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Abiotic Stress Management in Beach Trees Through Chlorophyll proportion Reshuffle: A Case Study from Peninsular India

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ABSTRACT
The present work is about beach tree species pigment content analysis and a method to explain how coastal trees manage abiotic stress through modification in chlorophyll and carotenoids. Pilot field visits were conducted for selecting the tree species for chlorophyll analysis, which gave a collection of 28 tree species from the four study sites (B1-B4). Eight tree species (P1-P8) were considered that are common in all the study sites and control from the natural stand (NS) was also considered. Total chlorophyll is higher than NS for samples from B3 for P1; B3 and B4 for P2, P4, P6; B2 for P3 and P7; B1, B3, and B4 for P5; B1, and B2 for P8. The study on Chlorophyll a/b ratio in P1 recorded a higher Chl a/b ratio than NS in specimens from B2, B3, and B4 for P1; B1, B3, and B4 for P2; B1 and B3 for P3; B4 for P4; B1 for P5; B1, B2 and B4 for P6; and B4 for P8. The highest Chl a/b was shown by P6 from B4 recorded as much as 7.29 and indicates high photon flux and nitrogen limitation.
KeyWords: *Abiotic stress management, Beach trees, Chlorophyll content, Photon flux, Chlorophyll a/b ratio*

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INTRODUCTION

The coastal belt of the terrestrial habitat is a dense grove of trees, which can be evaluated through biodiversity study in the area. Pressure on the coast has been increasing since the dawn of civilization [1]. Peninsular India in its southwest region, is dominated by coconut trees [2]. Living by the sea has to survive: salty winds, poor soil without mineral nutrition, rocky and sandy places, change in pH, temperatures, and many other environmental characteristics. Photo-inhibition of the photosynthetic pigment apparatus is affected by stress responses [3]. Photosynthesis maintains atmospheric oxygen levels and supplies all of the organic compounds and most of the energy necessary for life on earth [4]. Chlorophyll-a absorbs most energy from wavelengths of violet-blue and orange-red light whereas chlorophyll-b is more soluble in polar solvents. It is found that in shade-adapted chloroplasts there is a lower ratio of chlorophyll-a to chlorophyll-b [5]. Few studies have been conducted on coastal flora and studies on chlorophyll content of the coastal plants are limited. Therefore this study is focused on beach tree species pigment content analysis and methods to evolve to explain how coastal trees manage abiotic stress through modification in chlorophyll and carotenoids.

MATERIAL AND METHODS

Pilot field visits were conducted for selecting the tree species for chlorophyll analysis. Five plots of 100m^2 were taken and the list of trees in each plot was tabulated. This was repeated in all the four study sites (Table. 1). The binomial of trees were updated as regional and local flora [6], [7], [8]. Trees located in all four study sites were considered for pigment analysis.

