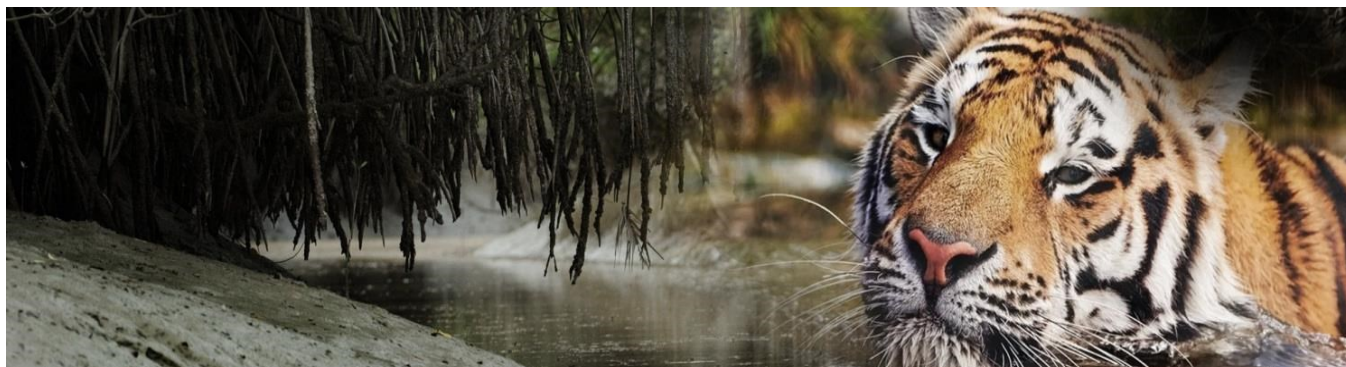


Zonation pattern of different mangrove species in the Sundarbans Tiger Reserve, India



Original Research Article

ISSN : 2456-1045 (Online)
(ICV-BS/Impact Value): 63.78
(GIF) Impact Factor: 4.126
Publishing Copyright @ International Journal Foundation
Journal Code: ARJMD/BS/V-24.0/I-1/C-4/APL-2018
Category : BIOLOGICAL SCIENCE
Volume : 24.0 / Chapter- IV / Issue -1 (APRIL-2018)
Journal Website: www.journalresearchijf.com
Paper Received: 22.04.2018
Paper Accepted: 30.04.2018
Date of Publication: 05-05-2018
Page: 25-38



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Citation of the Article

Dasgupta M.; Ghosh A. ; Mukherjee S.; Sarkar N.S. (2018)
Zonation pattern of different mangrove species in the Sundarbans Tiger Reserve, India; Advance Research Journal of Multidisciplinary Discoveries.24.(4), pp-25- 38

ABSTRACT

For the purpose of the study, soil samples were collected from the rhizospheres of different mangrove species in the Indian Sundarbans. Twenty three mangrove species commonly occurring in Sundarbans Tiger Reserve, were identified for this purpose. The soils were collected from 15 cm level of the upper soil zone for each of these mangrove rhizosphere under different locations. Efforts were made to correlate the recorded intensity levels of mangrove species with the studied properties of the soils in order to develop a gross idea about the possible habitat preference of different mangrove species.

Key words: Mangrove species, soil properties, zonation pattern

I. INTRODUCTION

Mangroves are woody plants that grow at the interface between land and sea in tropical and sub-tropical attitudes where they exist in conditions of high salinity, extreme tides, strong winds, high temperatures and muddy, anaerobic soils. There may be no other group of plants with such highly developed morphological and physiological adaptations to extreme conditions. Because of their environment, mangroves are necessarily tolerant of high salt levels and have mechanisms to take up water despite strong osmotic potentials. Some also take up salts, but excrete them through specialized glands in the leaves. Others transfer salts into senescent leaves or store them in the bark or the wood (Kathiresan 2001). The Indian Sundarbans falls under the jurisdiction of North 24-Parganas and South 24-Parganas districts in West Bengal comprising of 19 rural blocks (Fig – 1.1), covering a total area of 9630 sq. km. of which 5364.4 sq. km area is inhabited by human population and remaining 4226.6 sq. km is the present day Sundarbans mangals (Naskar & Guha Bakshi, 1987). Sundarbans mangrove forest area in Bangladesh is estimated to be about 66%, while Indian Sundarbans covers an area of about 34% of the total (Naskar & Mandal, 1999) (Fig.- 1.2). Since 1973, about 2585.10 sq. km area of south-eastern part of Sundarbans mangals were declared as Sundarbans Tiger Reserve.

The Indian Sundarbans is bestowed with the highest floral diversity in the form of mangroves, coastal wetland flora, beach flora, marsh and swamp flora (Naskar and Guha Bakshi, 1987; Naskar, 1993; Naskar and Mondal, 1999). Till today about 110 species includes about 25 species of true mangroves were identified (Ghosh *et al.*, 2003). Most of these plants are endemic in this inter-tidal high saline deltaic areas, for having their special adaptation in these physiologically dry soil. Besides these, about 40 numbers of mangrove associates and back mangrove species are also present in Sundarbans mangals (Naskar, 2004). The mangroves of this area thus have great significance both in terms of their direct role in resource utilization for forestry and fishery productions and also their indirect potentials in protecting coastlines and maintaining estuarine ecological balance (Ghosh *et al.*, 2002). Although some studies have been carried out to assess the characters of these mangrove soils (Sahoo *et al.*, 1985). While studying mangrove zonation pattern, several workers have shown that physiological adaptations to such variations may appear to be useful for explaining the observed zonations of mangroves (Smith, 1992, Satyanarayana *et al.*, 2002). Under this context, it was thought that studies on the rhizosphere soils of different mangroves are likely to provide some useful information on habitat preference of these mangrove species. In the present study, therefore, some important physico-chemical properties of mangrove rhizosphere soils of Sundarbans have been studied with relation to intensity of mangrove vegetations in the area. On the survey of different areas in the Indian Sundarbans both inside and outside the Sundarbans Tiger Reserve, patches of diverse plant groups were revealed (Naskar *et al.*, 2004). The mangroves of this area thus have great significance both in terms of their direct role in resource utilization for forestry and fishery production and also their indirect potentials in protecting coastlines and maintaining estuarine ecological balance (Ghosh *et al.*, 2002).

II. MATERIAL AND METHOD

During this study, collection of soil samples were done from the Indian part of Sundarbans covering 15 blocks of Sundarbans Tiger Reserve and their adjoining areas (Figure – 1.3). These blocks were divided into five major components *viz.* i) Eastern Zone ii) Western Zone iii) Central Zone iv) Northern Zone and v) Southern Zone according to their occurrence. Twenty three mangrove species commonly occurring in this soil zone were identified. Soil samples were collected from their root zones in different areas and analyzed for assessing the preferred habitat and nature of soil required for the specific mangrove species for their growth and survival.

The Standard Methods adopted for these analyses are as follows:

Salinity Cl⁻ ions can be conveniently estimated by titration with silver nitrate (AgNO₃) in the presence of chromate ions.

Organic Carbon (OC) The rapid titrimetric method of Walkley & Black (Walkley & Black, 1934) using heat of dilution was used for determination of organic carbon in soils. It influences various physicochemical properties of the soil including release of different nutrients to more available form. This method has an advantage that it excludes less active elementary carbon of soil (e.g. graphite) and includes only that part of OC.

Available nitrogen: The amount of N under easily mineralizable form was determined by oxidizing the soil organic matter with mild oxidizing agents so that only the easily mineralizable forms of organic nitrogen are oxidized. 0.32 percent potassium permanganate (KMnO₄) is commonly used for this purpose (Subbiah & Asija 1956).

Available Phosphorus The available phosphorous was estimated by using Olsen's sodium bicarbonate extractable method due to the alkaline nature of the soils in the Indian Sundarbans (Olsen, 1954).

III. RESULTS AND DISCUSSIONS

As has been discussed earlier (Dasgupta, 2018), salt contents of coastal saline soils tend to vary widely depending on rainfall and evaporation. However, studies on this property with a number of soils at a particular point of time is likely to provide a guideline about the relative variations of this property in different soils. Salinity values of rhizosphere soils under different mangrove species have been reported in Fig. 1.4. Although mangroves are, in general, salt tolerant plants, yet their levels of tolerance vary considerably among different species (Siddiqi, 2001). Variations in occurrence of mangrove species due to changes in salinity levels have been reported by Wells (1982), Smith (1992) and other workers. Kathiresan *et al.* (1996) reported mangal vegetations to be more luxuriant under lower salinity than in higher salinity ranges. In the present study also, such variations in adaptability to saline conditions have been observed by different mangrove species. Among commonly occurring mangroves, plants like *Avicennia* were found largely under comparatively lower saline stretches. Naidoo and Von-Willert (1995) reported that low saline conditions reduce carbon losses in *Avicennia* sp. and lead to greater CO₂ assimilation resulting in better growth of the plants. On the other hand, species like *Exoecaria* and *Phoenix* were observed in comparatively higher saline zones with a few exceptions. That such plants can accumulate excess salts in the leaf vacuoles has been reported by Azocar *et al.* (1992). *Sonneratia* plants, on the other hand, showed wide adaptations and could be found under a long range of salinity. The results thus indicate that although mangrove plants are essentially habituated to saline condition, yet they differ in their adaptability to levels of salinity. The occurrence of particular mangrove species in estuarine regions will, therefore, depend largely on the capacity of the mangroves to adapt the specific saline condition presented by the habitat.

Importance of organic carbon in formation of soil organic matter and, thereby, in influencing various physico-chemical and biological properties of soils have been discussed by Dasgupta (2003)²¹ and many other workers. Status of soil organic carbon in the root zones of various mangrove plants under different locations have been presented in Figure – 1.5. Distribution of some of the mangrove species were found to be related with the organic carbon status of the soils. While

different species of *Avicennia* and *Nypa* showed rhizosphere soils with comparatively high organic carbon content, species like *Exoecaria* and *Phoenix* were found mostly in soils with relatively low organic carbon status. This behavior may be due to differences in leaf production, fall and transportation by tidal water. *Exoecaria* and *Phoenix* being found mostly under highly saline zones were probably subjected to comparatively slower vegetative growth and thus contributed to lesser accumulation of organic matter in the soils. That mangrove vegetation is less luxuriant under higher salinities have been discussed by Kathiresan *et al* (1996). A large part of these organic matters was also washed away by the more intense tidal flow under the high saline zones thus resulting in further lowering of organic carbon content of these soils. In general, intensity of mangrove vegetation in different locations was observed to show a positive relationship with organic carbon status of the soils. However, the correlation was not observed to be statistically significant (Table –1).

