SPECTRAL LIBRARY DATABASE FOR THE MANGROVES OF INDIA

A Guide for the Spectral Library of Mangroves of Indian East Coast

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1. INTRODUCTION

1.1. Mangrove Ecosystem

"Mangroves" is the term used to represent either a single plant or forest community which are salt tolerant halophytes, woody in nature, generally thrive in the muddy and anaerobic substratum of intertidal regions in tropical and sub-tropical coastlines. Mangroves are usually found in estuarine regions where mixing of fresh and saline water takes place. Mangrove environment is characterized by extreme weather conditions such as high temperature, strong winds, turbulent inundation, and saline soil. In order to withstand such extreme conditions, they develop some physio-morphological adaptations like specialized roots and layered cell membranes to avoid the entry of salts, prolonged tube like breathing structure called pneumatophores, and viviparous seedlings to germinate in parent tree. In earlier times, mangroves were thought to be unproductive transitional systems; however, they gain recognition in recent times due to their high productivity and efficient carbon sequestration capability. Furthermore, mangrove ecosystem acts as a breeding and feeding ground for large varieties of fishes, mollusks, crustaceans, and other related fauna. Therefore, mangroves are credited for its autotrophic nature which helps to maintain coastal food chain (Alongi, 2002).

According to the habitat and physiological adaptations, mangroves can be broadly classified into two categories: 1) ***true or exclusive mangroves*** occur only in core intertidal region (mangal) or only rarely elsewhere; and 2) ***associate or non-exclusive mangroves*** typically occur in the landward margin of mangal and often in transition zone between mangrove and other niche such as rainforest, salt marsh, or lowland freshwater swamps. Many epiphytes also grow on mangrove trees; these include an assortment of creepers, orchids, ferns, and other plants, many of which cannot tolerate salt and, therefore, grow only in the mangrove canopy.

1.2. Global Distribution of Mangroves

As per the World Atlas of Mangroves 2010, the mangroves are distributed over 123 countries in the tropical and sub-tropical regions of the world. The global spatial coverage of mangroves is around 150,000 sq. km. The highest concentration of mangrove cover is found in South East Asia followed by South America, North Central America, West and Central Africa, and South Asia. The maximum distribution of mangroves is found to be lying between 5°N and 5°S latitudes which can be categorized into two major realms: the Indo-

West Pacific (IWP) realm and the Atlantic Caribbean Eastern Pacific (ACEP) realm (Spadling et al., 2010), where the extensive spatial coverage and rich species diversity are observed. The mangrove cover in South Asia is of 10,344 sq. km., which is about 6.8% of the global cover (FSI, 2017). As far as the exact number of mangrove species categorized as "true mangroves" is concerned, still confusion prevails. According to different classifications, different numbers of true mangrove species are reported. In these classification, such categorizations are completely author specific and the number ranges between 54 and 73. However, FAO has categorized and listed out the true mangrove species identified in the world and is given in Table 1.1 (FAO, 2007).

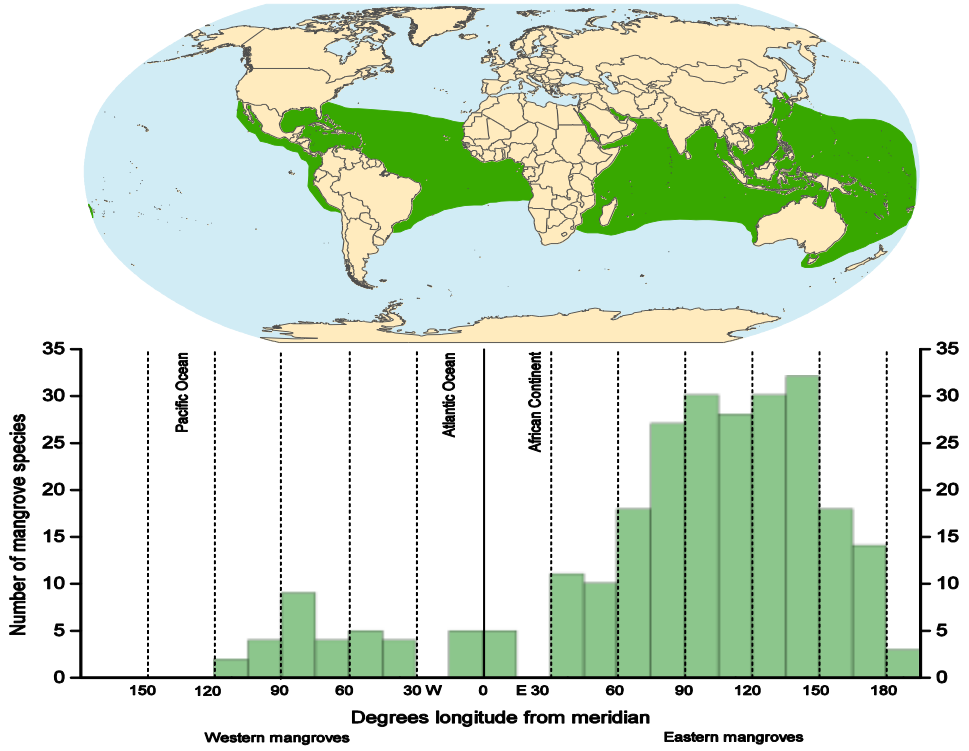

Figure 1.1 Global distribution and diversity of mangroves (Tomlinson, 1994)

1.3. Status of Mangroves in India

The spatial coverage of mangrove has been assessed by the Forest Survey of India using remotely sensed data since the year 1987. The areal coverage of mangroves in 1987 was 4,046 sq. km. The As per the report of State of Forests (2017), the mangrove cover in India is about 4,921 sq. km., which is about 3.3% of the global cover. The increase in mangroves area is mainly attributed due to the conservative efforts such as plantation and regeneration. India holds the major share of mangrove cover in South Asia with a share of about 45.8% of the total mangrove cover in South Asia.

Table 1.1 List of True Mangrove Species as listed by FAO Forestry Report (2007)

Family	Species	Family	Species
Acanthaceae	*Acanthus ebracteatus**	*Rhizophoracea*	*Bruguiera cylindrica**
	*Acanthus ilicifolius**		*Bruguiera exaristata*
	Acanthus xiamenensis		*Bruguiera gymnorrhiza**
Avicenniaceae	*Avicennia alba**		*Bruguiera hainesii*
	Avicennia bicolor		*Bruguiera parviflora**
	Avicennia eucalyptifolia		*Bruguiera sexangula**
	Avicennia germinans		*Ceriops australis*
	Avicennia integra		*Ceriops decandra**
	Avicennia lanata		*Ceriops somalensis*
	*Avicennia marina**		*Ceriops tagal**
	*Avicennia officinalis**		*Kandelia candel**
	Avicennia rumphiana		*Kandelia obovata*
	Avicennia schaueriana		*Rhizophora x annamalayana**
Bombacaceae	*Camptostemon philippinensis*		*Rhizophora apiculata**
	Camptostemon schultzii		*Rhizophora harrisonii*
Combretaceae	*Conocarpus erectus*		*Rhizophora x lamarckii**
	Laguncularia racemosa		*Rhizophora mangle*
	*Lumnitzera littorea**		*Rhizophora mucronata**
	*Lumnitzera racemosa**		*Rhizophora racemosa*
	Lumnitzera x rosea		*Rhizophora samoensis*
Caesalpiniaceae	*Cynometra iripa**		*Rhizophora x selala*
	Cynometra ramiflora		*Rhizophora stylosa**
Euphorbiaceae	*Excoecaria agallocha**	*Rubiaceae*	*Scyphiphora hydrophylacea**
	Excoecaria indica	*Sonneratiaceae*	*Sonneratia alba**
Lythraceae	*Pemphis acidula*		*Sonneratia apetala**
Meliaceae	*Xylocarpus granatum**		*Sonneratia caseolaris**
	*Xylocarpus mekongensis**		*Sonneratia griffithii**
	Xylocarpus rumphii		*Sonneratia x gulngai*
	*Xylocarpus moluccensis**		
Myrsinaceae	*Aegiceras corniculatum**		*Sonneratia hainanensis*
	Aegiceras floridum		*Sonneratia ovate*
Myrtaceae	*Osbornia octodonta*		*Sonneratia x urama*
Palmae	*Nypa fruticans**	*Sterculiaceae*	*Heritiera fomes**
Pellicieraceae	*Pelliciera rhizophorae*		*Heritiera globosa*
Plumbaginaceae	*Aegialitis annulata*		*Heritiera kanikensis**
	*Aegialitis rotundifolia**		*Heritiera littoralis**
Pteridaceae	*Acrostichum aureum**		
	*Acrostichum speciosum**		

Species highlighted with symbol * are seen in Indian coast (Barik and Chowdhury, 2014; Ravishankar, Gnanappazham, et al., 2004a; Ravishankar, Navamuniyammal, et al., 2004b; Spadling et al., 2010).

The Sundarbans mangroves in West Bengal state is the largest mangrove ecosystem in India and covers almost half of the mangrove area in India. The Indian east coast exhibits richer species diversity than that of the western coast because of rich muddy alluvial

substratum and fresh water supply along broader deltas and estuarine regions. Among Indian provinces, West Bengal holds the major share (2,114 sq. km.), followed by Gujarat (1140 sq. km.), and Andaman and Nicobar islands (617 sq. km.) (FSI, 2017) (Table 1.2).

Table 1.2 Areal coverage of Mangroves in Indian Provinces in the year 2017

State/Union Territory	Mangrove Cover (in sq. Km.)	Percentage Cover
Andhra Pradesh	404	8.21
Goa	26	0.53
Gujarat	1140	23.17
Karnataka	10	0.20
Kerala	9	0.18
Maharashtra	304	6.18
Odisha	243	4.94
Tamil Nadu	49	1.00
West Bengal	2114	42.96
A & N Islands	617	12.54
Daman & Diu	3	0.06
Puducherry	2	0.04
Total	**4921**	**100.00**

Source: State of Forest Report: Mangroves; Forest Survey of India (2017)

1.4. Field Spectrometry

Field spectrometry is the technique which is used to quantify the radiance, irradiance, transmission/ reflectance from various earth surface features in the field condition (ASD, 2001; Jackson et al., 1980). It provides ground truth information and is regarded as the precursor of hyperspectral image analysis. Filed spectrometry is applied to get detailed knowledge about the relationship between the characteristic feature of the material and the spectral reflectance in the Electromagnetic radiation (EMR) domain. Ground truth data is the vital information for any type of remote sensing data analysis to assess its accuracy. While categorical and qualitative ground truth data is used for multispectral data analysis, the accuracy levels of hyperspectral image analysis could be enhanced by incorporating in-situ spectral data collected using spectroradiometer.

Spectral library of earth features will be the ideal complementary information to the ground truth data in training hyperspectral image classification algorithm. Spectral data is used for the discriminating features having a similar response to the light energy (spectral

characteristics) such as minerals, vegetation types, soil and water quality parameters. It is being actively used in last two decades in forestry and vegetation sciences for species identification, classification, health status monitoring, nutrient intake estimation, invasive species monitoring etc.