TABLE 1. LIST OF TREES RECORDED IN THE PILOT STUDY

Family	Botanical Name	B1	B2	B3	B4
Annonaceae	*Annona muricata* L.	-	-	-	*
Annonaceae	*Annona squamosa* L.	-	*	-	-
Annonaceae	*Annona reticulate* L.	-	-	-	*
Annonaceae	*Polyalthia longifolia* (Sonn.) Thwaites	-	-	-	*
Clusiaceae	*Calophyllum inophyllum* L.	*	*	*	*
Malvaceae	*Taliparitiliaceum* (L.) Fryxell	*	*	*	*
Bombacaceae	*Ceiba pentandra* (L.) Gaertn.	-	-	-	*
Sterculiaceae	*Sterculia foetida* L.	-	-	-	*
Elaeocarpaceae	*Muntingia calabura* L.	-	-	-	*
Anacardiaceae	*Mangifera indica* L.	-	*		-
Fabaceae	*Gliricidia sepium* (Jacq.) Walp.	*	*	*	*
Fabaceae	*Pongamia pinnata* (L.) Pierre	*	*	*	*
Caesalpiniaceae	*Delonix regia* (Hook.)Raf.	-	-	-	*
Caesalpiniaceae	*Tamarindus indica* L.	-	-	*	-
Mimosaceae	*Acacia mangium* Willd.	-	-	*	-
Mimosaceae	*Pithecellobium dulce* (Roxb.) Benth.	-	-	-	*
Mimosaceae	*Samanea saman* (Jacq.)Merr.	-	*	-	-
Combretaceae	*Terminalia catappa* L.	*	*	*	*
Lythraceae	*Lagerstroemia speciosa* (L.)Pers.	-	-	-	*
Rubiaceae	*Morinda citrifolia* L.	-	-	*	*
Apocynaceae	*Alstonia scholaris* (L.) R.Br.	-	*	-	*
Bignoniaceae	*Millingtonia hortensis* L.f.	-	-	-	*
Bignoniaceae	*Spathodea campanulata* P.Beauv.	-	-	*	*
Moraceae	*Ficus benghalensis* L.	-	-	-	*
Moraceae	*Ficus benjamina* L.	-	-	-	*
Moraceae	*Ficus religiosa* L.	*	*	*	*
Casuarinaceae	*Casuarina litorea* Rumph.	*	*	*	*
Arecaceae	*Cocos nucifera* L.	*	*	*	*

The eight tree species selected for the chlorophyll analysis studies are *Calophyllum inophyllum* (P1), *Taliparitiliaceum* (P2), *Gliricidia sepium* (P3), *Pongamia pinnata* (P4), *Terminalia catappa* (P5), *Ficus religiosa* (P6), *Casuarina litorea* (P7), *Cocos nucifera* (P8). Samples from respective species from the natural stands served as control (NS). Four beach sites where the study and the material collection were performed are Edavanakkad (S1), Vypin (S2), Cherai (S3), and Fort Kochi (S4)**.** Field visits were conducted from February 2015 to July 2019**.** Arnon's chlorophyll (Chl) estimation method [9] was used in the present study. Samples were collected twice a year during the study period and the average data obtained are presented.

RESULTS

Data on chlorophyll-a content, Chlorophyll-b, total Chl, Chl pigment ratio, carotenoid in the selected tree species namely *Calophyllum inophyllum* (P1), *Taliparitiliaceum* (P2), *Gliricidia sepium* (P3), *Pongamia pinnata* (P4), *Terminalia catappa* (P5), *Ficus religiosa* (P6), *Casuarina litorea* (P7), *Cocos nucifera* (P8) are presented in Figure 1-5. It is clear from figure 1, that P1, P3, P4 have higher Chl-a content in samples from B2 and B4 whereas P2 and P7 recorded lower values than the plant from natural habitat. P5 recorded higher Chl content in B1, B2, and B3; P6 has a higher value than natural stand-in B4 (0.1114 mg g^1). In the case of P8 samples from B1 and b4 recorded higher Chl-a content than specimens from NS. Chlorophyll-b content in the leaves of the species under study are given in figure 2 and it shows higher value than NS for samples from B3 and B4 in P1, B4 in P2 (0.76 mg g^1); B2 and B3 in P3 (0.0316 mg g^1, 0.042mg g^1); B2 (0.0243 mg g^1: 0.026 mg g^1), B3 (0.262 mg g^1: 0.045 mg g^1) and B4 (0.06 mg g^1:0.0546 mg g^1) in P4 and P5; B3 in P6; B1 (0.0388 mg g^1) and B2 (0.0376 mg g^1). Total Chlorophyll content in the leaves of the species under study are given in figure 3 and it is obvious that total chlorophyll is higher than NS for samples from B3 for P1; B3 and B4 for P2, P4, P6; B2 for P3 and P7; B1, B3 and B4 for P5; B1, and B2 for P8. Analysis of carotenoid content for the species under study is given in figure 4. According to the values, it is obvious that there is a higher value for B4 specimens in P1 and P5; B2 and B3 specimens in

P2; B3 and B4 specimens in P3 and P4. Average data on the carotene content in leaf specimens do not show a higher value than NS for plants P6, P7, and P8.

