

Growth of mangrove seedlings in the intertidal area of Vellar estuary, southeast coast of India

K Kathiresan, N Rajendran & G Thangadurai

Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai 608 502, Tamil Nadu, India

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Growth of *Rhizophora apiculata* Blume seedlings in lower intertidal zones, grew more rapidly than those in upper intertidal ones. The growth was about 2.5-fold greater and the leaf sprouting was about 4-fold higher in the seedlings growing in the lowermost intertidal zone than those in uppermost intertidal zone. The growth was also rapid towards the monsoon month of December associated with low salinity and high levels of nutrients. There was about 5-fold more of seedling growth and about 4-fold higher of leaf sprouting in December than those in summer months (April, July).

Ecological studies in different mangrove regions of India have been made¹⁻⁵. Climatology and hydrology play an important role in the distribution and growth of mangroves and these baseline data are essential for undertaking afforestation work². Hence, the present study has been made to analyse the growth responses of *Rhizophora apiculata* Blume to climatological and hydrological factors and to varied intertidal zones.

Materials and Methods

The Vellar estuary is always open to the sea (Bay of Bengal) and is never closed completely by a sand bar, even during summer months (Fig. 1). The tidal range is about 1 m and its influence can be noticed more than 6 km from the mouth. The maximum width of the estuary is about 200 m while the depth is 6 m during high tide. The average width and depth are 100 m and 2.5 m respectively. In the intertidal zone, seven plots of 4 m² area each, were marked with a nylon rope from high tide to low tide mark in a linear fashion.

Mature propagules of *Rhizophora apiculata* seedlings with a length of 28 ± 2 cm collected from the Pichavaram mangrove forest (Fig. 1), during February 1992 and planted with a spacing of 0.5 m between the propagules in the plots (60% silty clay and 40% sand). The propagules were allowed to establish for a six month period and observations were made during low tides at monthly intervals from September 1992 to

August 1993. Parameters measured were temperature (atmosphere and sediment), salinity (water and sediment) using a hand refractometer-Erma, Japan and rainfall. Sediment samples were collected up to 15 cm depth, at four places from each plot, shade-dried, ground in pestle and mortar, and stored in polythene bags until analysed for nitrogen⁶, phosphorus⁷ and

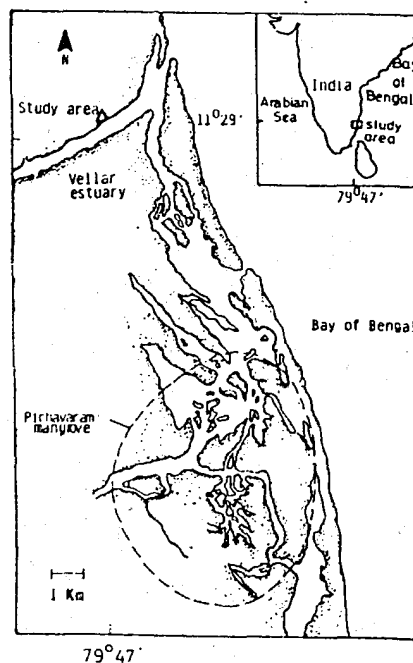


Fig. 1—Map of study area

potassium⁷. Growth of the mangrove seedlings was studied by measuring plant height and leaf number of 70 seedlings, from seven intertidal plots (10 seedlings/plot) at monthly intervals.

Results and Discussion

Rainfall—The total annual rainfall for the study period was 1277.2 mm. Maximum and minimum monthly rainfall recorded were 434.4 mm (Dec. 1992) and 20.8 mm (July 1993) respectively (Fig. 2). The habitat of the present study received the highest rainfall during the northeast monsoon (Oct.-Dec.) (Fig. 2). The rainfall during the summer month (June) was poor due to the weak southwest monsoon.

Temperature—The temperature was maximum during summer and minimum during the monsoon months (Fig. 2). Sediment temperature of the habitat ranged from 25.21°C (Dec. 1992) to 31.21°C (May 1993). Atmospheric temperature varied from 28°C

(Dec. 1992) to 34°C (May 1993). The sediment temperature also varied with the intertidal zone, and was higher in the upper intertidal zone (31°C) compared to that in the lower intertidal zone (28.5°C) (Fig. 2).

Salinity—The salinity was maximum during summer and minimum during monsoon months. The values ranged from 11.2 (Nov. 1992) to 31.5×10^{-3} (May 1993) in the sediment and from 10 (Dec. 1992) to 34×10^{-3} (April 1992) in the water (Fig. 2). There was not much of variation in sediment salinity in different levels of intertidal zones (Fig. 2). Low values of salinity in monsoon months can be attributed to monsoon run-off and also to direct precipitation.