1.5. Development of Spectral Library for Mangroves

Several site-specific spectral libraries were collected so far for various species including, non-native species (Underwood, 2003), wetland species (R. J. Zomer et al., 2009), Mediterranean species (Manakos et al., 2010), shrubland species (Jiménez and Díaz-Delgado, 2015), coral reefs (Kutser et al., 2006), and agricultural crops (Datt et al., 2003; Nidamanuri and Zbell, 2012; Rao et al., 2007). Considering mangroves, only a few studies have been conducted in collection and analysis of the spectral information in laboratory and field conditions. (Vaiphasa et al., (2005) have collected laboratory spectral signatures in the wavelength domain of 350nm to 2500nm for 16 tropical mangrove species in AoSawi, Chumporn Province of Thailand. Field spectral data in the wavelength range of 350nm to 1050nm were collected from five mangroves species in Tok Bali, Kelantan and Setiu, Terengganu in Malaysia (Kamaruzaman and Kasawani, 2007). Laboratory spectral signatures were collected for three mangrove species of Punte Galeta, Caribbean coast of Panama (Wang and Sousa, 2009) and mangroves in degraded and healthy conditions in the coastal lagoon south of the city of Mazatlán in the Mexican State of Sinaloa (Zhang et al., 2014).

In this project, we attempt to develop an exclusive spectral library for mangroves in Indian east coast. This research project would provide researchers with the reference spectral reflectance data, particularly for mangroves. This data could be used by researchers who are interested in hyperspectral data analysis for species discrimination, biophysical, and biochemical parameter retrieval etc. This manual explains sampling methodology, field and laboratory spectral signature collection protocols, and post-processing techniques involved to develop a spectral library of mangroves in Indian east coast.

2. STUDY AREA DESCRIPTION

2.1. Bhitarkanika National Park, Odisha, India

Bhitarkanika National Park (BNP) is situated in the north-eastern part of Kendrapara district, Odisha. It is the fourth largest contiguous mangrove ecosystem in mainland India next to the Sundarbans, Gujarat and Andhra Pradesh. It is located at the deltaic region formed from the confluence of Brahmani, Baitrani, Maipura, and Dhamra rivers (Figure 2.1). Geographically, the study area extends between 20° 38′ 19″ N and 20° 47′ 27″ N latitudes, and 86° 49′ 26″ E and 87° 05′ 48″ E longitudes. The rich alluvial deposits of the gently sloping terrain in Bhitarkanika support rich flora and fauna. The location is well-known for its ecological and biological diversity, and the total area of Bhitarkanika Wildlife Sanctuary is 672 sq. km. Out of this, the core area of 145 sq. km. is covered by true and associated mangroves. This core area was declared as the National Park in the year 1998. Later in August 2002, Bhitarkanika was declared as the "Ramsar Wetland of International Importance" (Ramsar Site Number: 1205), considering its rich biodiversity and ecological importance. There are 76 mangrove species present in BNP, of which 30 are true species and 46 are associated species. *Avicennia marina, Avicennia officinalis, Ceriops decandra, Excoecaria agallocha, Heritiera fomes, Kandelia candel, Sonneratia apetala, Sonneratia caseolaris, Xylocarpus granatum,* and *Xylocarpus moluccensis. Heritiera kanikensis* is the only endemic species seen in the sanctuary. *Sonneratia griffithii,* and *Merope angulata* are some of the endangered species found in the study area (Kar and Satapathy, 2012; Patnaik et al., 2000; Upadhyay and Mishra, 2008). The area experiences semi-diurnal tides with high and low tides twice a day. The tidal amplitude varies between 2 and 3.5 m in the upstream region and between 3.5 and 6 m near to the river mouths (Ravishankar et al., 2004b). Panda et al., (2017) had undergone field work in Bhitarkanika National Park between 2014 and 2016, and recorded 29 true mangrove species and 72 associate species. The recorded true mangrove species belong to 11 families and 15 genera and the associates recorded belong to 39 family and 56 genera.

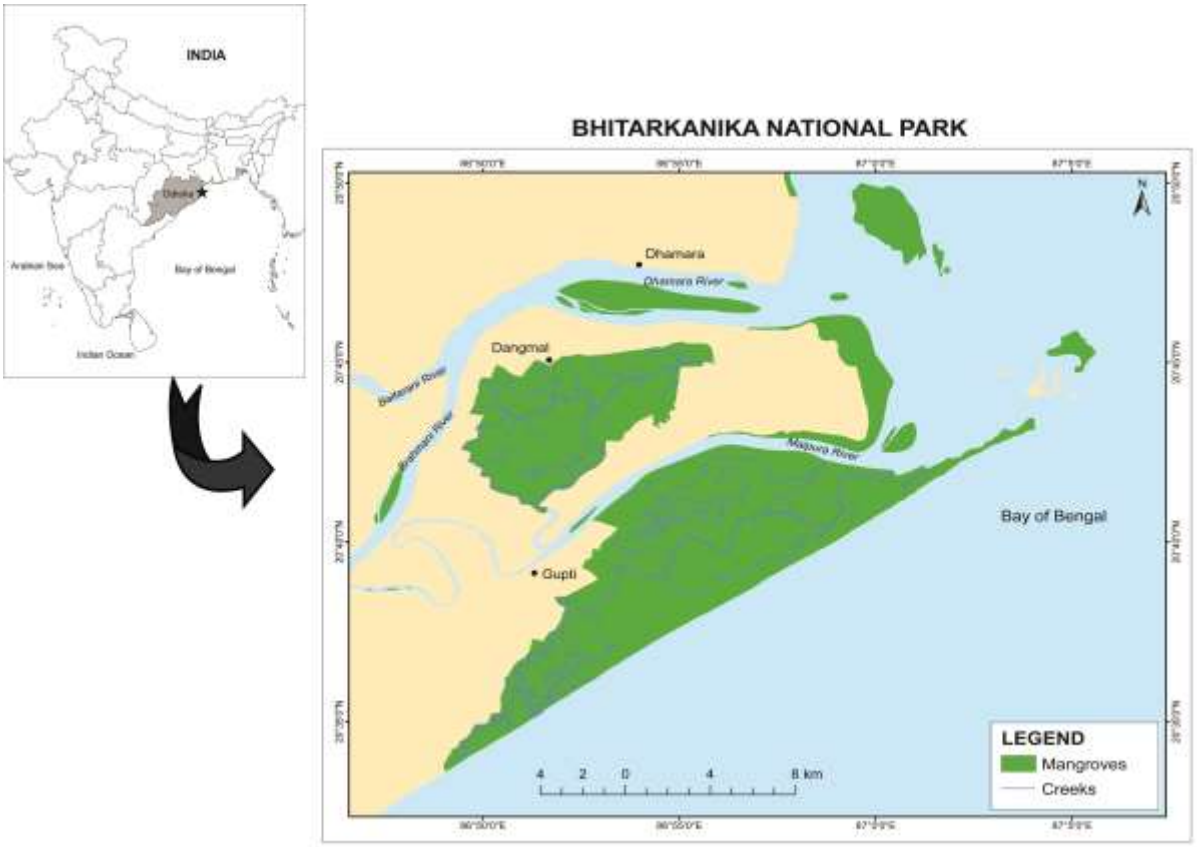

Figure 2.1 Location map of study area, Bhitarkanika National Park, Odisha, India

3. SPECTRAL DATA COLLECTION

For collecting spectral reflectance data, we used ASD Fieldspec 3® spectroradiometer which records reflectance in the wavelength range of 350nm to 2500nm at a spectral resolution of 3nm and 10nm with the sampling interval of 1.4nm and 2nm in Visible Near Infra-Red (VNIR: 350nm to 1000nm) and Short Wave Infra-Red (SWIR: 1001nm to 2500nm) wavelength range respectively. The ASD Fieldspec 3® spectroradiometer has three detectors: one 512 channel silicon photodiode array for VNIR region (350nm to 1000nm) and two Indium Gallium Arsenide (InGaAs) detectors which are thermo-electrically cooled to record the radiance from two SWIR regions (SWIR 1: 1001nm to 1830nm, and SWIR 2: 1831nm to 2500nm) (ASD, 2010). The list of 34 mangrove (25 true and 9 associated) species for which the spectral data collected are listed in Table 3.1.

The remaining five true mangrove species present in Bhitarkanika such as *Acanthus volubilis, Cyanometra ramiflora, Heritiera kanikensis, Rhizophora stylosa,* and *Sonneratia griffithii* were very rare and extremely difficult to find during our field expeditions because of its remote location (Nayak, 2004). So, spectral signatures were collected for 25 out of 30 true mangrove species present in Bhitarkanika.

3.1. Field spectral data

The ASD Fieldspec 3® spectroradiometer sensor was positioned at an average height of 60cm above the target in nadir position using 25° angular field of view (FOV) (i.e., bare fiber optic) to measure bidirectional diffuse spectral reflectance values at the canopy level in field condition. The selection of height and angular FOV of fiber optic sensor is crucial as they determine the size or diameter of the target being sensed. The standard white reference panel Spectralon®, the calibrated barium sulphate plate was used to measure white reference spectra in each set of measurements. The coordinates of each sample plots were precisely recorded using Global Positioning System (Figure 3.2). All readings were taken on sunny days with clear sky between 10:00 am and 02:00 pm so that the sun zenith angle would be near nadir (Figure 3.3a). Parameters such as sun zenith angle and sky condition have a major impact on overall intensity and illumination geometry.

Table 3.1 List of mangrove species (25 true and 9 associated) selected for spectral data collection

List of True Mangrove Species		
Sl. No	**Family**	**Name of the species**
1	*Acanthaceae*	*Acanthus ilicifolius L.*
2	*Avicenniaceae*	*Avicennia alba*
3		*Avicennia marina*
4		*Avicennia officinalis*
5	*Caesalpiniaceae*	*Cynometra iripa*
6	*Combretaceae*	*Lumnitzera racemosa*
7	*Euphorbiaceae*	*Excoecaria agallocha*
8	*Meliaceae*	*Amoora cucullata*
9		*Xylocarpus granatum*
10		*Xylocarpus mekongensis*
11		*Xylocarpus moluccensis*
12	*Myrsinaceae*	*Aegiceras corniculatum*
13	*Plumbaginaceae*	*Aegialitis rotundifolia*
14	*Rhizophoraceae*	*Bruguiera gymnorrhiza*
15		*Bruguiera parviflora*
16		*Bruguiera sexangula*
17		*Ceriops decandra*
18		*Ceriops tagal*
19		*Kandelia candel*
20		*Rhizophora apiculata*
21		*Rhizophora mucronata*
22	*Sonneratiaceae*	*Sonneratia apetala*
23		*Sonneratia caseolaris*
24	*Sterculiaceae*	*Heritiera fomes*
25		*Heritiera littoralis*
List of Associated Mangrove Species		
26	*Apocynaceae*	*Cerebra odollam*
27	*Arecaceae*	*Phoenix paludosa*
28	*Caesalpiniaceae*	*Intsia bijuga*
29	*Chenopodiaceae*	*Suaeda maritime*
30	*Pteridaceae*	*Acrostichum aureum*
31	*Rutaceae*	*Merope angulata*
32	*Salvadoraceae*	*Salvadora persica*
33	*Tamaricaceae*	*Tamarix troupii*
34	*Tiliaceae*	*Brownlowia tersa*

Diffuse incoming radiation from the sun at off-nadir position can affect the spectral characteristics of the material under observation. In the forest environment, if the target is shadowed, direct solar illumination is not the only source of illumination but it is accompanied with diffused and scattered illumination from the surrounding environment (Curtiss and Goetz, 2012). The general sampling rules and precautions to be adopted during field spectral data collection were followed during our field spectral data collection (R. Zomer and Ustin, 1999). In the field condition, the number of spectra collected depends on several

factors such as present sun illumination, cloud cover and presence of a species in a sample plot.

