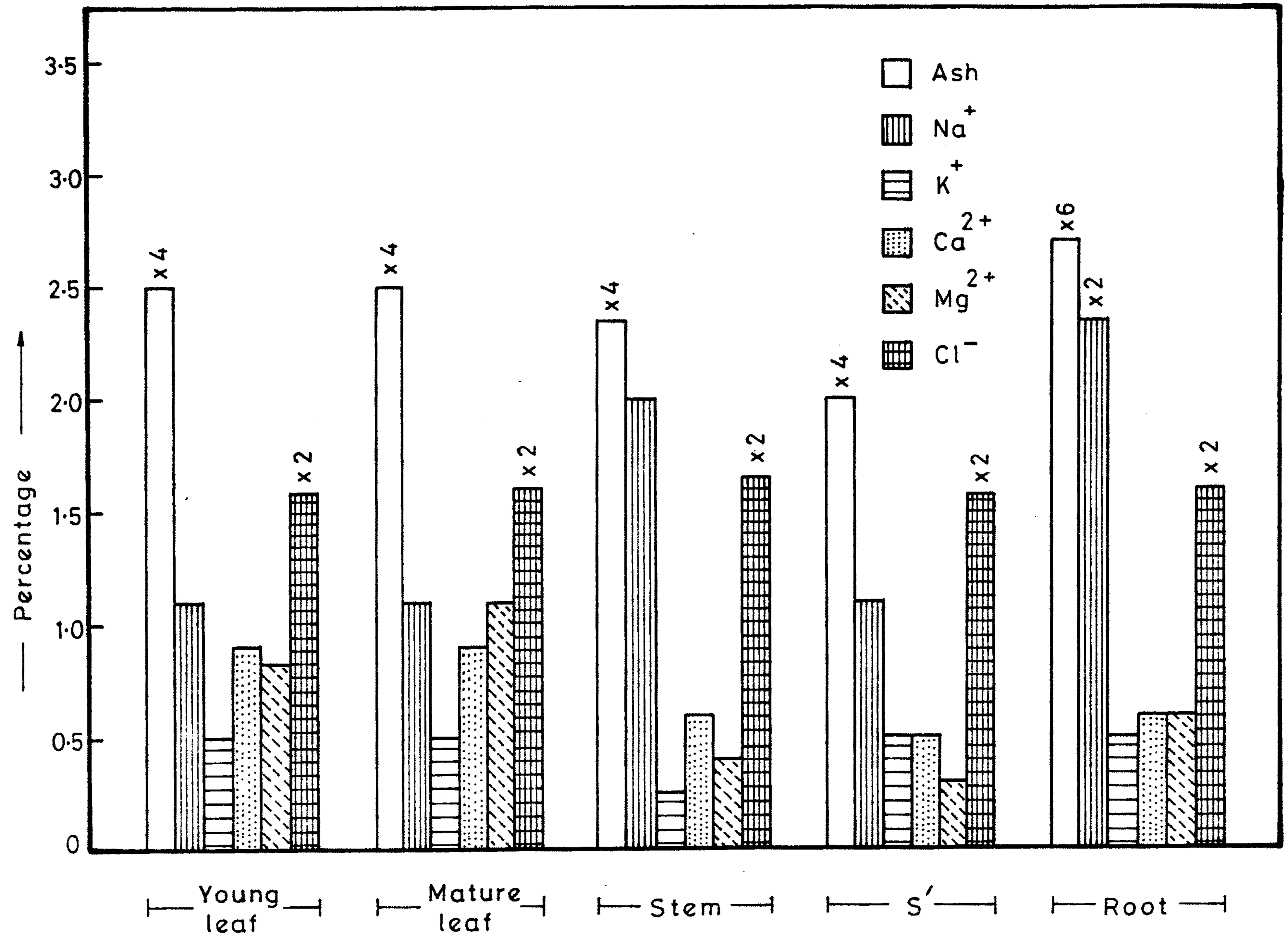


FIG. 7 : MINERAL ELEMENTS AND ASH PERCENTAGE FROM THE SEEDLINGS OF *Rhizophora mucronata*

Ecological model

For a better representation of species behaviour either in the community or in its indiviual life an ecological model helps to a great extent. Several such attempts have been made for population dynamics, single species model, models of interacting species etc. (e.g. Krebs,1978, Nisbet and Gurney,1982).

In the present study a model has been proposed to understand the behaviour of mangrove species at seedling stage with respect to mineral compostion as a function of ion regulation. It is assumed that endogenous elemental level varies within different organs of the seelding depending upon :

a> Life form - It is assumed that the life from of species, namely, tree, shrub and herb, affects uptake and accumlation of different elements.

b> Category - Mangroves have been classified based on their adaptation for salt regulation as salt excreting, salt accumlating and salt excluding ones. Based on this adaptation for ion regulation, behaviour of the seedling will change.

c> Reproduction - Vivipary is an adaptive feature met with only members of family Rhizophoraceae, however, genus Avicennia and Aegiceras possess crytovivipary. Other plants have no vivipary. This mode of adaptation is expected to impose upon some change in endogenous ionic concentration of different mangroves, again as a part of ion regulation in the species. Thus ionic concentration in the species is a function of total sum of above mentioned charaerstics. These charateristics are taken as the altimate product of environmental conditions and heredity. Therefore, it is expected that the range of highest and lowest values of any element in the plant body will be dependent upon these characteritics. The verbal expression of the model is :

Behaviour of the species = Life from + Category in classification + Reproduction mode + Range of ionic distribution as % difference (between highest and lowest values for the element).