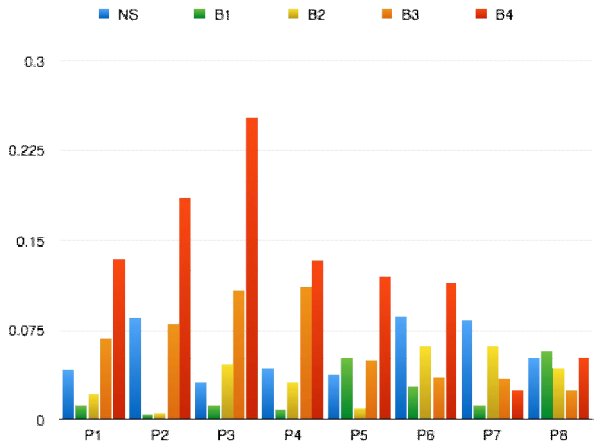

Fig. 1. Chlorophyll-a content in the Species under study (P1-P8) from different beaches (B1-B4)

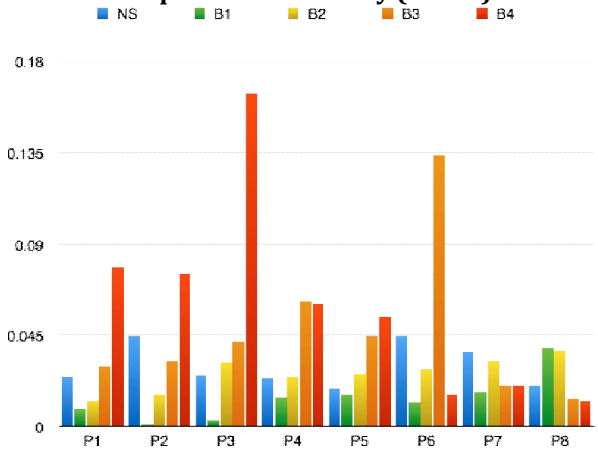

Fig. 2. Chlorophyll-b content in the Species under study (P1-P8) from different beaches (B1-B4)

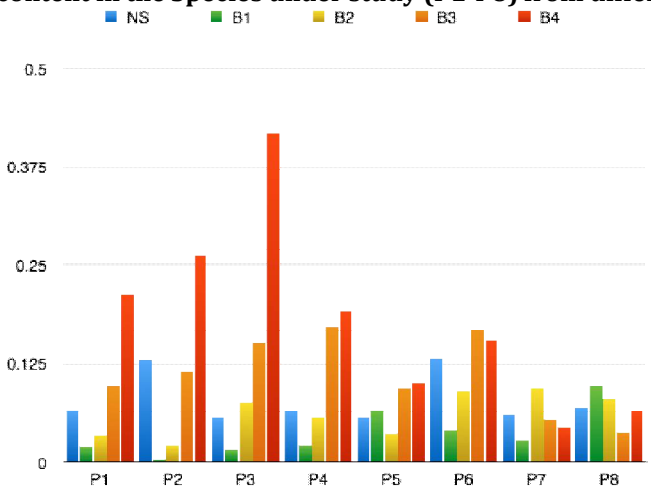

Fig. 3. Total Chlorophyll content in the Species under study (P1-P8) from different beaches (B1-B4)

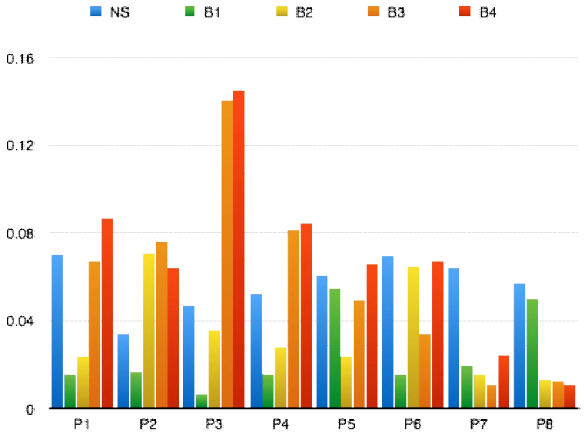

Fig. 4. Carotenoid content in the Species under study (P1-P8) from different beaches (B1-B4)