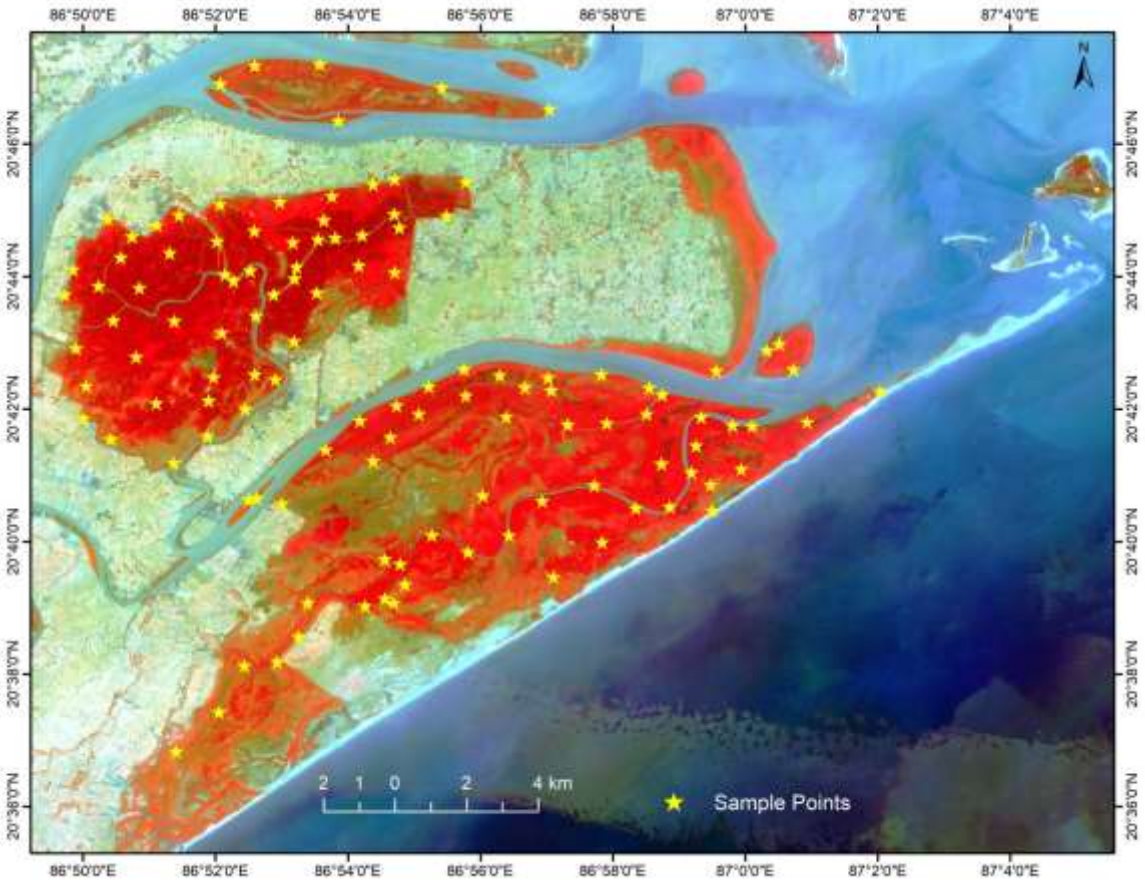

Figure 3.3 False Colour Composite (FCC) image of the study area derived from Sentinel-2 sensor showing the locations of sample plots

3.2. Laboratory spectral data

Fresh mature leaves from upper and lower part of canopies of mangrove species were collected since leaves at different positions in the canopy might exhibit distinct spectral characteristics because of their differences in photosynthetic properties or water content (Wang and Sousa, 2009). Collected leaves were then packed in air-tight covers to preserve the freshness and transported carefully to the laboratory to measure leaf-level laboratory spectral measurement. The fiber optic sensor cable was mounted using a pistol grip and tripod at a height of 60cm and kept in 90° angle to the leaf sample.

a.

b.

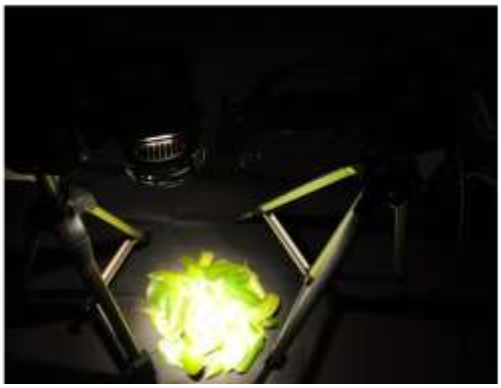

Figure 3.3 Collection of spectral signatures in (a) field and (b) laboratory conditions.

A tungsten filament halogen lamp was used for artificial light source and mounted at the same position as the sensor which gave constant electromagnetic radiation energy in the wavelength range of 400nm to 2500nm. A black cloth was spread on the surface and complete measurement was made in a dark room set up in the laboratory to avoid noise from adjacent objects. The collected leaves were segregated into 20 piles of the same amount and spectral measurements were made. Enough care was taken to make sure that each pile was thick enough to cover the field of view of the sensor and leaves facing upwards (Figure 3.3b). About 150 spectra were collected for each species. All these steps of laboratory measurements were made within four hours to avoid degradation of cells which eventually affects the optical properties of leaves and show anomalies in their spectral reflectance (Vaiphasa et al., 2005).

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4. PROCESSING OF SPECTRA

The spectral data collected in field and laboratory conditions are needed to be processed prior to spectral library building as they could be used as the reference for spectral matching technique and species level discrimination. Prior to post-processing of spectra, all field spectra were visually interpreted to remove spectral samples which are highly affected due to poor light conditions and saturation problem during field data collection. The flow of post-processing techniques is schematically represented in Figure 4.3.

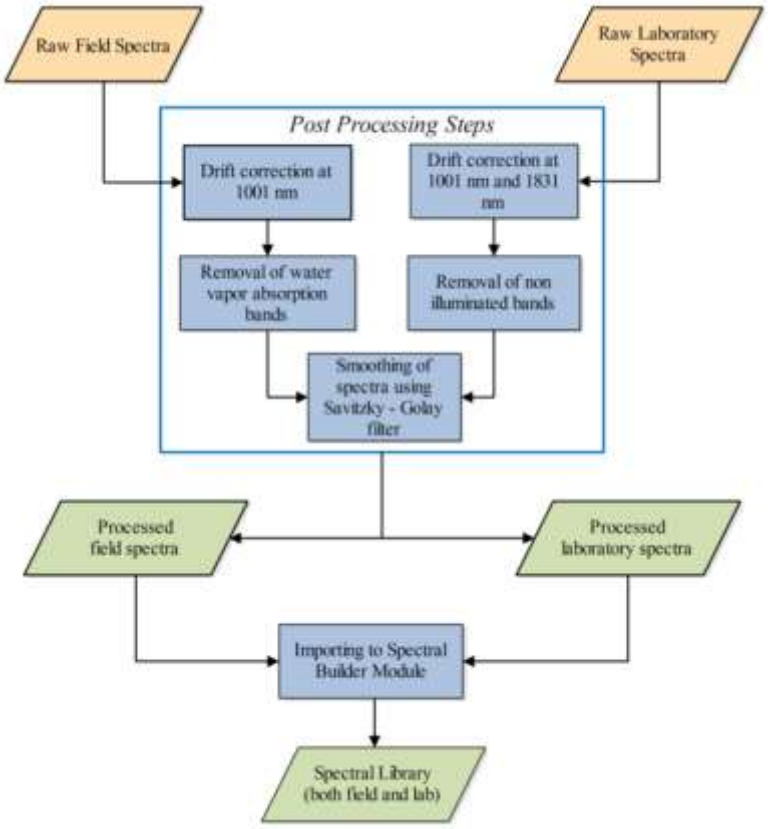


Figure 4.3 Methodology flowchart showing steps involved in post processing of raw spectra to build spectral library.

The detailed methodology followed in processing of spectra in our project is explained in the following article:

Kumar Arun Prasad, Lakshmanan Gnanappazham, Vaithilingam Selvam, Ramasamy Ramasubramanian, and Chandra Sekar Kar (2015). Developing a spectral library of mangrove species of Indian east coast using field spectroscopy, *Geocarto International*, 30:5, 580-599. doi: 10.1080/10106049.2014.985743.

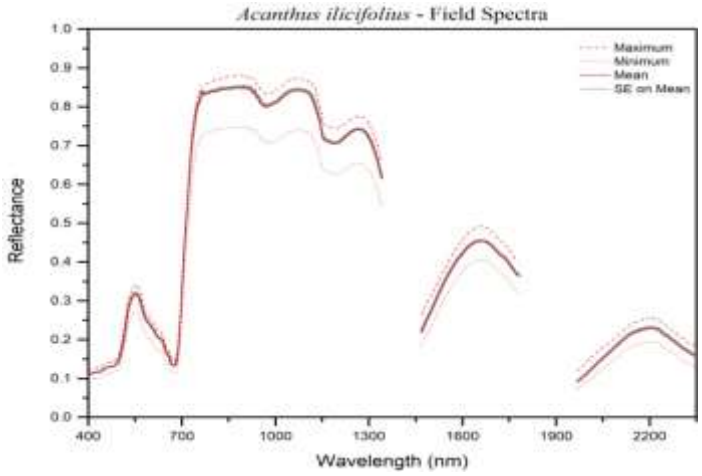
5. SPECTRAL LIBRARY OF MANGROVES

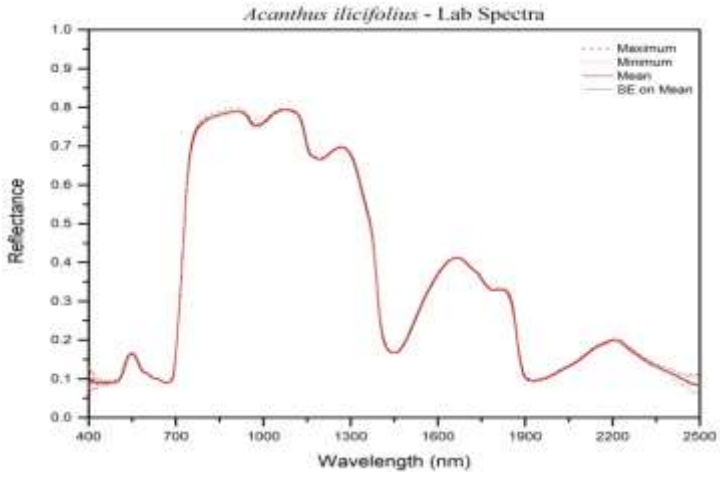
5.1. *Acanthus ilicifolius* L.