Total sediment nitrogen—The levels of total nitrogen (Fig. 3) ranged from 2.33 (April 1992) to 3.40 g m^{-2} (Jan. 1993). The level was high during January and this was due to the fresh water which brings in

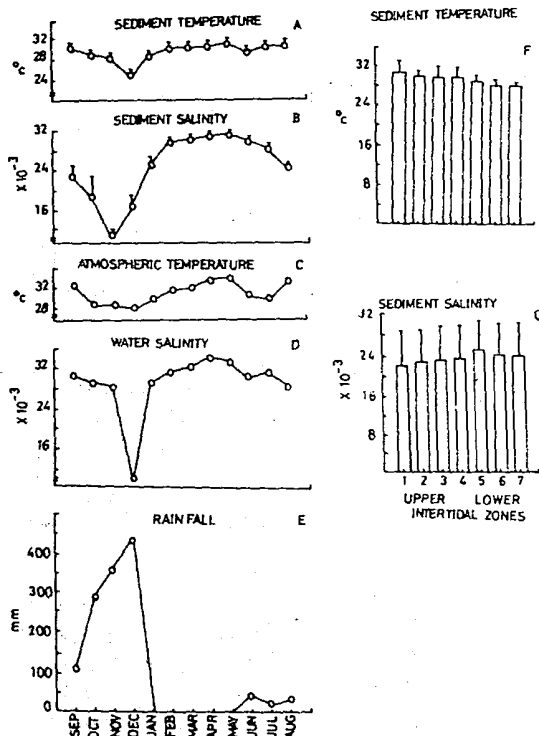


Fig. 2—Monthly variations of : A) sediment temperature, B) sediment salinity, C) atmospheric temperature, D) water salinity, E) rainfall; and intertidal variations of sediment temperature F) and sediment salinity, G) of the study area.

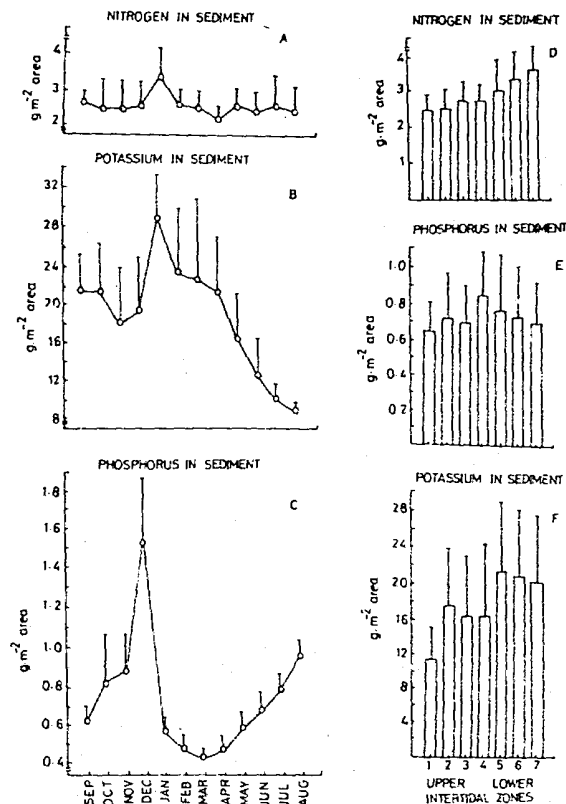


Fig. 3—Monthly variations of : A) nitrogen, B) potassium, C) phosphorus; and intertidal variations of nitrogen D), phosphorus E) and potassium, F) in sediment of the study area.

abundant N_2 -rich terrigenous deposits and their subsequent settling on the estuarine soil. The nitrogen was higher in lower intertidal zone (3.69 g.m^{-2}) than that in upper intertidal zone (2.4 g.m^{-2}).

Total sediment phosphorus—The content of total phosphorus in the sediment ranged from 0.42 (May 1993) to 1.52 g.m^{-2} (Dec. 1992) (Fig. 3). The content was also higher at lower intertidal zone (0.84 g.m^{-2}) than that in upper intertidal zone (0.65 g.m^{-2}). The changes in the levels of phosphorus in sediment could be linked with the influx of phosphorus from upstream regions and also its regeneration into the overlying water column under suitable conditions. Also, the production of H_2S by anaerobic microbes, enhances the eutrophication of phosphorus⁸.

Total sediment potassium—The level of total potassium ranged from 8.76 (Aug. 1992) to 28.97 g.m^{-2} (Jan. 1993) (Fig. 3), and was also higher at lower intertidal zone (2.15 g.m^{-2}) than that at upper

intertidal zone (1.12 g.m^{-2}). The level of potassium was influenced by heavy seasonal rainfall resulting in the peak values during January. The observed low level of K^+ during summer and early premonsoon seasons could be due to utilisation by phytoplankton and cessation of freshwater inflow.

Growth of mangrove seedlings—Seedlings growth rate (Fig. 4) ranged from 10.2 (April 1993) to $55.2 \text{ mm.month}^{-1}$ (Dec. 1993), and there was about 5-fold more growth in the monsoon month than in summer month. The leaves sprouted (Fig. 4) ranged from 9.5% (July 1993) to 39% (Dec. 1992), and there was about 4-fold more leaves produced during monsoon. The monsoon runoff in the estuarine system brings about profound changes such as lowering of salinity and increase in turbulence and nutrient levels (Figs. 2,3) which might have favoured the growth and leaf sprouting of mangrove seedlings (Fig. 4). This is in accordance with the fact that mangrove forests are highly developed in the areas of either high annual direct precipitation and/or high surface water runoff from upland watersheds⁹.