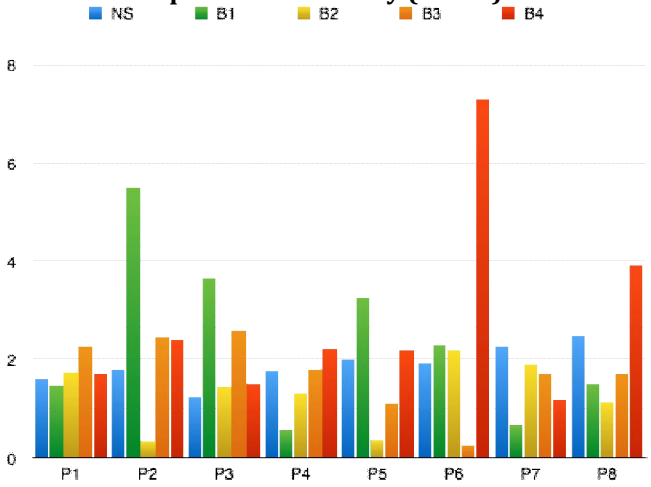

Fig. 5. Chlorophyll a/b ratio in the Species under study (P1-P8) from different beaches (B1-B4)

The study on Chlorophyll a/b ratio is given in figure 5, which indicates the following: P1 recorded higher Chl a/b ratio than Ns in specimens from B2, B3, and B4 for P1; B1, B3, and B4 for P2; B1 and B3 for P3; B4 for P4; B1 for P5; B1, B2 and B4 for P6; and B4 for P8.

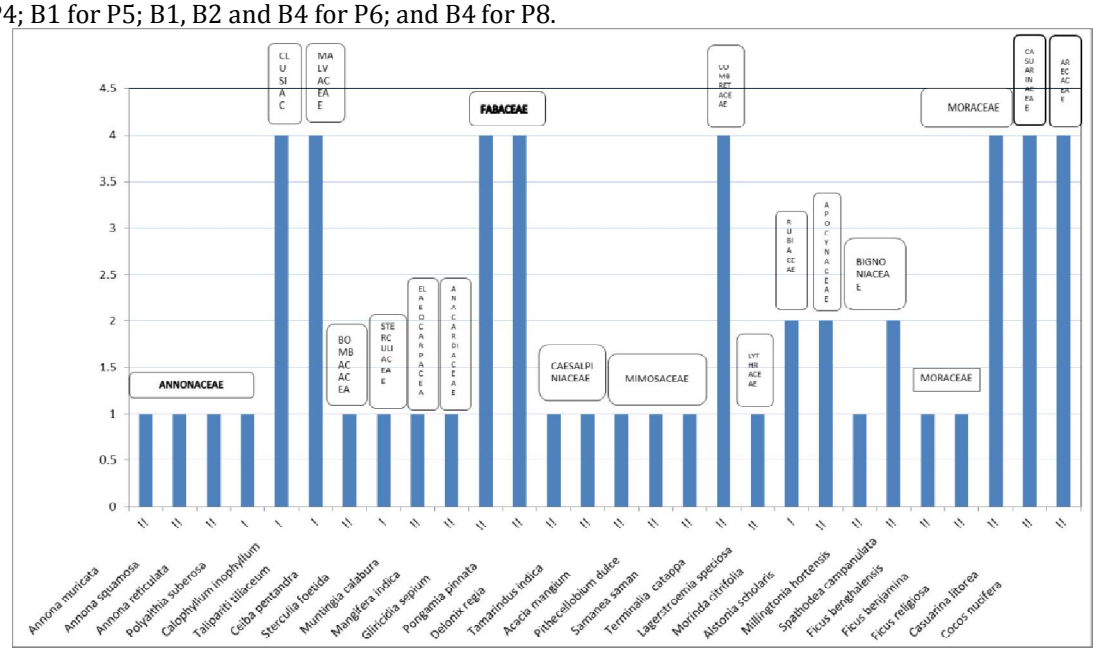

Figure 6. The pattern of tree species distribution in the study sites (recorded during the pilot study)