Family: *Acanthaceae*

Local/Common name: Harakancha

English name: Holli-leaved mangrove

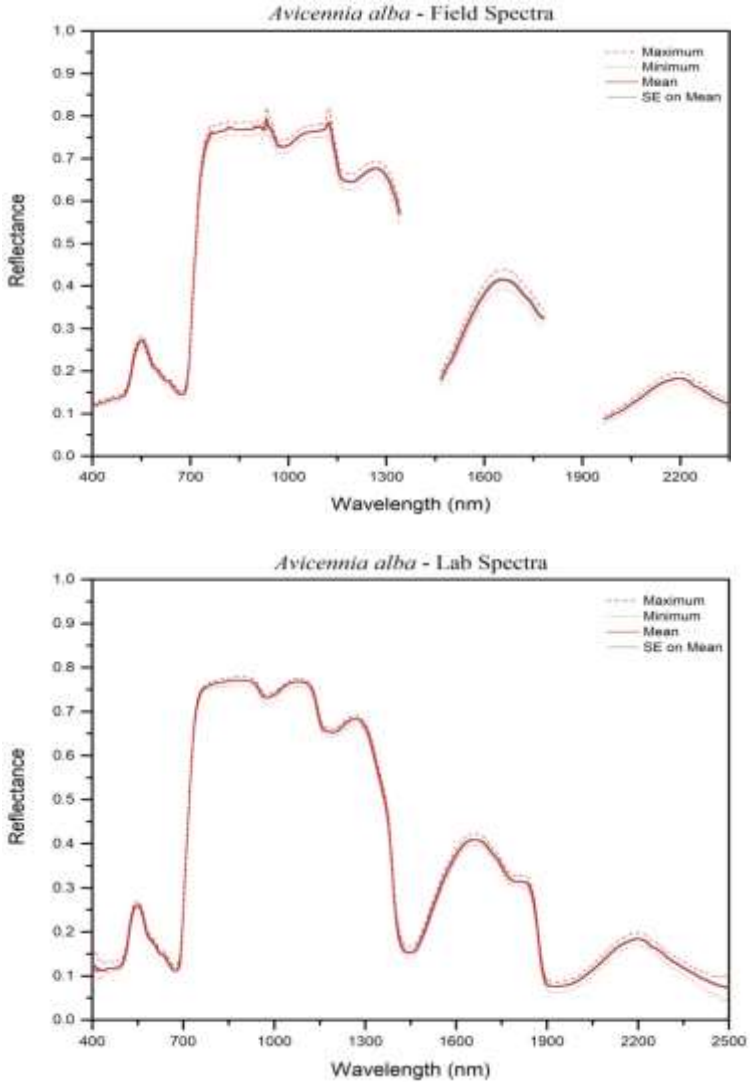




5.2. *Avicennia alba.* Blume

Family: *Avicenniaceae*

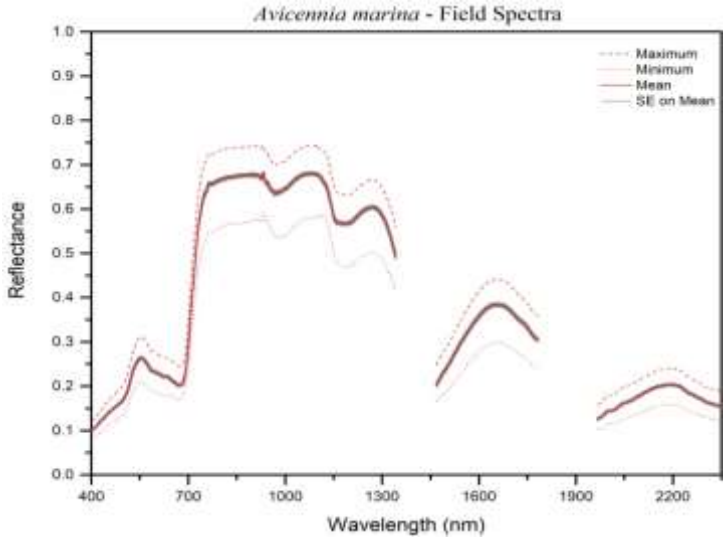
Local/Common name: Kala Bani

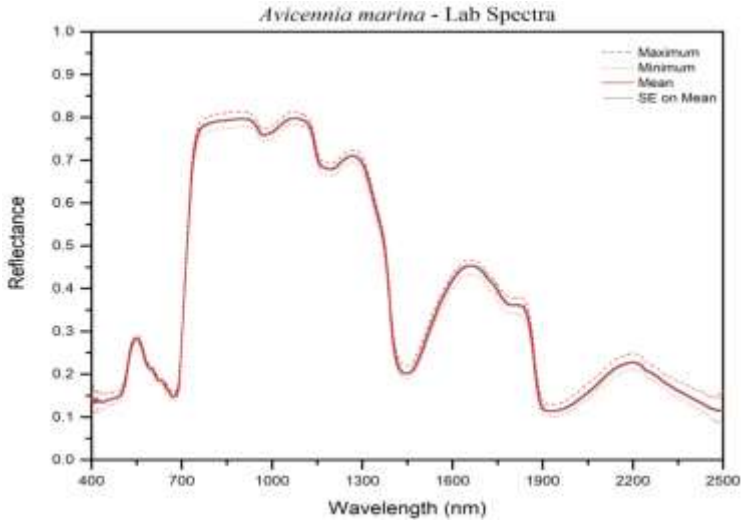


5.3. *Avicennia marina* (Forsk.)

Family: *Avicenniaceae*

Local/Common name: Singala Bani

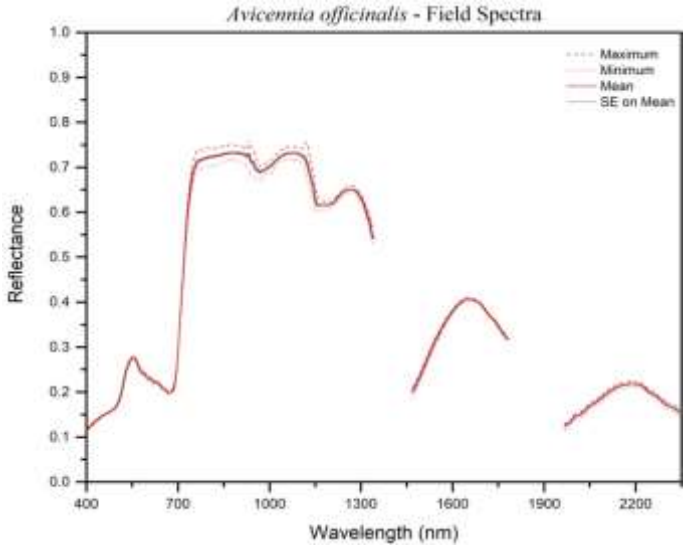


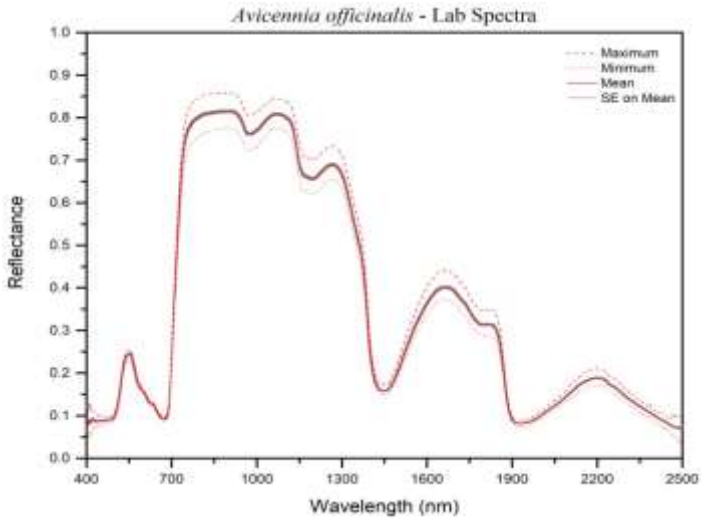


5.4. *Avicennia officinalis* L.