Status of available nitrogen in the rhizosphere soils of different mangrove species, as estimated for easily mineralizable form, have been presented in Figure – 1.6. The values appeared to be low, in general. Although nitrogen forms an essential component of plant nutrition, the availability of nitrogen in the studied mangrove soils may be influenced by several factors, especially the washing of the mineralized nitrogen by tidal water. This mobility of nitrogen in these inter-tidal soils makes the assessment of nitrogen nutrition to mangrove vegetation very difficult and it was not possible to find out the independent effect of available nitrogen of mangrove soils on different species from the present investigation. However, since adequate availability of nitrogen is essential for vegetative growth of any plant, low availability of this nutrient element appeared to be a critical soil factor in influencing the intensity of mangrove vegetation, in general, and the relationship was found to be statistically significant Table-1).

Available Phosphorus

Variations in available soil phosphorous status in the root zones of different mangrove species have been presented in Figure – 1.7. The mangrove soils tended to exhibit moderate to high concentrations of phosphorus in available form. Such easy availability of soil phosphorus to the mangroves made the assessment of the relationship between these soil property and occurrence of different species of mangroves difficult. However, the mangrove plants like *Nypa* and *Phoenix* generally occurred in the soils with comparatively higher available phosphorus status. On the other hand, species like *Exoecaria*, *Sonneratia*, *Avicennia* were found under entire ranges of available soil phosphorus. However, in general, this property was not found to exert profound influences on occurrence of different mangrove species and also on gross intensity of mangrove vegetation (Table – 1).

This study indicates that several properties of the rhizosphere soils tend to influence and are also influenced by the nature of mangrove vegetation in these soils. However, these relationships are mostly interdependent and hence getting clear pictures of such relationships are often difficult. Among the studied properties, availability of nitrogen in rhizosphere soils appeared to be significantly correlated with the intensity of mangrove vegetation. However, some of the soil properties of mangrove forests may vary widely in different seasons under the fragile environment of Sundarbans and more detailed investigations is necessary to develop a clear idea in this regard.

In view of the observed trends of associations of some of the studied properties with occurrences of different mangrove species in Sundarbans soils, an effort was made to assess the habitat preferences of different mangrove species with regard to a few properties of rhizosphere soils *viz.* salinity, organic carbon and availability of nitrogen and phosphorus. These properties were primarily observed to show good amount of variations in the studied soils and were considered to influence, to some extent, occurrences of different mangrove species. For this purpose, the mean soil properties of the rhizospheres of 23 numbers of common mangrove species for each block were calculated and have been presented separately in figures 1.4 to 1.7. The figures indicate that there exist variable preferences for salinity by some mangrove species in Sundarbans soils. While species like *S. caseolaris* was observed to grow mostly in low saline zones, species like *B. sexangula* showed wide adaptation with regard to this property. On the other hand, *B. parviflora* was found to occur in comparatively higher salinity values with very narrow range in all the five zones. With regard to organic carbon status, *K. candel*, *C.tagal* etc were found to occur mostly in soils with higher organic carbon values while *B. cylindrica* and *S. caseolaris* were observed under lower organic carbon ranges. Available nitrogen status were predominantly low in the studied soils. However, some of the species like *S. caseolaris* was found to grow even in very low available nitrogen status. On the other hand, species like *A. alba*, *C. tagal* etc. were found in soils with comparatively higher available nitrogen values. Availability of phosphorus was moderate to high in the soils under study. However, among them, *S. caseolaris* was found in comparatively lower ranges while *B. sexangula* was observed in wide ranges of the nutrient. Many other habitat preferences for different mangrove species have been observed in the figures. All these observations indicate that the varying natures of soils of Sundarbans can sustain wide ranges of mangrove species. However, the preference for habitat for these species needs to be borne in mind when preparing any mangrove conservation program.



Fig : 1.1. Map of the Districts 24 Parganas South & North and the present Sundarbans area with mangrove forest.

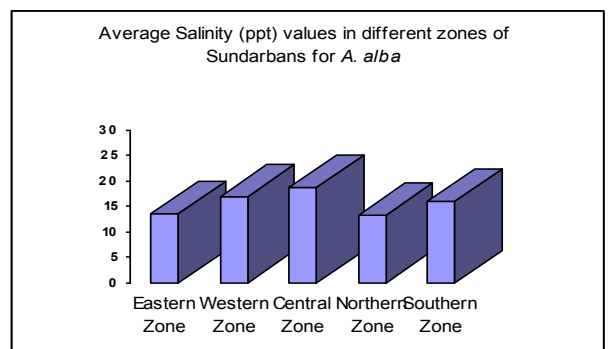
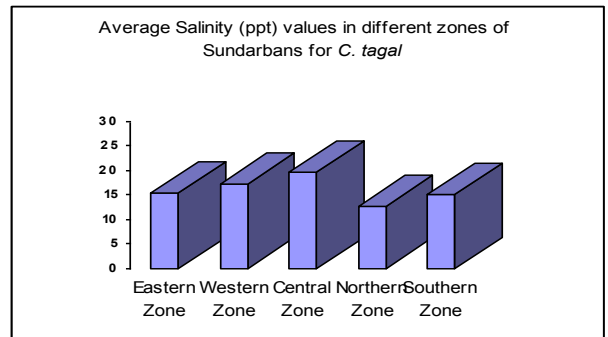
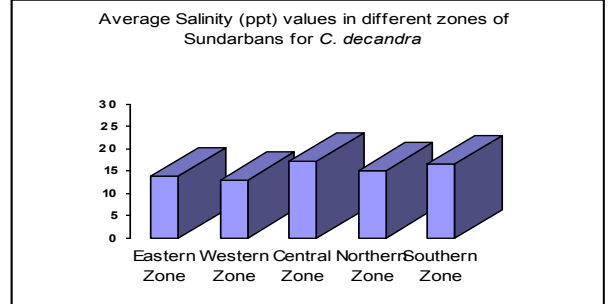
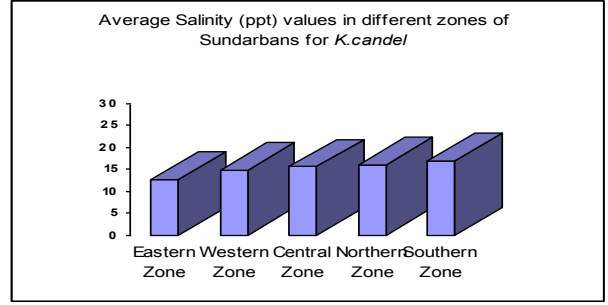
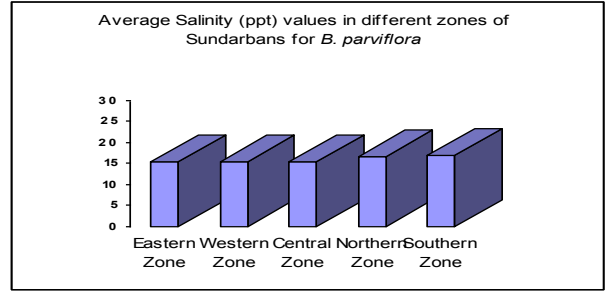
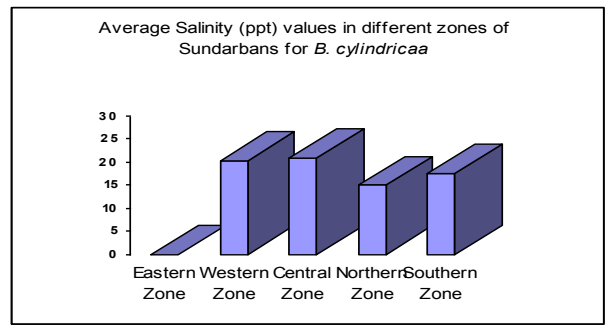
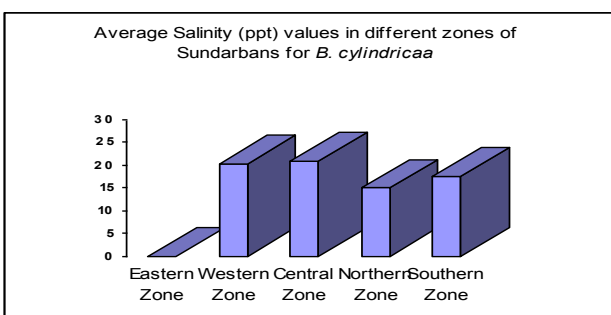
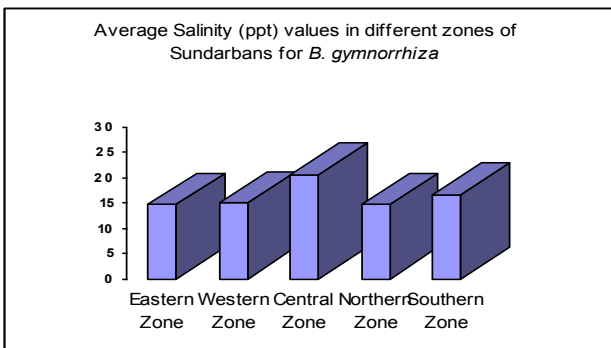
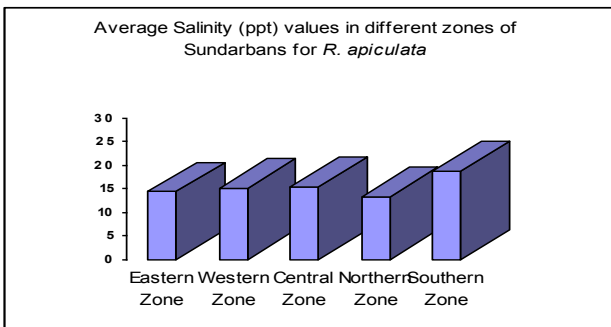
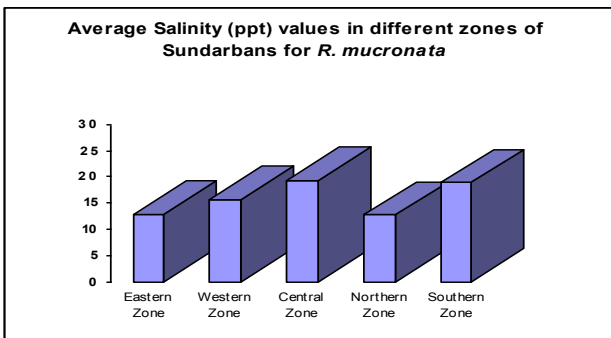