DISCUSSION

From the pilot study data, it is obvious that B4 beach has the highest tree species diversity. On examining the list it is more or less clear that many are cultivated species, which is carried out by the local

government or privately owned business centers as it is a beach that attracts a lot of foreign tourists round the year. From government records, it is clear that B4 beach is landfilled one, and filled in soil may be the reason to support high tree species diversity. A total of 28 tree species were obtained from the 4 beaches. Among the 18 different families, Fabaceae is found the adapted family (Fig.6). Wider distribution is shown by certain tree species such as *Calophyllum inophyllum, Taliparitiliaceum, Gliricidia sepium, Pongamia pinnata, Terminalia catappa, Ficus religiosa, Casuarina litorea,* and *Cocos nucifera.* Chlorophyll-a, total chlorophyll, and carotenoids were found to be higher in P3 of B4, whereas chlorophyll-b was higher in P6 of S3. Chlorophyll a/b ratios were found to be higher in trees of the B4 site. The highest Chl a/b was shown by P6 from B4, and the ratio is 7.29. If Chl a/b ratio is > 3.2- 4, Photosynthetic photon flux will be higher [10]. According to the result obtained, the majority of the tree species are showing lower Chl a/b ratios and this, therefore, gives a clear indication that they are adapted and acclimatized to the area. This refers that the photosynthetic photon flux rate is lower in the majority of the tree species collected from both coastal areas and natural stands. It can be also projected that the species can be used in future plantation programs along with coastal belts and beaches of tropical areas with similar climates. [11], showed the effect of NaCl in the growth and development of sunflowers. Randall et. al. [12], [13] rightly said that decreased content of this chlorophyll protein accounts for the elevated chlorophyll **a/b** ratios and the reduced photosynthetic unit sizes of the two cell types in stressed plants and acclimation of tropical woody plants to nitrogen limitation [5]. The study conducted in natural forests for chlorophyll-a, chlorophyll-b, and total chlorophyll and chlorophyll a/b ratio fall in values ranging between 0.87–15.92 mg g^1 [14]. The present study to access abiotic stress is a highly reliable and reproducible one as it selected tree species, which faces all seasons throughout the year. Even though in some cases the Chl a/b has shown (P6 from B4) as much as 7.29 the data obtained can predict the trees which are acclimatized in the area and are suitable for future cultivation or planting purposes on beaches.

CONCLUSIONS

A coastline represents a dynamic, fragile physical and biological environment that is constantly changing in response to natural processes as well as human activities. It holds great attraction for man as it provides him with a variety of resources for food, construction, recreation, transportation, and aesthetics. It also provides a natural protective barrier for inland areas against violent storms as well as daily or seasonal attacks by wind and waves. This project mainly aimed at comparing the tree diversity, photosynthetic activity, and rate of abiotic stress of beach trees with that growing under mesophytic conditions. Samples of the trees were collected from 4 beaches and undergone for chlorophyll estimation & spectrophotometric method. Trees of B4 beach showed a higher amount of pigment content than the other 3 beaches and the natural stands. The photosynthetic efficiency of trees is largely affected by the landfilling of the beach area. All the trees of natural stands are showing an almost similar amount of chlorophyll content. The present study is a model of its kind to access abiotic stress. The merit of the study is its reliability and reproducibility. It poses a great future for gene manipulation studies for stress-resistant genes in the trees.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

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