Family: *Avicenniaceae*

Local/Common name: Dhala Bani

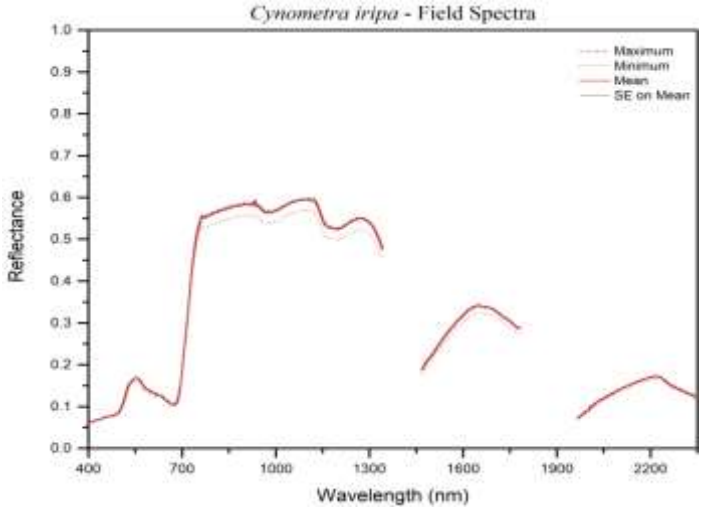


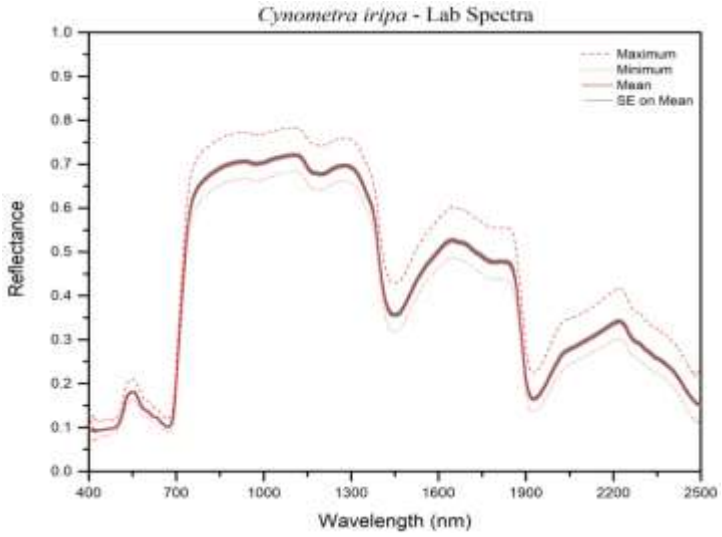


5.5. *Cynometra iripa*

Family: *Caesalpiniaceae*

Local/Common name: Singada

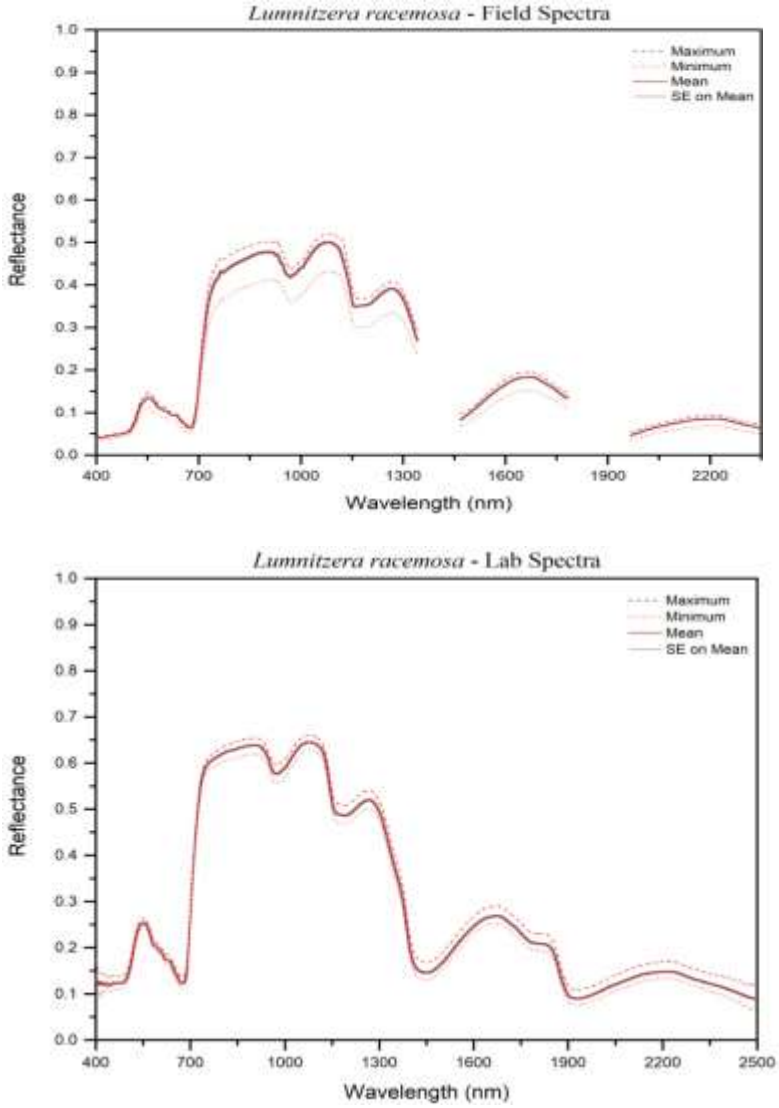




5.6. *Lumnitzera racemosa.* Willd

Family: *Combretaceae*

Local/Common name: Churunda

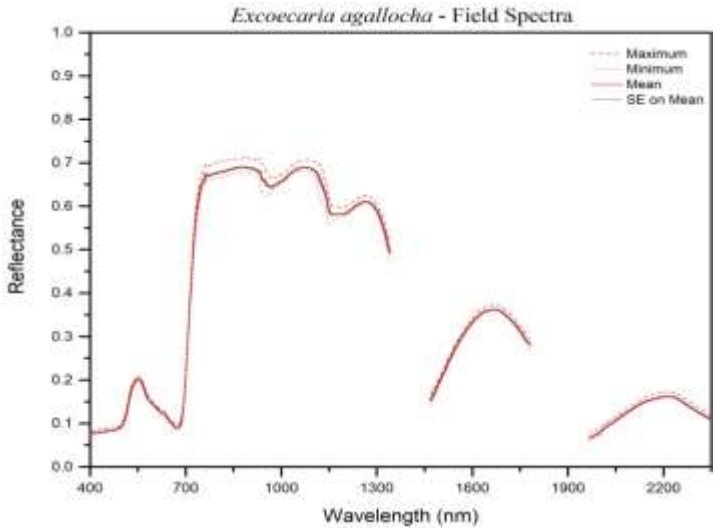


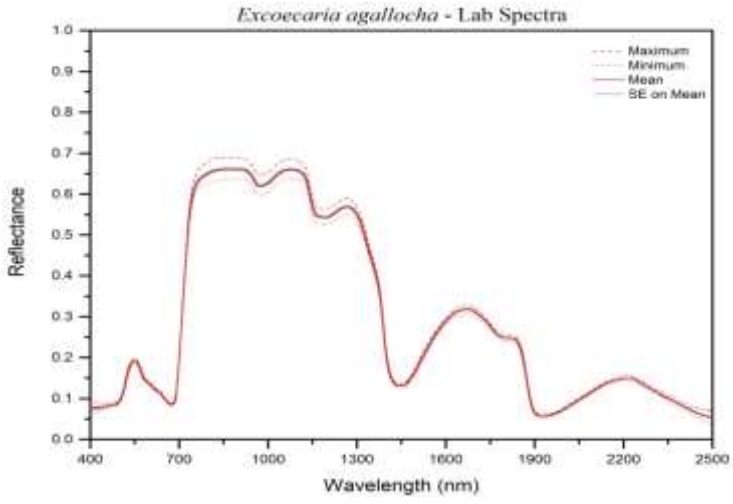
5.7. *Excoecaria agallocha.* L

Family: *Euphorbiaceae*

Local/Common name: Guan

English name: Blinding mangrove

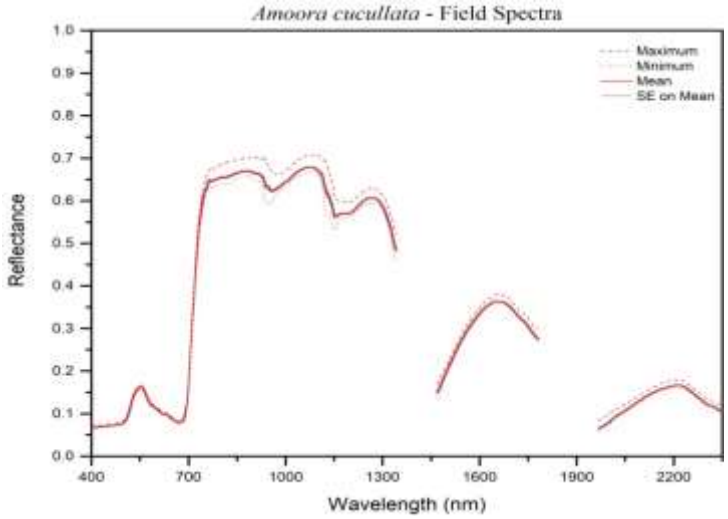


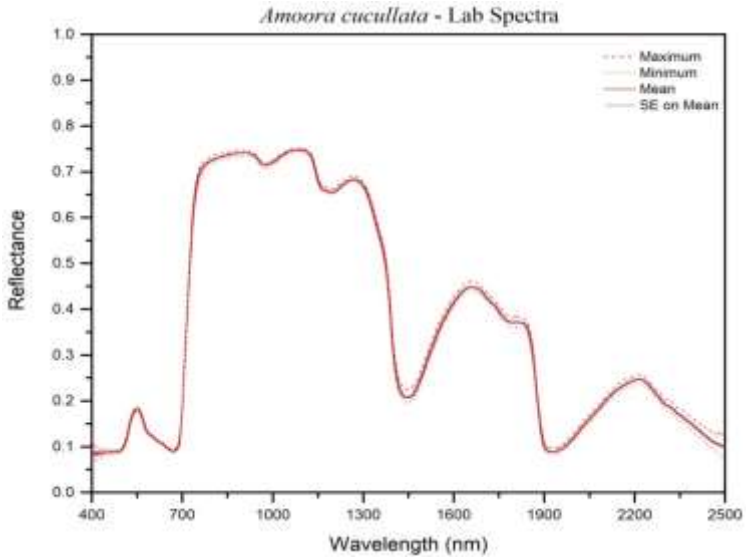


5.8. *Amoora cucullata (Aglaia cucullata)* Roxb.