Fig : 1.2 Sundarban - spanning India and Bangladesh

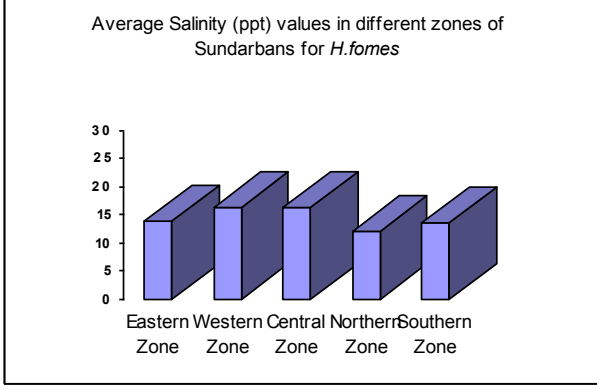
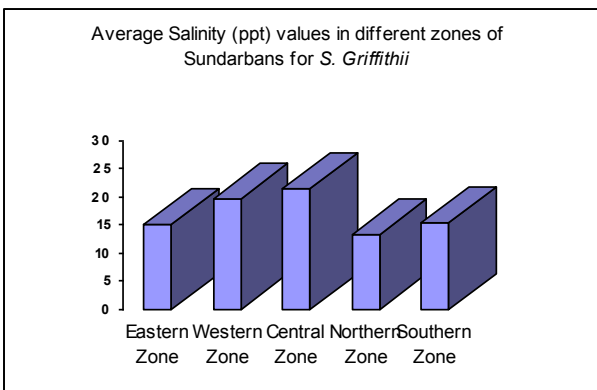
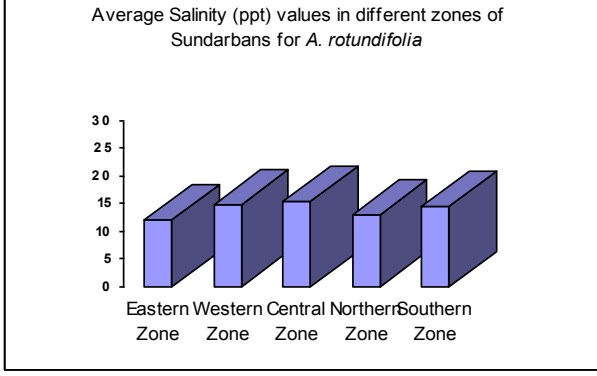
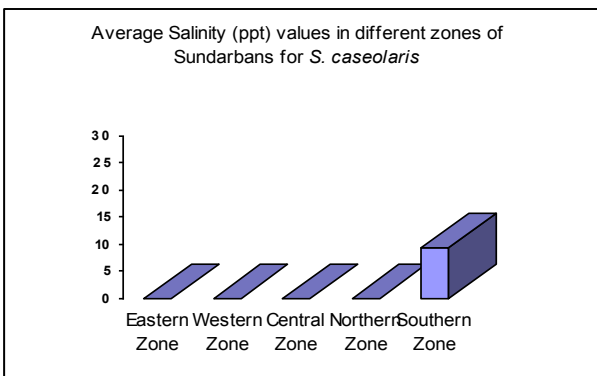
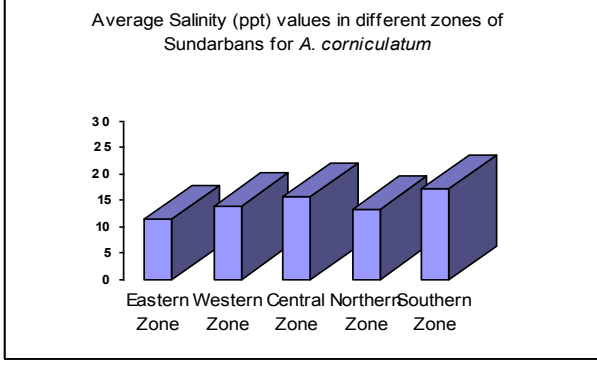
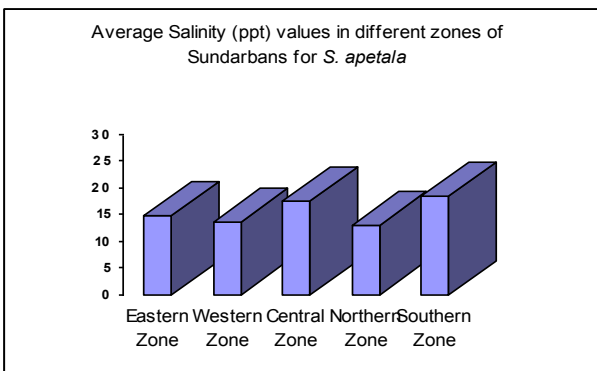
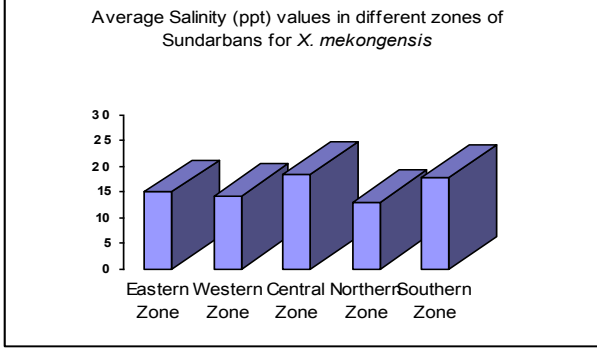
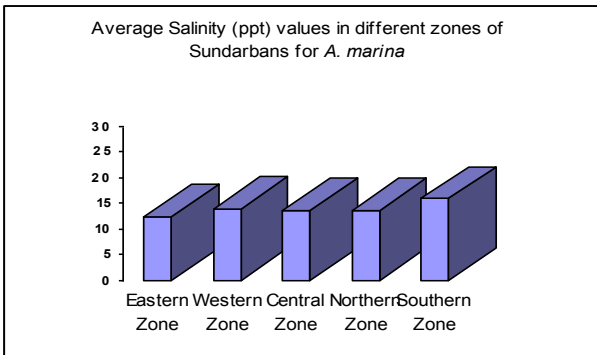
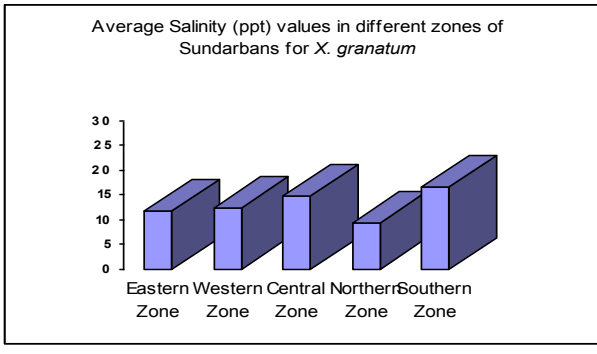
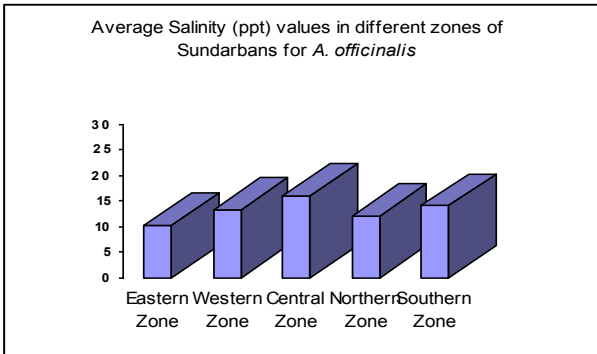


Fig: 1.3. Sundarban Tiger Reserve area showing 15 blocks

Fig – 1.4. Association of different mangrove species with soil salinity (ppt) in different zones of Sundarbans Tiger Reserve.