To confirm whether the lowering of salinity during the monsoon improves the seedling performance, an experiment was conducted. Mature propagules of *Rhizophora apiculata* ($28 \pm 2 \text{ cm}$ long) were placed separately in 500 ml beakers containing 250 ml of Arnon & Hoagland¹⁰ nutrient medium, with differing NaCl salinities of 5, 10, 15, 20, 25, 30, 35 and

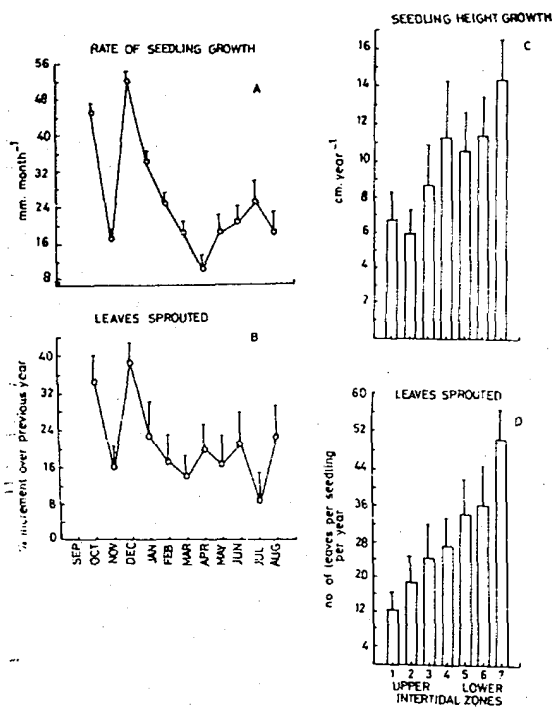


Fig. 4—Monthly variations of : A) rate of seedling growth, B) per cent increment in leaves sprouted over previous year, and intertidal variations of seedling height growth C) and leaves sprouted D) in seedlings of *Rhizophora apiculata* Blume.

Table 1—Influence of salinity on shoot growth in seedlings of *Rhizophora apiculata* Blume grown in Arnon-Hoagland nutrient medium for 60 days at $28 \pm 2^\circ\text{C}$ under laboratory conditions

Test salinity ($\times 10^{-3}$)	Shoot height (cm/plant)	Leaves (no./plant)	Leaf area (cm^2/plant)
0	11.8 ± 2.8	2.0 ± 0.0	17.1 ± 4.1
5	9.5 ± 3.6	2.0 ± 0.0	13.7 ± 1.7
10	7.8 ± 2.0	2.0 ± 0.0	8.5 ± 1.2
15	3.0 ± 0.9	2.0 ± 0.0	2.9 ± 1.3
20	0.9 ± 1.2	0.8 ± 0.9	1.0 ± 1.5
25	—	—	—
30	—	—	—
35	—	—	—
40	—	—	—

—Shoot growth negligible

40×10^{-3} . After 60 days of growth, the seedlings were observed for their shoot growth characteristics and the data are shown in Table 1. It is clear from the data that the shoot height growth and leaf area reduced with increasing salinity levels. But, there was no change in number of leaves up to the test salinity of 15×10^{-3} . All the growth parameters were too negligible to measure in the test salinities of 25, 30, 35 and 40×10^{-3} . Thus the seedlings growth enhanced under low saline conditions, which prevail in monsoon months (Fig. 2).

The seedling growth was minimum ($10.3 \text{ mm.month}^{-1}$) during April (Fig. 4) which can be attributed to high salinity and high solar radiation which hampered the photosynthetic activity¹¹ and hence the reduced growth. The leaf sprouting was drastically reduced in the premonsoon month of July, which might be due to the stress imposed by the high wind velocity in the month.

The seedling growth was high in the lower intertidal zone and low in the upper intertidal zone. It ranged from 5.90 to 14.46 cm.year^{-1} (Fig. 4). Thus, there was about 2.5-fold growth in lowermost intertidal zone than that in uppermost intertidal zone. Also the seedlings produced more leaves at lowermost intertidal zone that was about 4-fold higher than those at uppermost intertidal zones. (Fig. 4). This is in agreement with the occurrence of *Rhizophora* species, along the fringes of natural habitats^{4,12}. The lower intertidal areas were also rich in nutrient levels (Fig. 3) which might have favoured the growth of mangrove seedlings (Fig. 4). It has already been proved experimentally that sediment potassium improved seedling growth of *R. apiculata*¹³. The lower intertidal zones are characterized by higher tidal inundation, water-logging and lower level of available oxygen (redox potential). To these conditions, *R. apiculata* is tolerant¹⁴ and hence is growing better in the lower intertidal zones.

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