So as to give mathametical expression to these characteistick unit values are described (already given in material and methods).

It is seen from of Table 10 that the index values for each class of mangrove seedlings form a group. In other words, for each of the class they fall within a specific range e.g. in case of sodium for excreting type of mangroves index values range between 24 and 32. It is interesting to note that for all elements A. corniculatum gives highest values in group whereas A. ilicifolius gives lowest one. In case of salt accumulating type index values are 25 and 28. This class represents lowest values amongst the three categories for all the elements. The highest values have been observed for salt excluding type of species.

These values for sodium are 45 and 46. This trend of index values is maintained for sodium, potassium, calcium, magnesium, iron and chlorides. Also moisture content obays the equation.

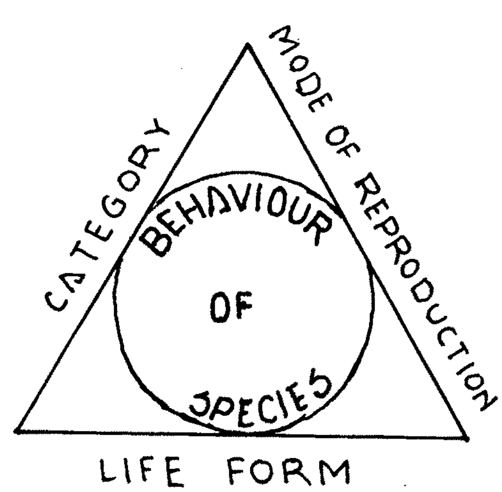
It is evident from the Table that there are three distinct classes which support the earlier views (Walter, 1961, Waisel, 1972 and Joshi et.al. 1975). On one hand the Table proves the proposed model i.e. ionic levels are dependent variable which vary as the function of life form and type of different adaptations in the species ; on the other hand it also helps grouping and/ or testing the species for its mechanism of ion regulation. Offcourse the present study cannot spell out mechanism of ion regulation but can indicate whether similar type of mechanism is possibly ? existing in two species. Therefore, it is useful for a comparative study. It is very likely, that Lumnitzera and Sonneratia may have different ways of dealing with ion regulation. This is what the model projects.

Sonneratia and Lumnitzera, represent salt accumulating type. Both the species reproduce by seed germination on soil, i.e. no special mode of reproduction in responce to saline environment such as vivipary. In these plants salt accumulation takes place with simultancous water absorption so as to bring about the dilution effect (Jennings 1968). The only difference between these two species is their life form.

S. alba is a big tree whereas *L. racemosa* is a large shrub. This single factor amongst the these can bring about changes in behaviour of the species. Therefore, difference in index values are observed. However, they form a group based on other two characteristics and hence the index values also represent a range for the group.

It is quite interesting to note that in *A. ilicifolius* index values tend to be closer to second category that is accumulating type of mangroves. Eventhough the plant possesses salt glands in the leaf, the salt is accumulated to some extent. Kulkarni and Bhosale (1985) have studied salt excretion from *A. ilicifolius* using $_{36}Cl$. It shows that in this species both mechanisms of salt regulation are operating, viz, salt excretion and salt accumulation. Therefore, the index values are transitional (intermediate). Thus, the index values, though are relative and can not be permanent, are very useful to explain the species behaviour.

A gemometrical model can also be derived from the foregoing discussions.



In an equilateral trangle each side will represent one charateristic such as life form and a central circle will represent behaviors. (This model is summery of mathemetical model).

For instance, Table 5 depicts Na/K ratio from different parts of mangrove seedlings. From over all observations of Table it is evident that plants under same group do not follow a common trend, they differ from one another for the presence of highest and lowest Na/k ratio in their organs. From such observation one cannot classify these plants as has been possible in other cases. But by taking help of ecological model this is possible because due to index values these plants come under categories considered. Because of the use of ecological model grouping of these plants becomes easy.

Table - XIX

Index values based on ecological model for different mangrove species

	Mois--ture	Org--anic cont.	Na	K	Ca	Mg	Fe	Cl	Na/ /K
Avicennia officinalis	28.00	30.00	30.00	31.00	31.00	31.00	35.00	27.0	33.0
Aegiceras corniculatium	30.00	31.00	33.00	34.00	31.00	34.00	36.00	29.0	36.0
Acanthus ilicifolius	22.00	24.00	24.00	26.00	25.00	28.00	28.05	21.0	26.0
Sonneratia alba	20.00	24.00	25.00	25.00	23.00	24.00	26.06	22.0	28.0
Lumnitzera racemosa	23.00	27.00	28.00	29.00	27.00	26.00	27.09	28.0	26.0
Ceriops tagal	42.00	45.00	45.00	47.00	42.00	45.00	46.01	40.0	47.0
Rhizophora mucronata	40.00	40.00	46.00	38.00	42.00	43.00	43.02	38.0	46.0

Figures rounded to nearest digit .