Family: *Meliaceae*

Local/Common name: Ooanra

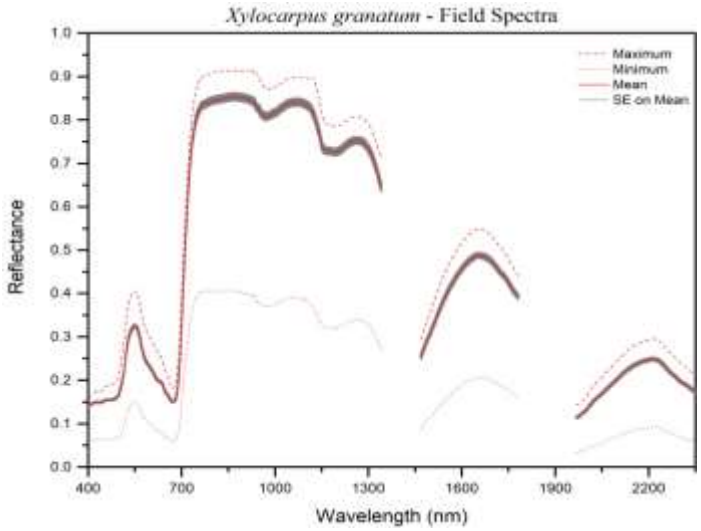


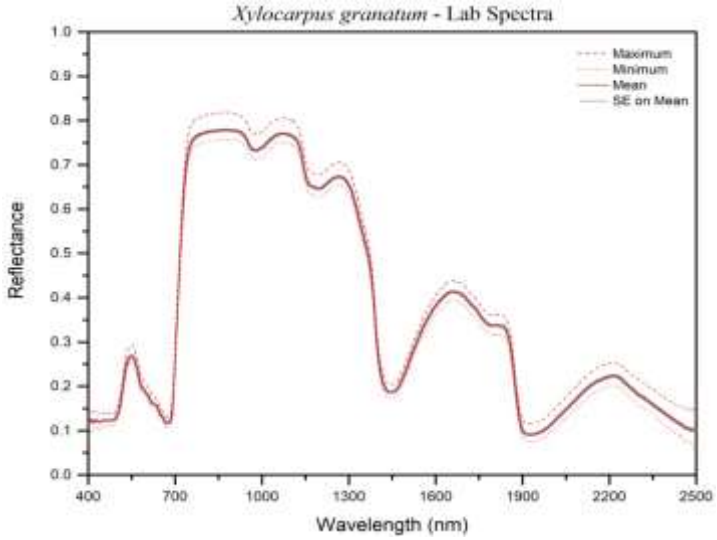


5.9. *Xylocarpus granatum*. Koeing

Family: *Meliaceae*

Local/Common name: Sisumar

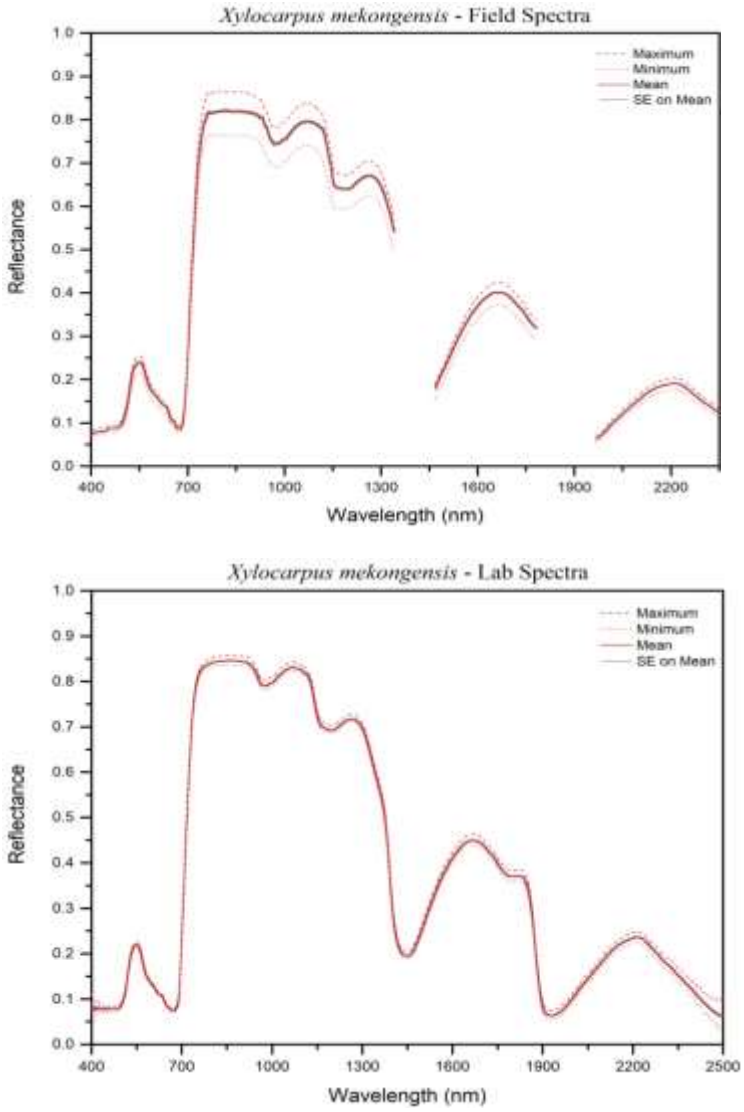




5.10. *Xylocarpus mekongensis* Pierre 1897

Family: *Meliaceae*

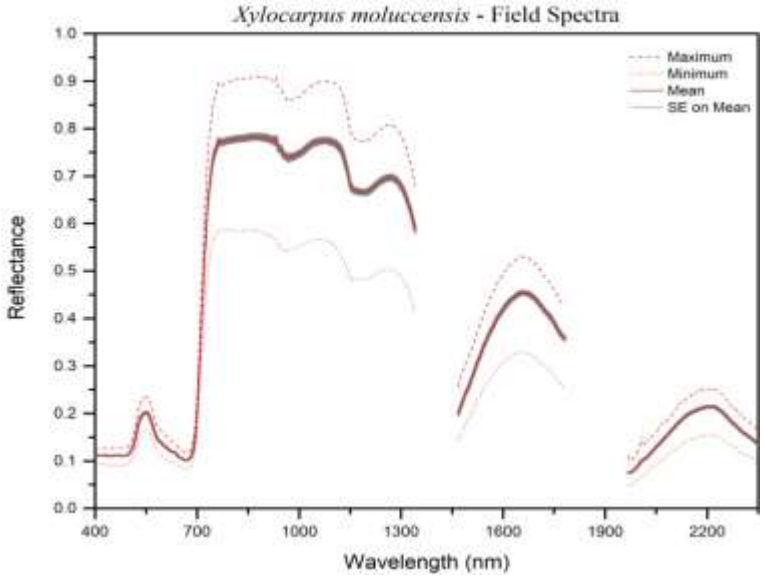
Local/Common name: Pitamari

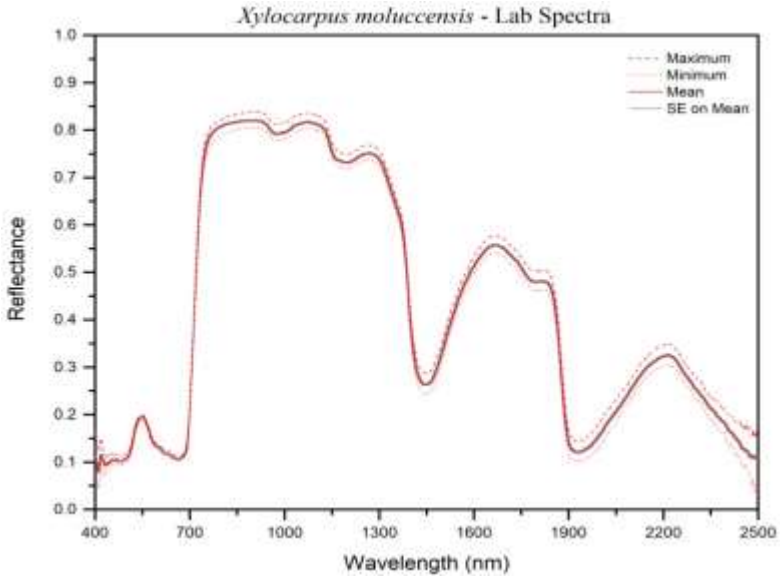


5.11. *Xylocarpus moluccensis* (Lamk.) Roem.

Family: *Meliaceae*

Local/Common name: Pitakorua



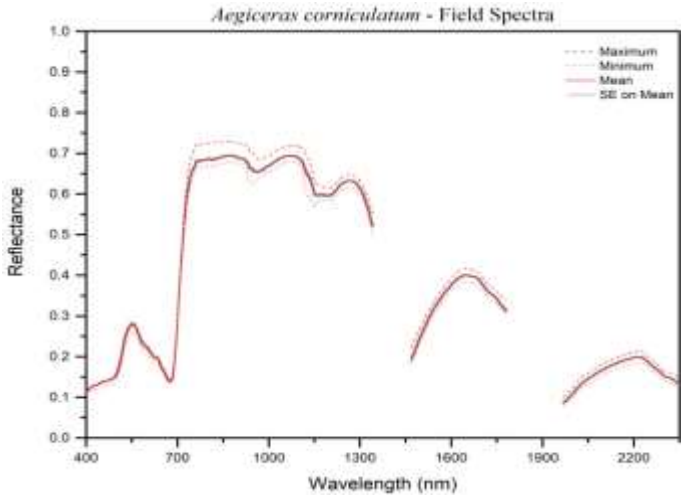


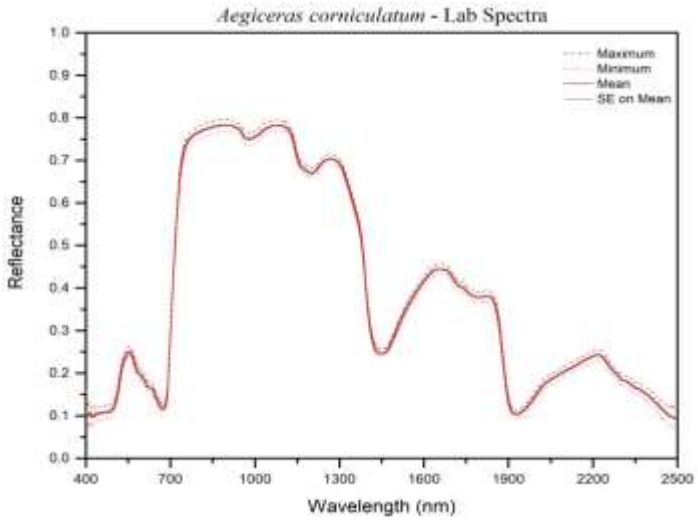
5.12. *Aegiceras corniculatum* (L.) Blanco.

Family: *Myrsinaceae*

Local/Common name: Kharsi

English name: River mangrove



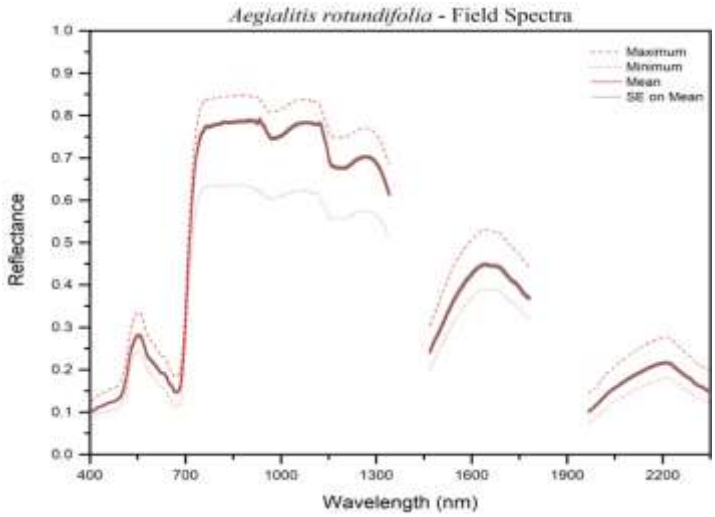


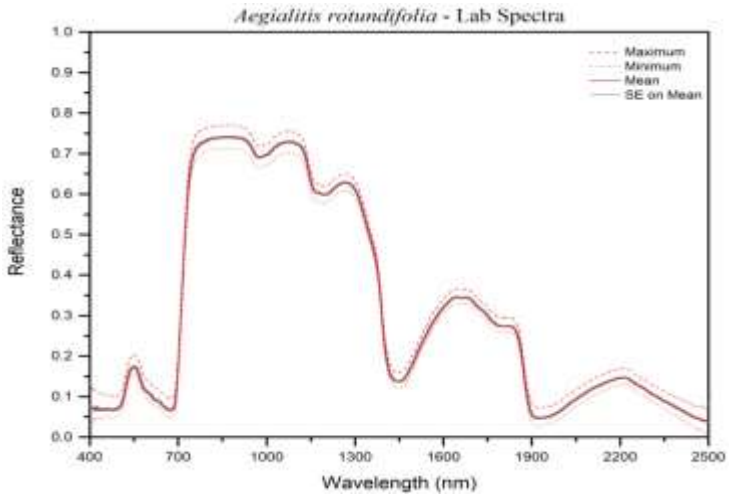
5.13. *Aegialitis rotundifolia* Roxb.