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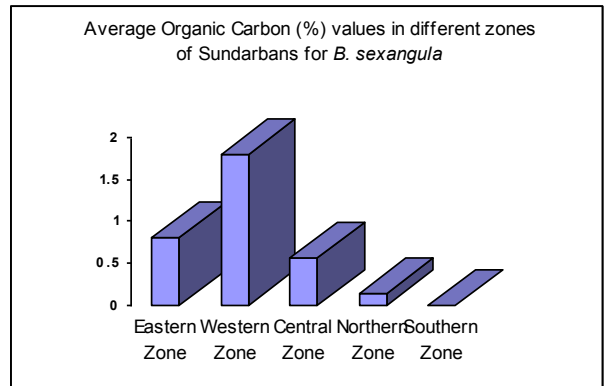
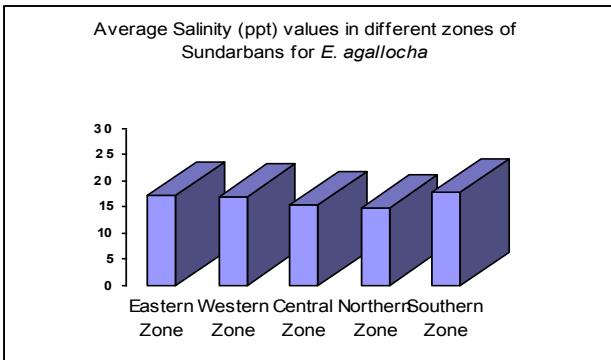
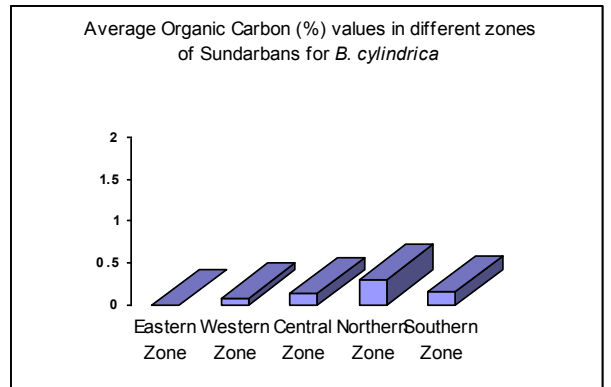
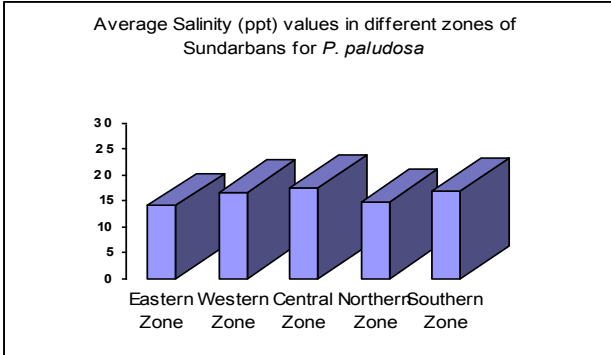
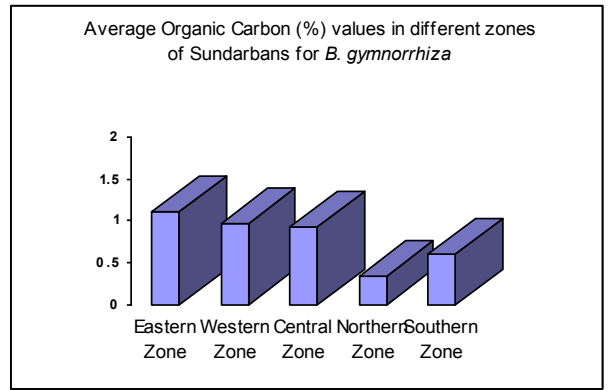
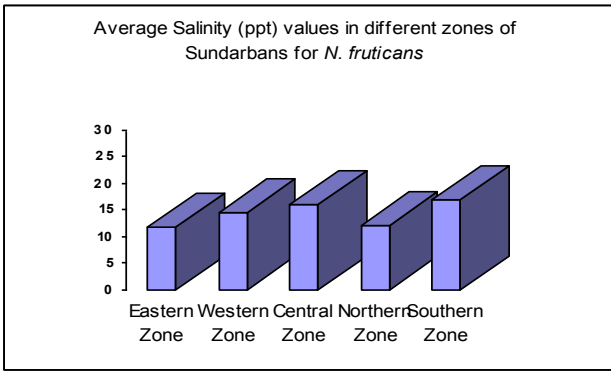
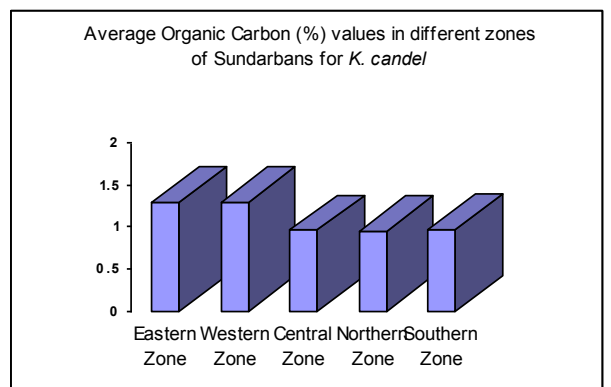
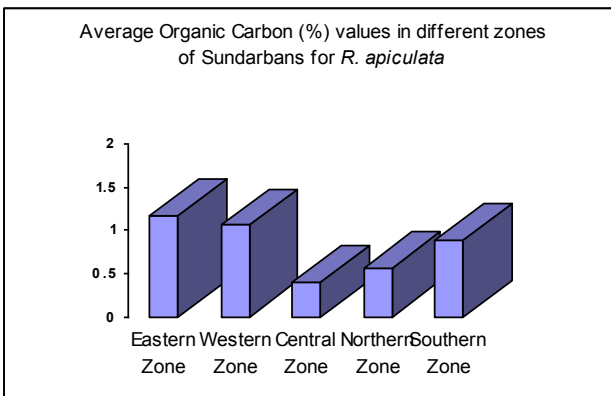
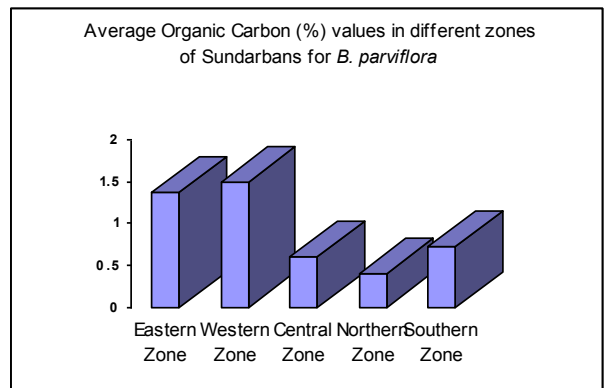
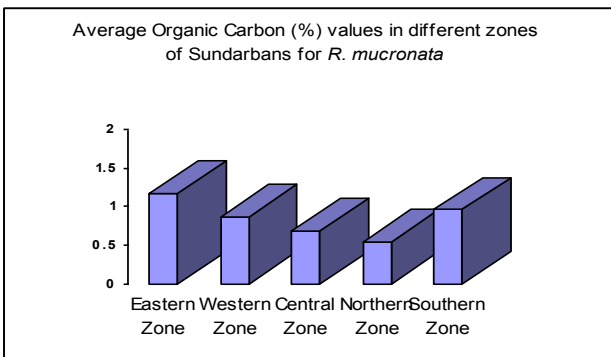
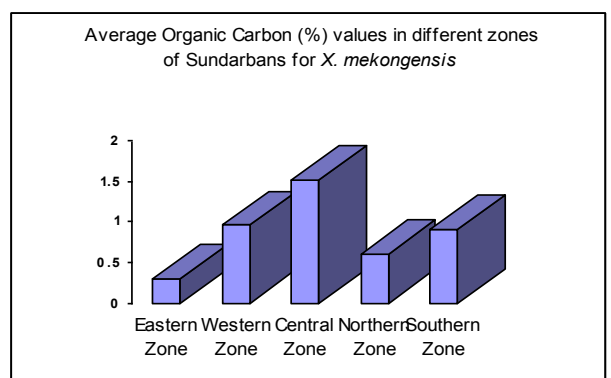
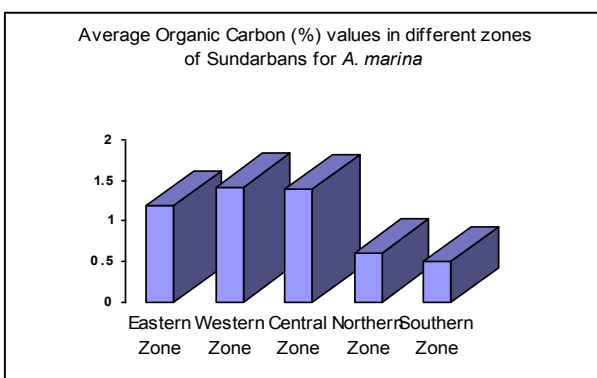
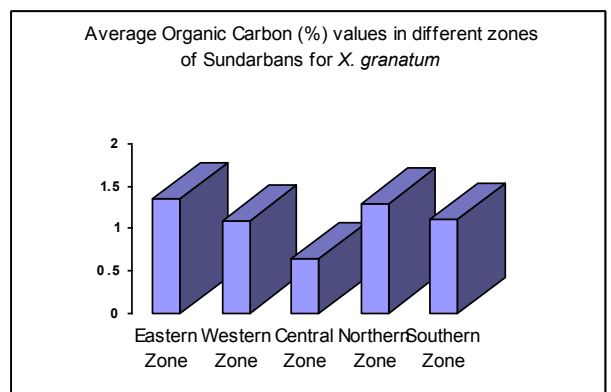
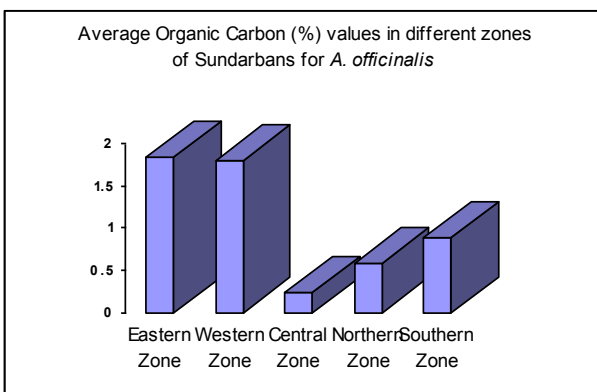
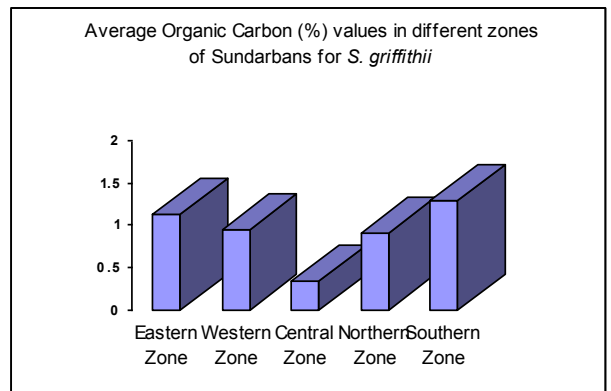
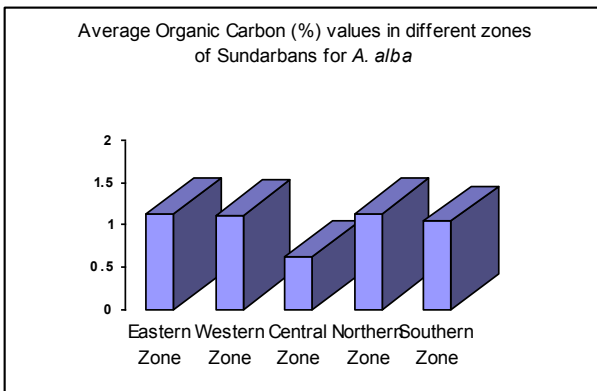
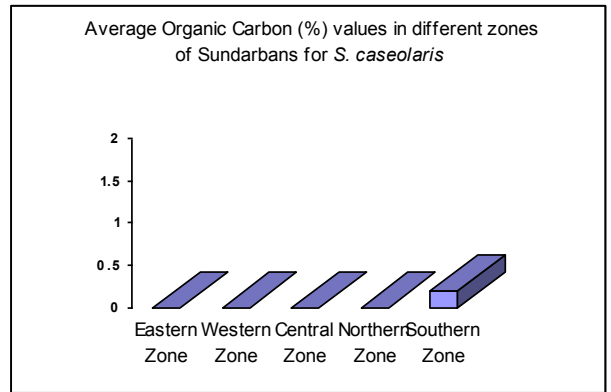
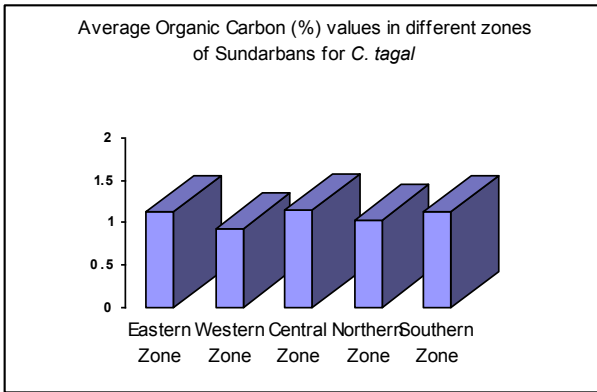
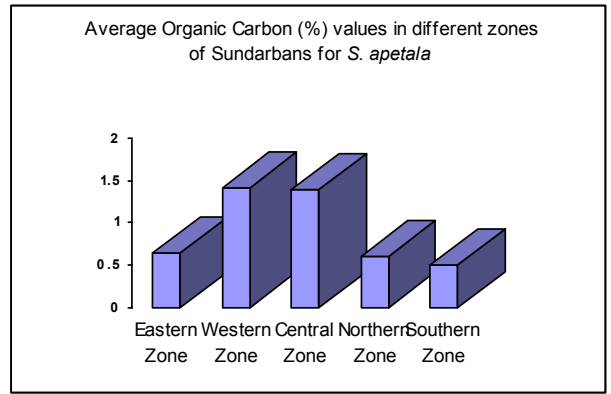
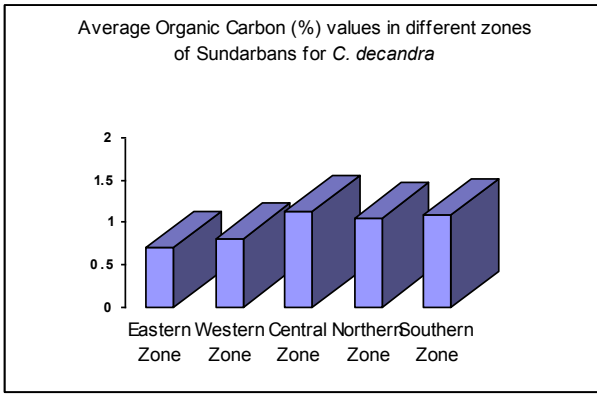


Fig. – 1.5. Association of different mangrove species with soil organic carbon (%) in different zones of Sundarbans Tiger Reserve

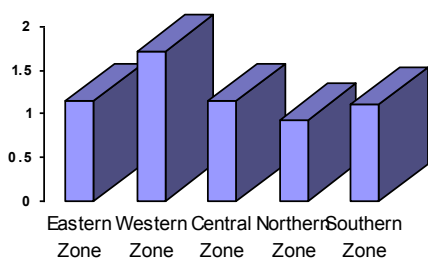
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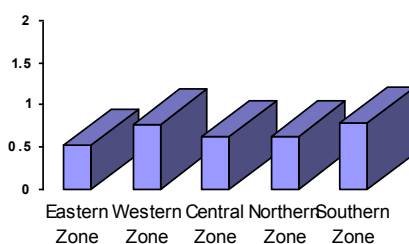


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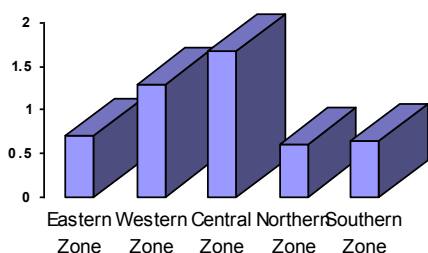
Average Organic Carbon (%) values in different zones of Sundarbans for *A. corniculatum*



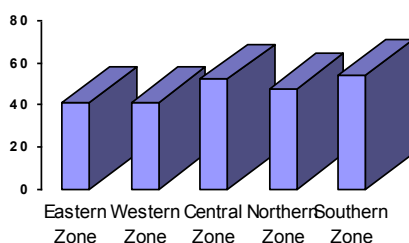
Average Organic Carbon (%) values in different zones of Sundarbans for *E. agallocha*



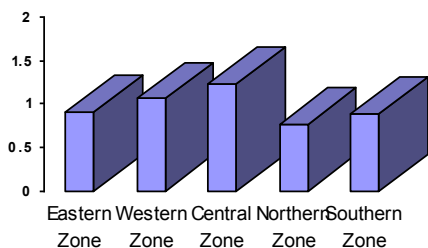
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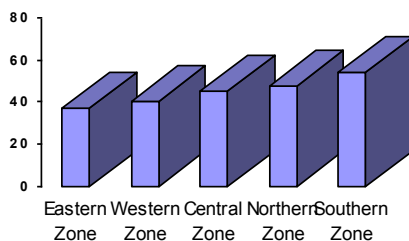
Easily Mineralisable Nitrogen (mg/kg) values in different zones of Sundarbans for *R. mucronata*



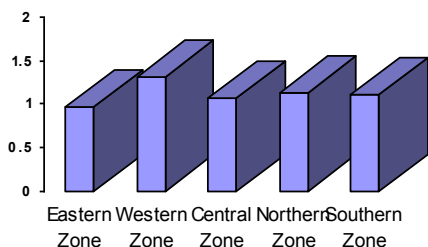
Average Organic Carbon (%) values in different zones of Sundarbans for *H. fomes*



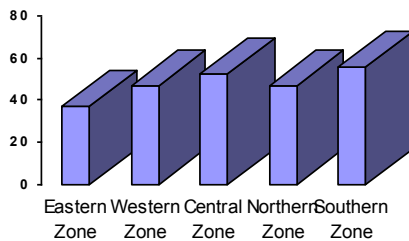
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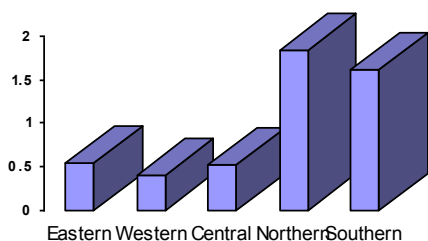
Average Organic Carbon (%) values in different zones of Sundarbans for *N. fruticans*



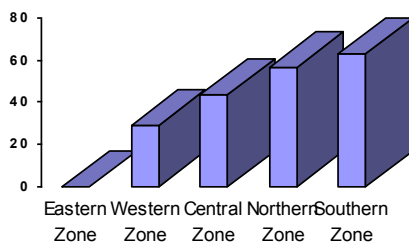
Easily Mineralisable Nitrogen (mg/kg) values in different zones of Sundarbans for *B. gymnorhiza*



Average Organic Carbon (%) values in different zones of Sundarbans for *P. paludosa*