Family: *Plumbaginaceae*

Local/Common name: Banarua

English name: Club mangrove

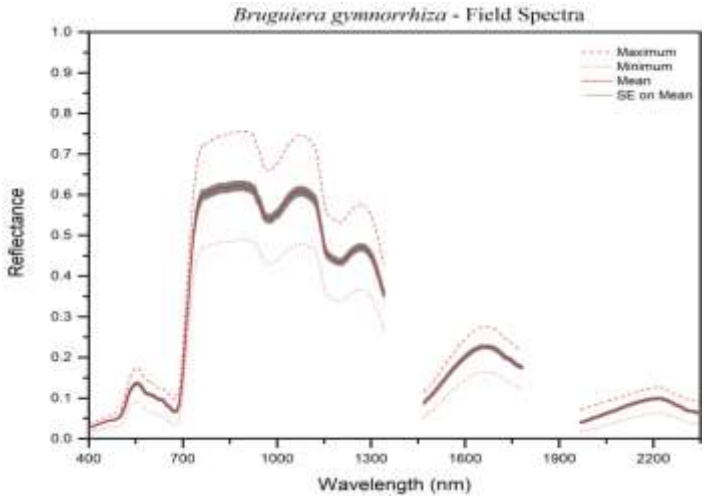


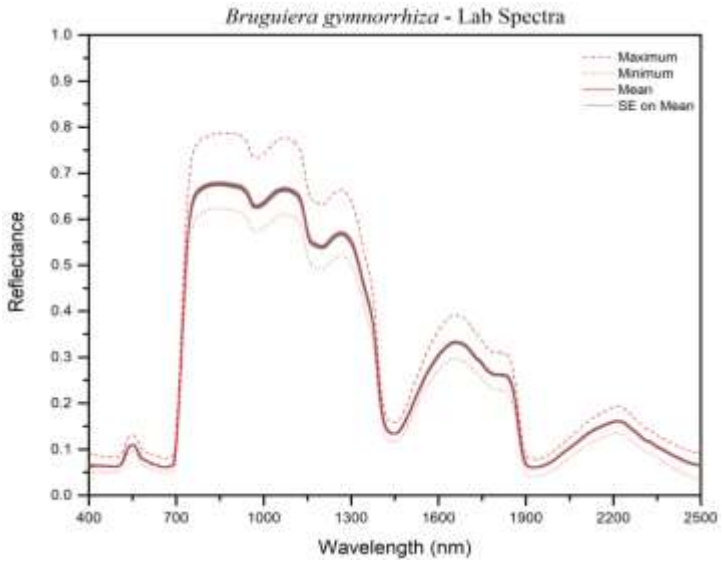


5.14. *Bruguiera gymnorrhiza* (L) Lamk.

Family: *Rhizophoraceae*

Local/Common name: Bandari

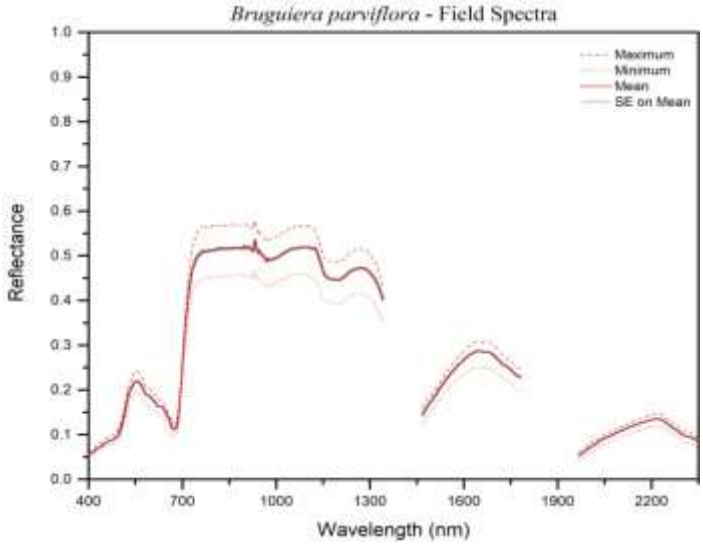


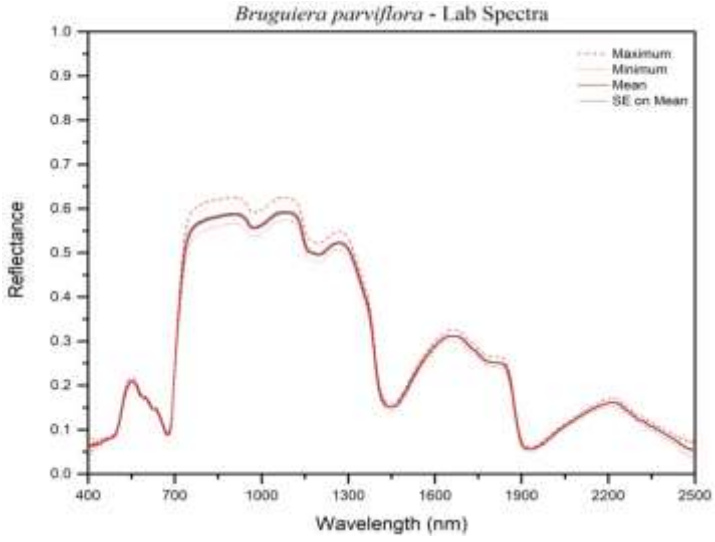


5.15. *Bruguiera parviflora.* W&A.

Family: *Rhizophoraceae*

Local/Common name: Dot

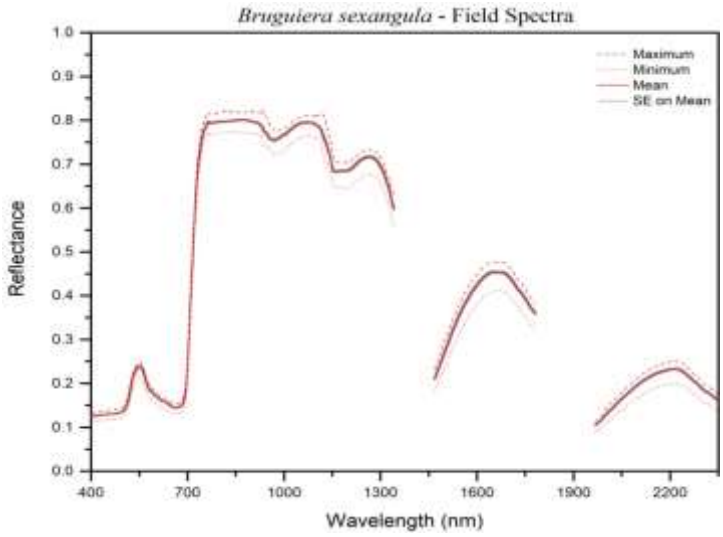


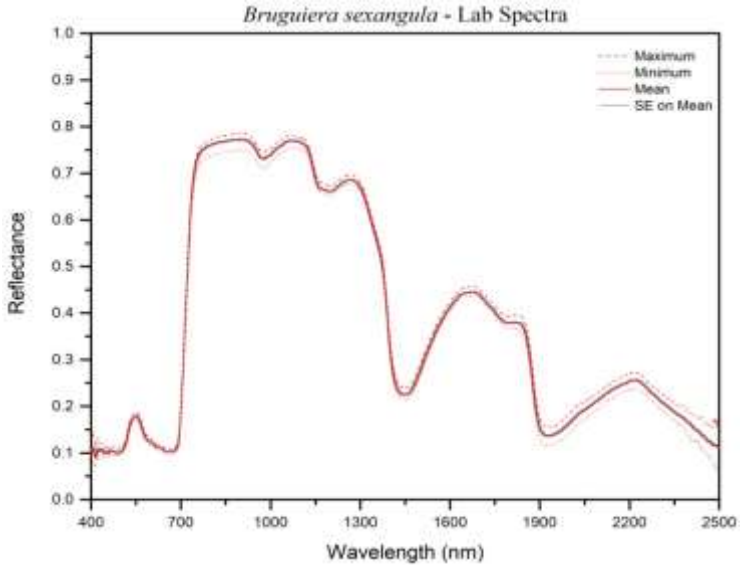


5.16. *Bruguiera sexangula* (Lour.) Poir

Family: *Rhizophoraceae*

Local/Common name: Bandari



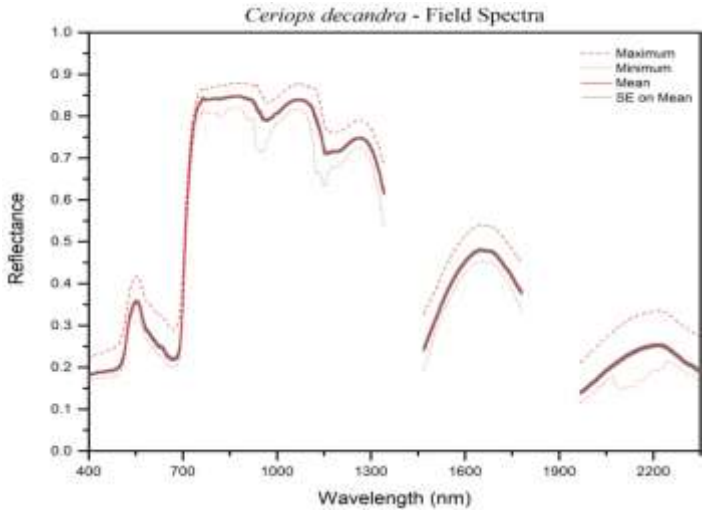


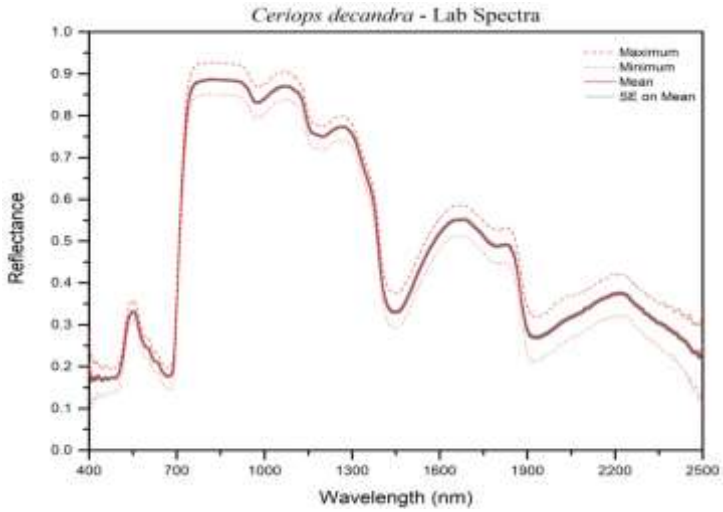
5.17. *Ceriops decandra* (Griff)