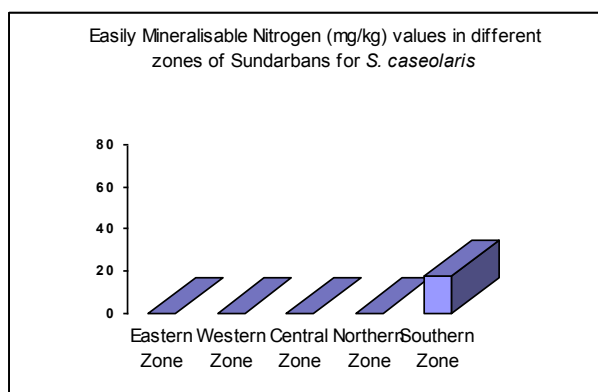
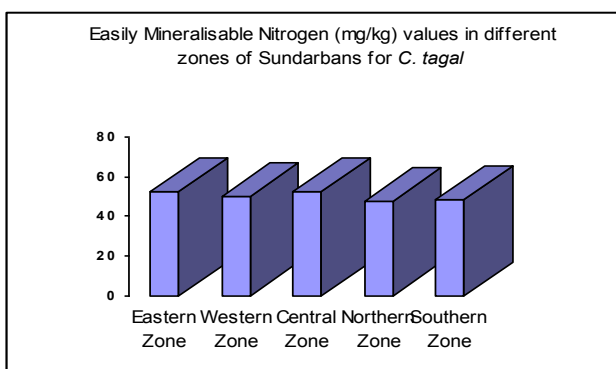
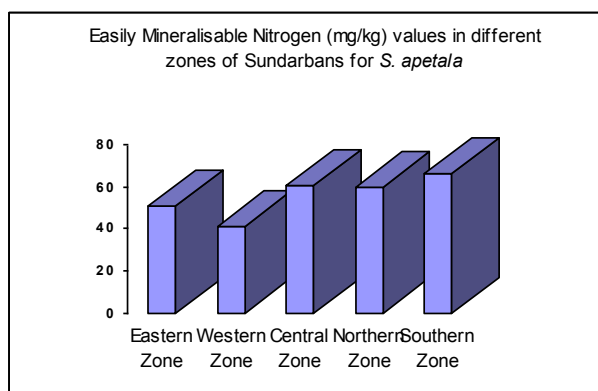
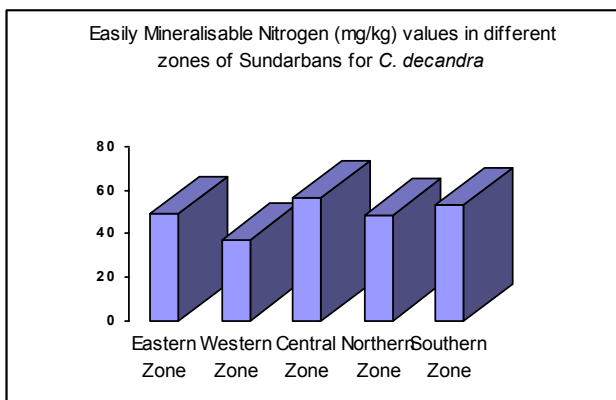
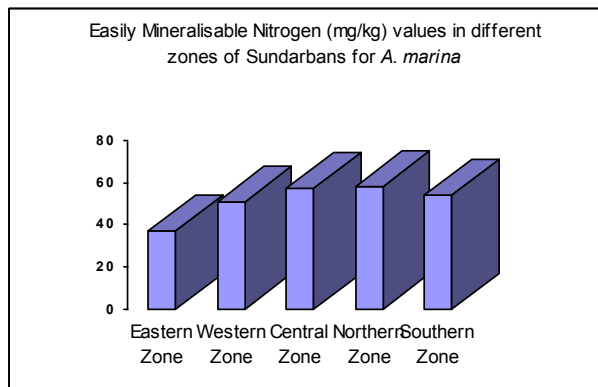
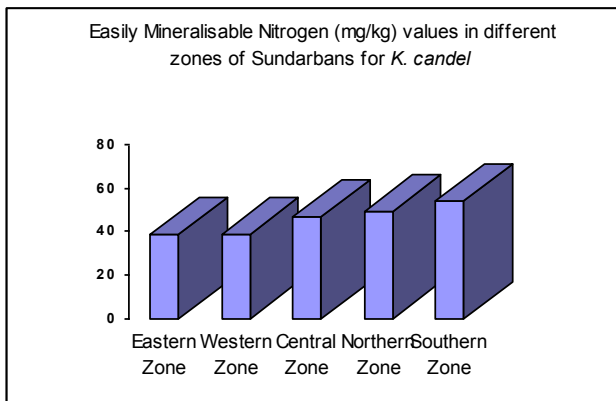
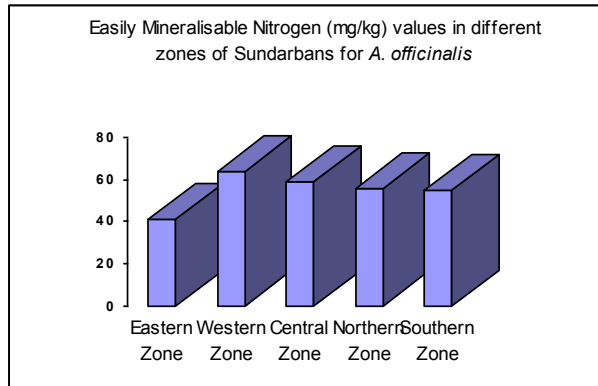
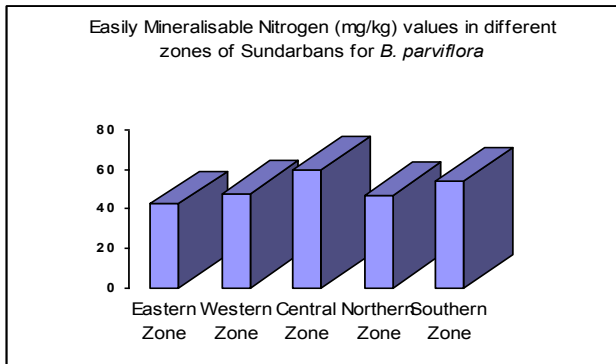
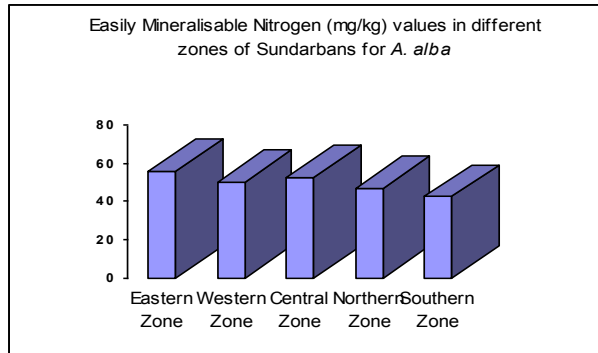
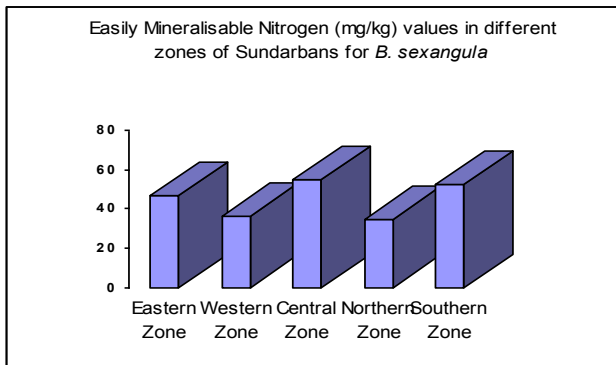


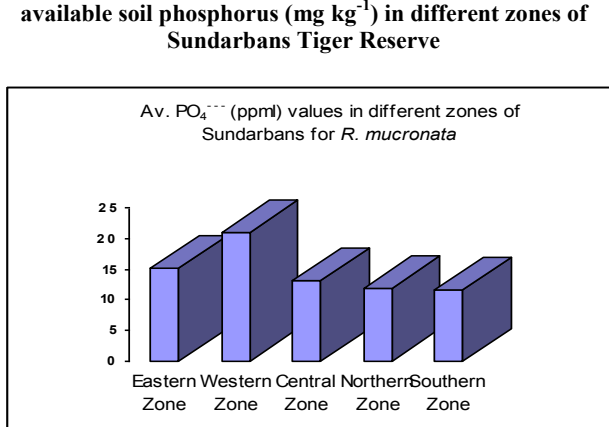
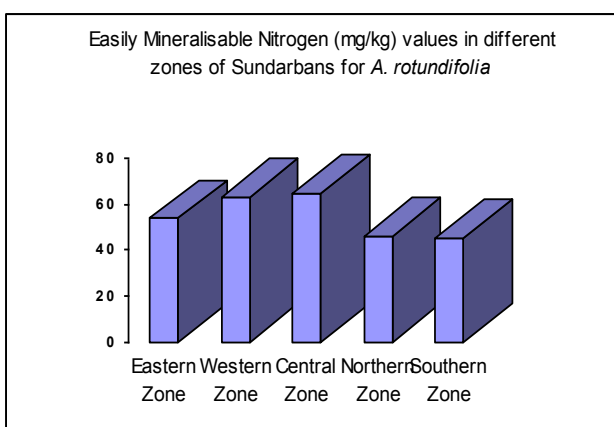
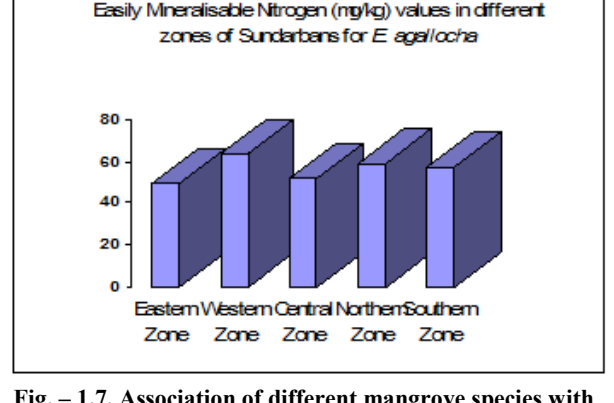
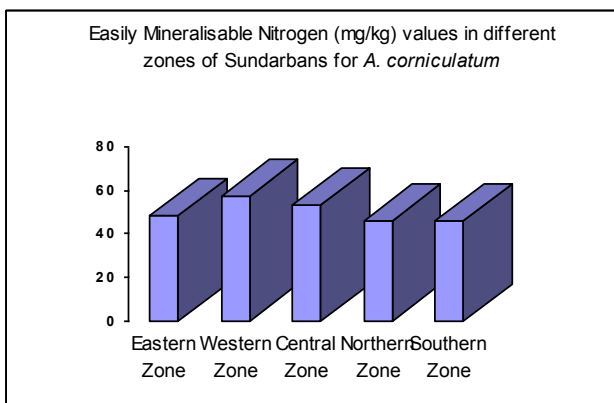
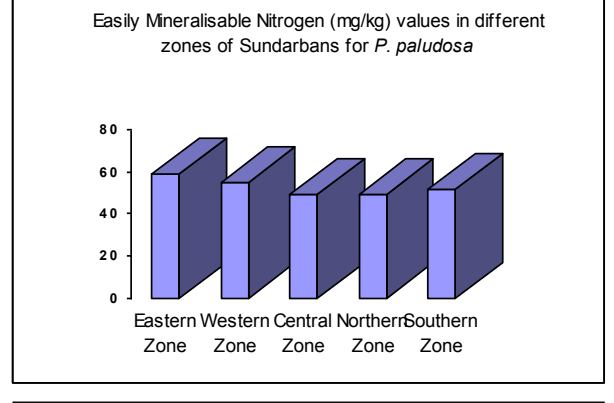
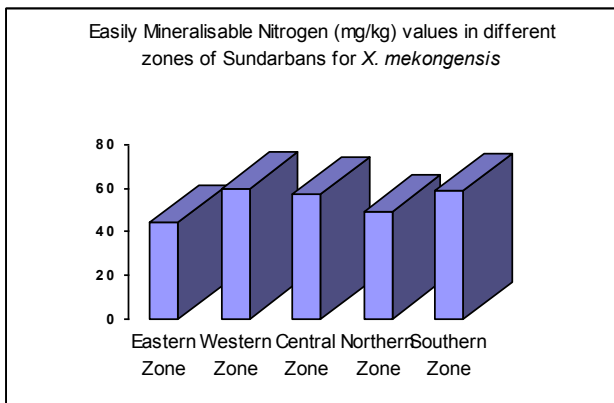
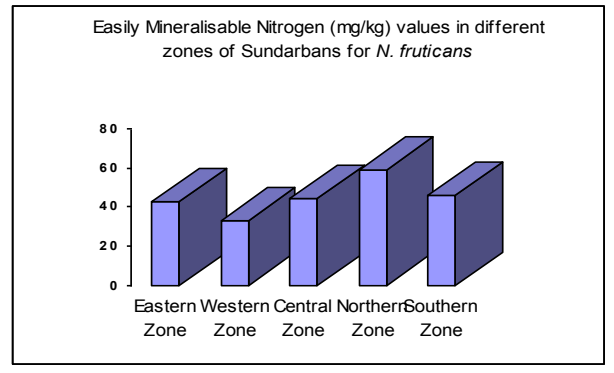
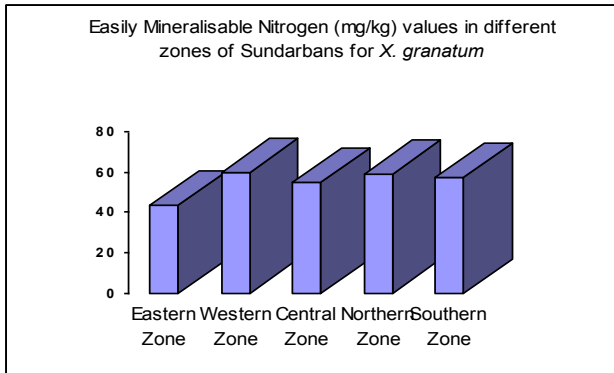
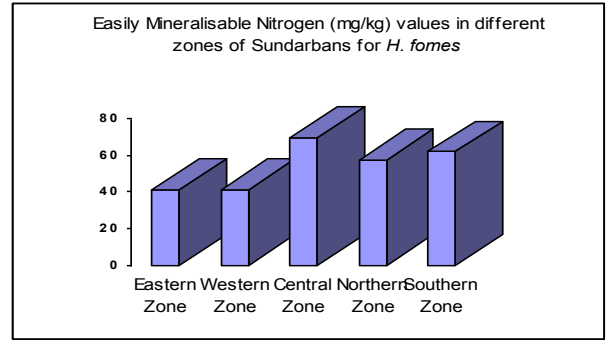
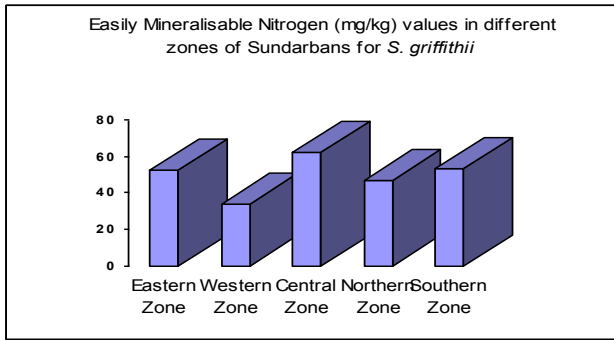
Easily Mineralisable Nitrogen (mg/kg) values in different zones of Sundarbans for *B. cylindrica*



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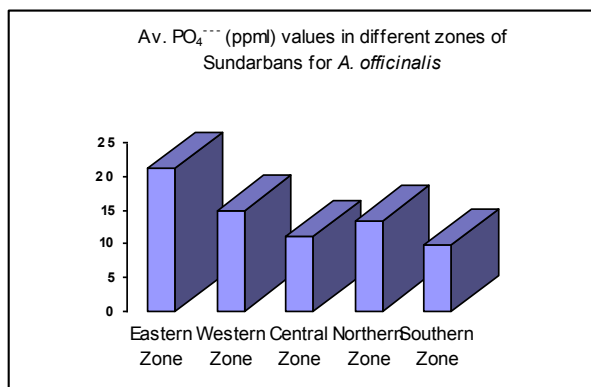
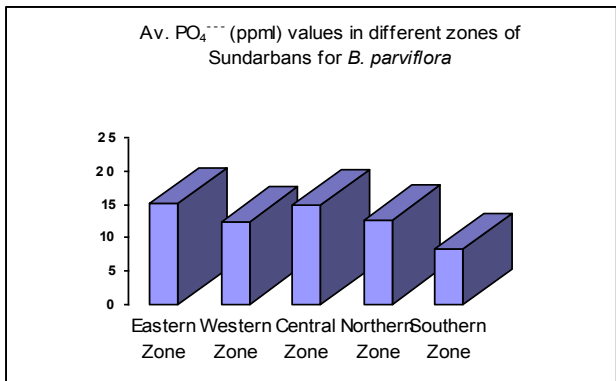
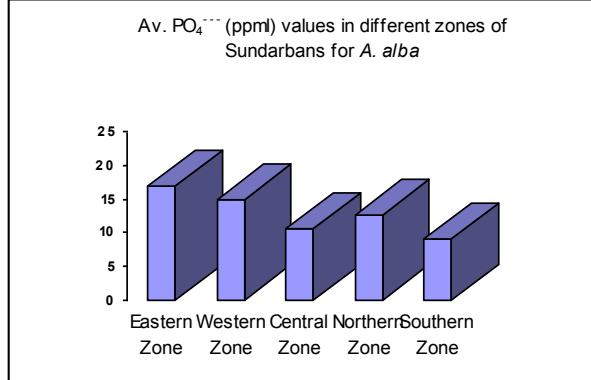
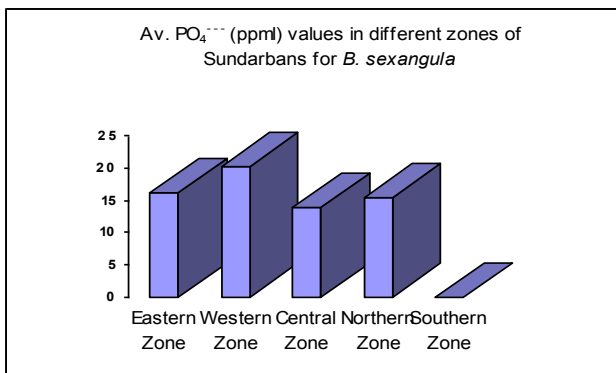
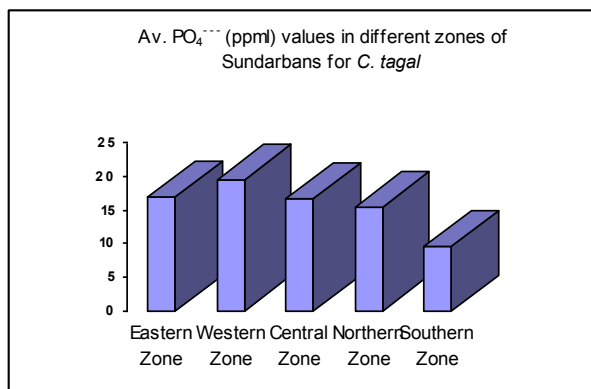
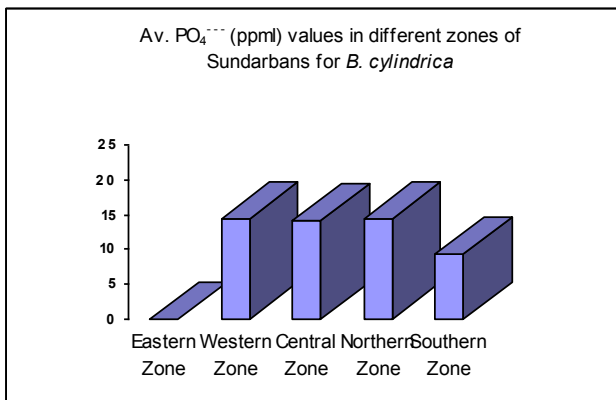
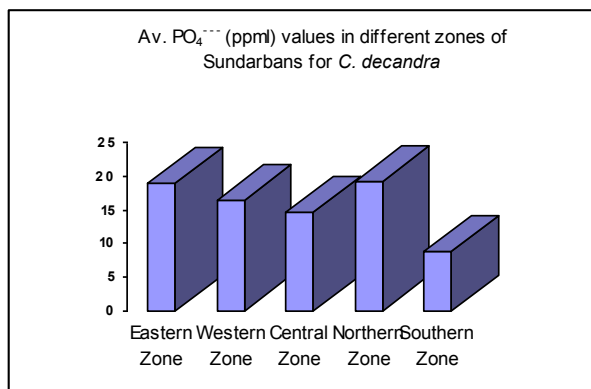
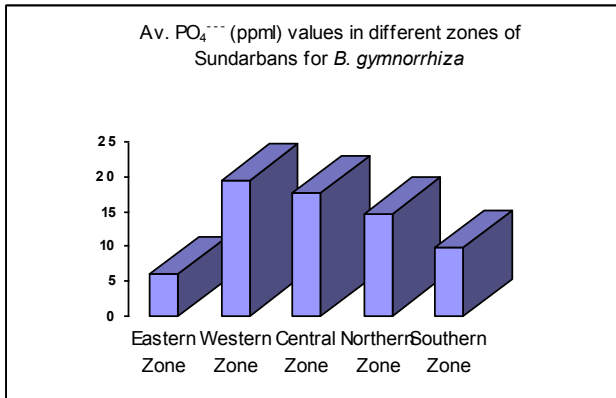
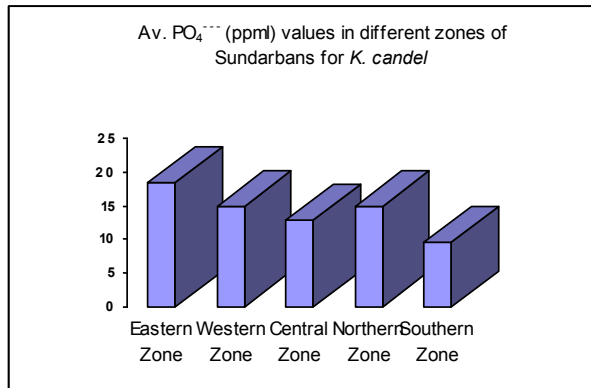
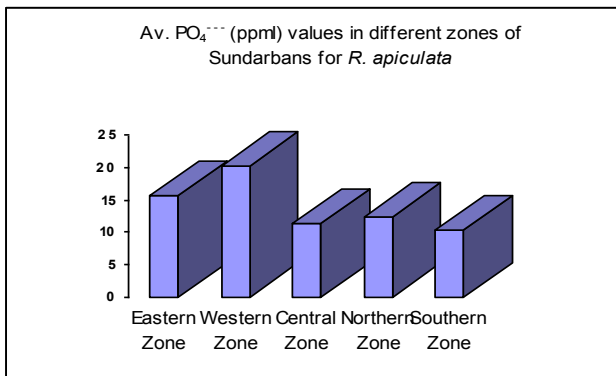
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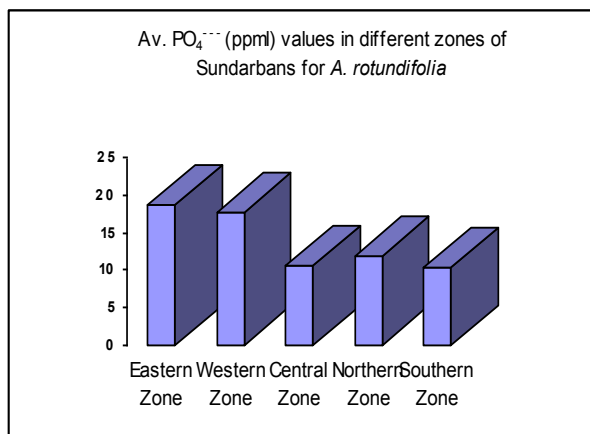
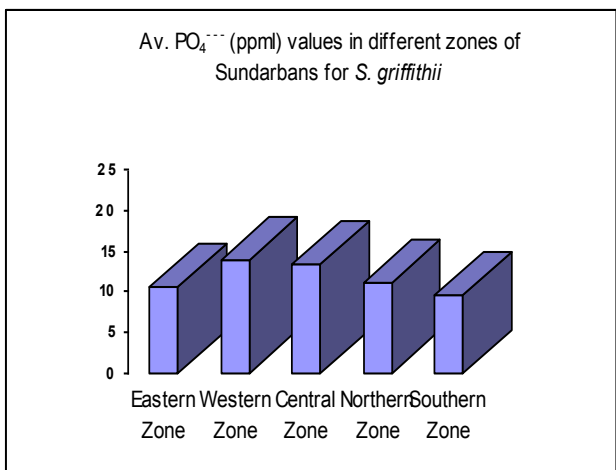
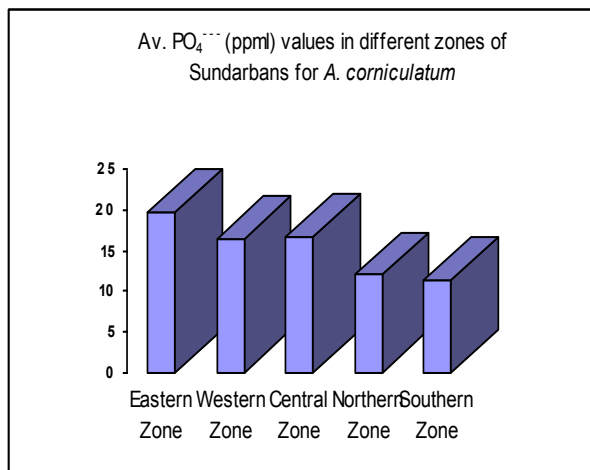
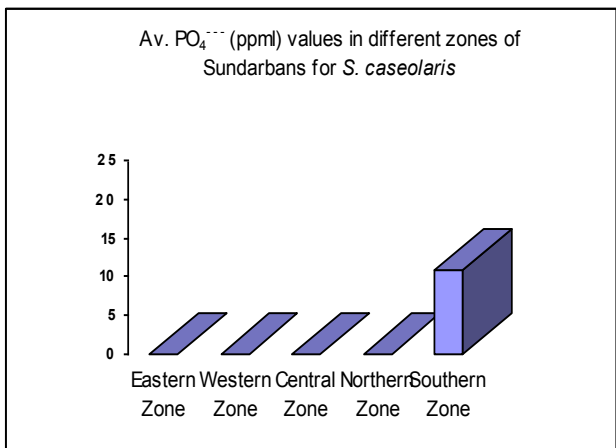
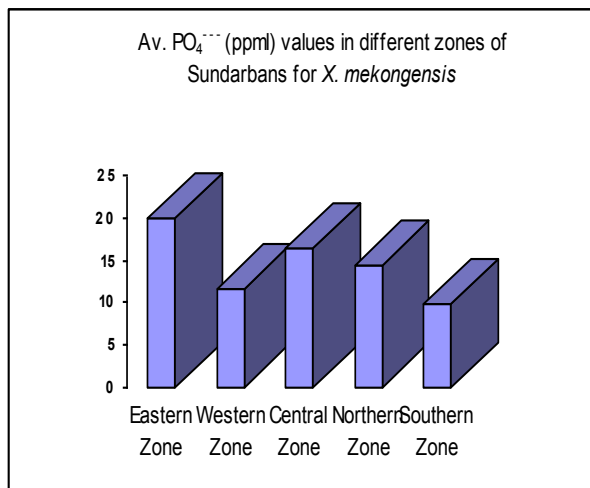
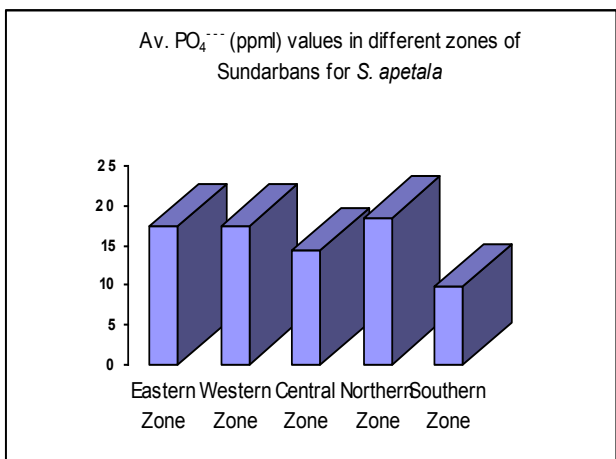
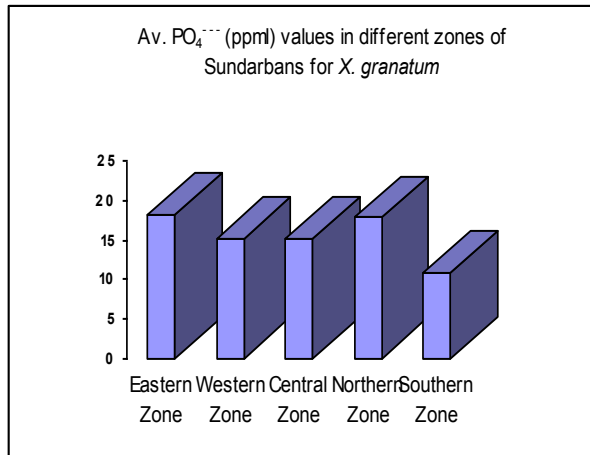
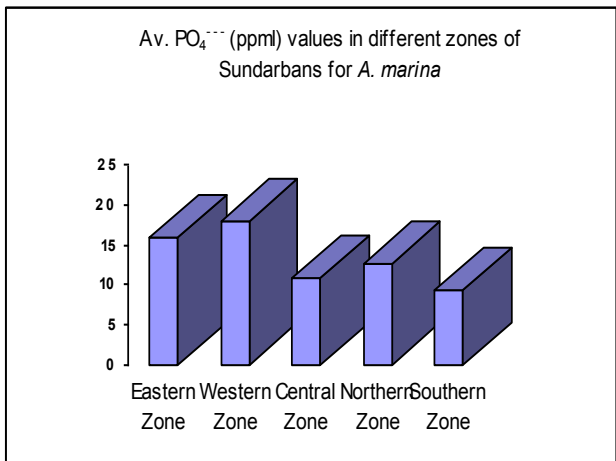


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Fig. – 1.7. Association of different mangrove species with available soil phosphorus ($mg\ kg^{-1}$) in different zones of Sundarbans Tiger Reserve



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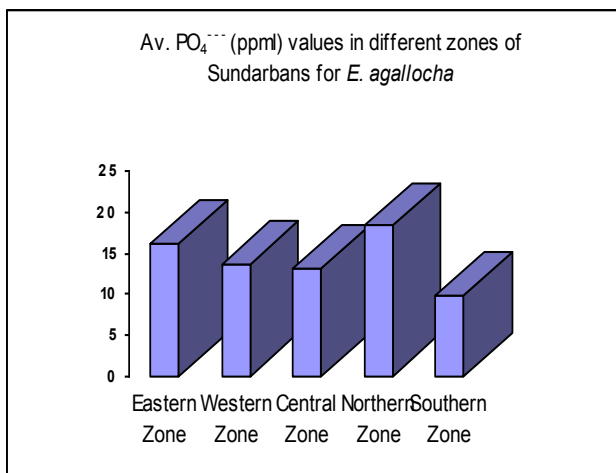
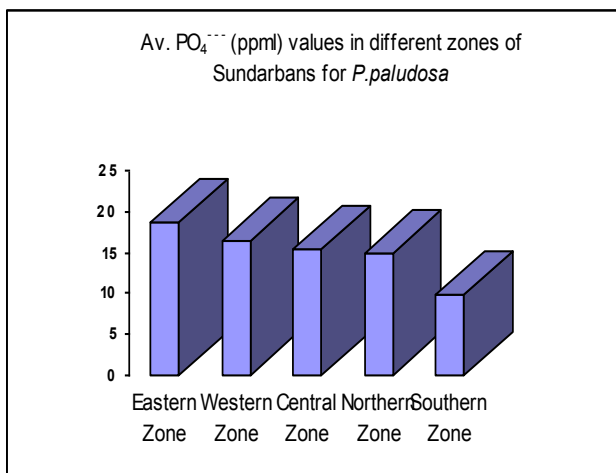
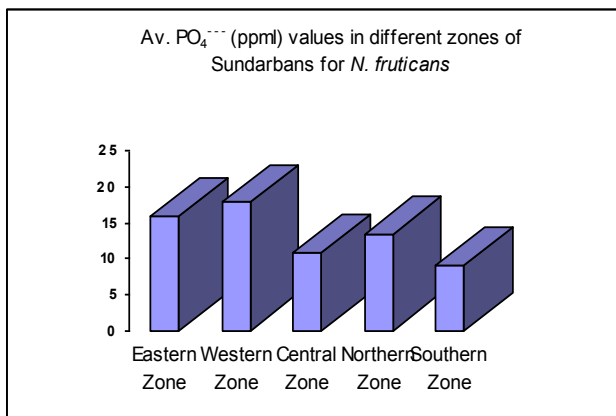
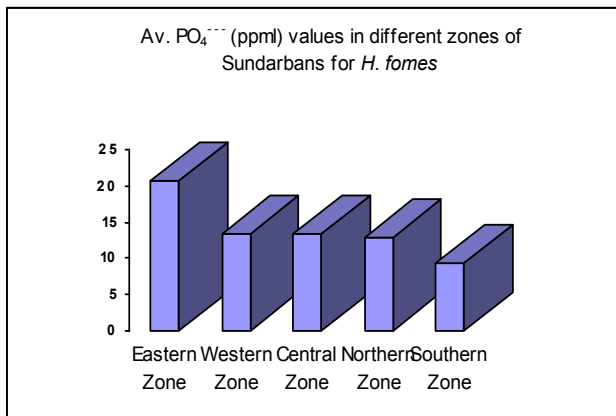


Table – 1. Correlation coefficients of different properties of mangrove rhizosphere soils with relation to intensity of vegetation.

Properties	Correlation co-efficient	Significance
Salinity	0.159732	NS
Organic Carbon	0.31834	NS
Available Nitrogen	0.729802	S
Available Phosphorus	0.05165	NS

S = Significant at 5% level
NS = Non Significant

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