Family: *Rhizophoraceae*

Local/Common name: Garani

English name: Yellow mangrove

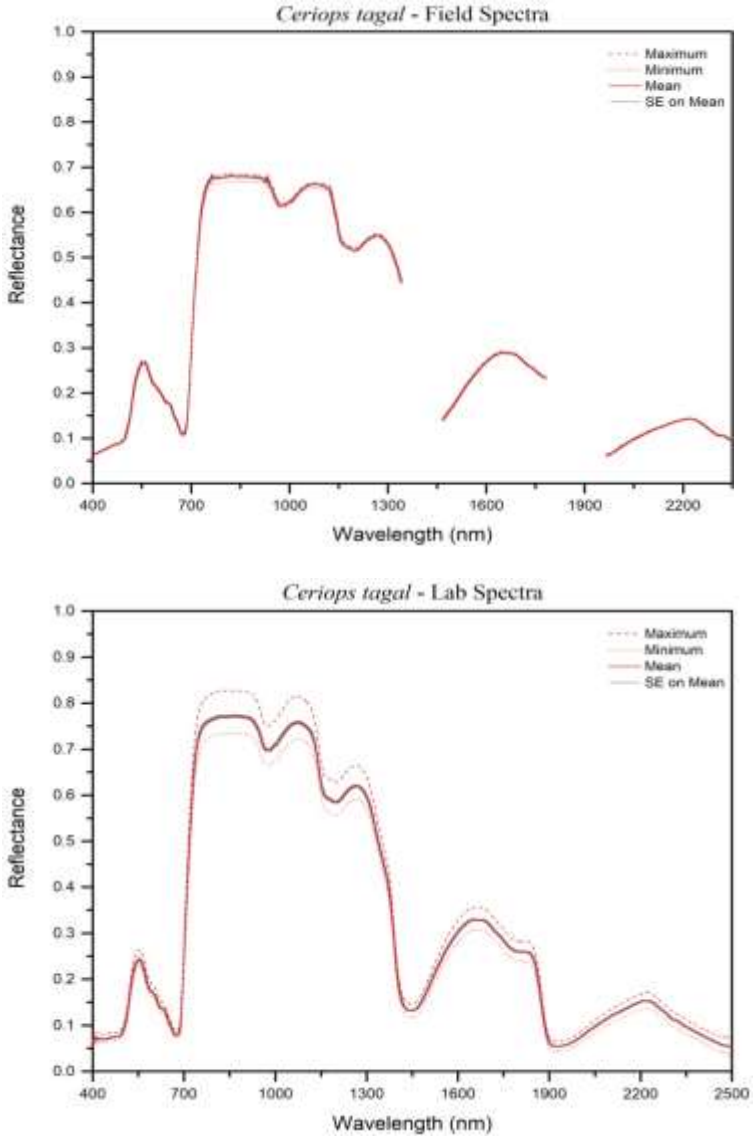




5.18. *Ceriops tagal* (Perr.) C. B. Rabinson

Family: *Rhizophoraceae*

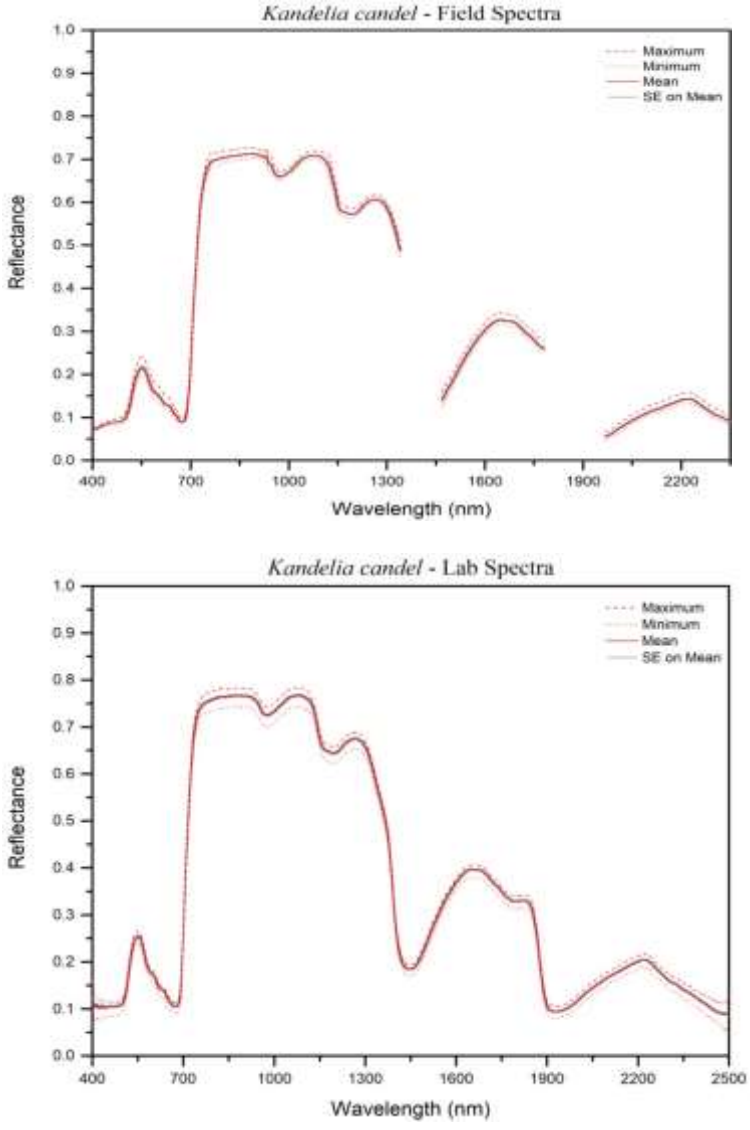
Local/Common name: Garani



5.19. *Kandelia candel* (L.) Druce 1914

Family: *Rhizophoraceae*

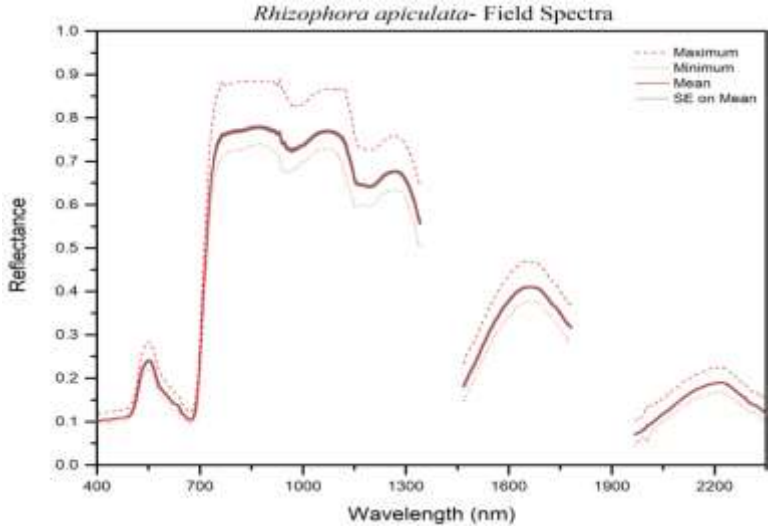
Local/Common name: Sinduka

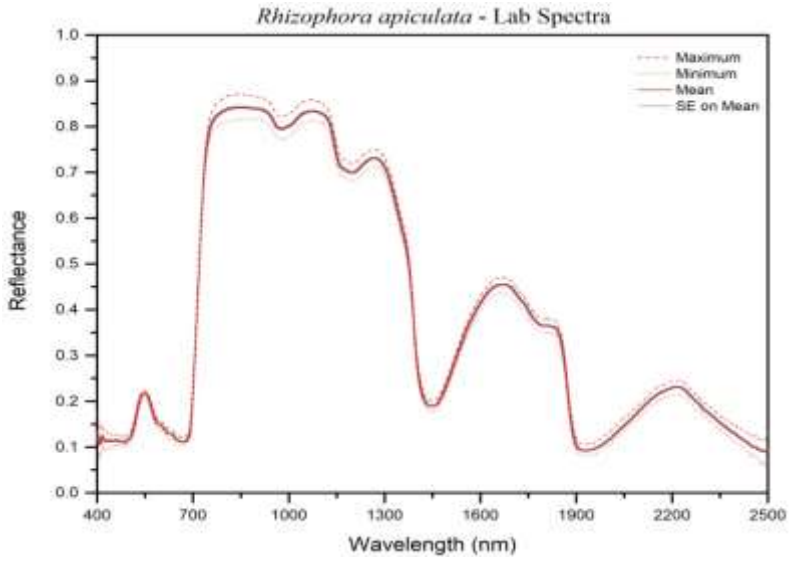


5.20. *Rhizophora apiculata.* Blume

Family: *Rhizophoraceae*

Local/Common name: Rai

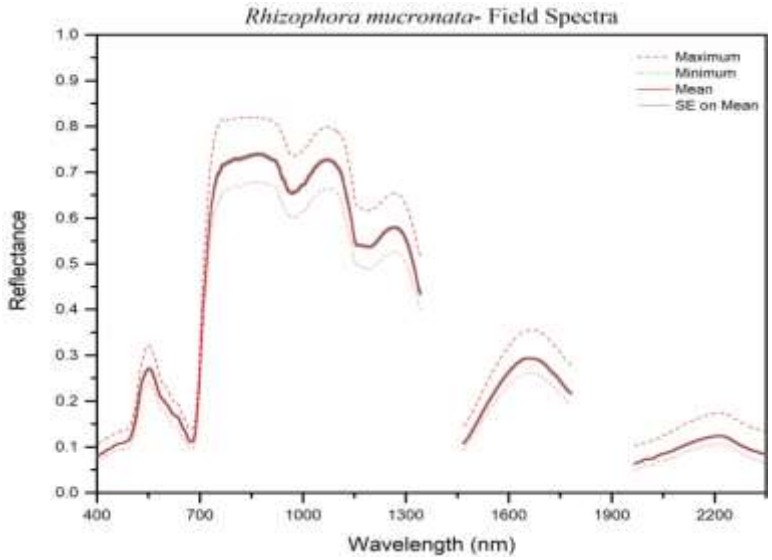


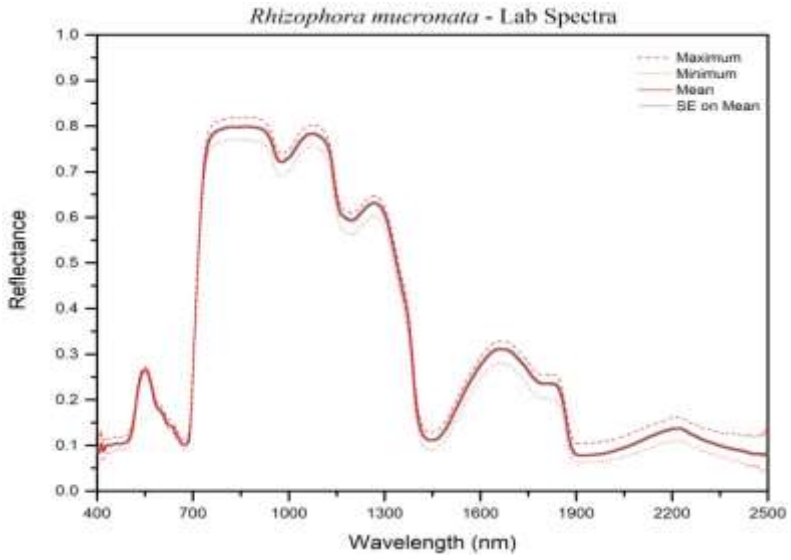


5.21. *Rhizophora mucronata.* Lamk

Family: *Rhizophoraceae*

Local/Common name: Rai

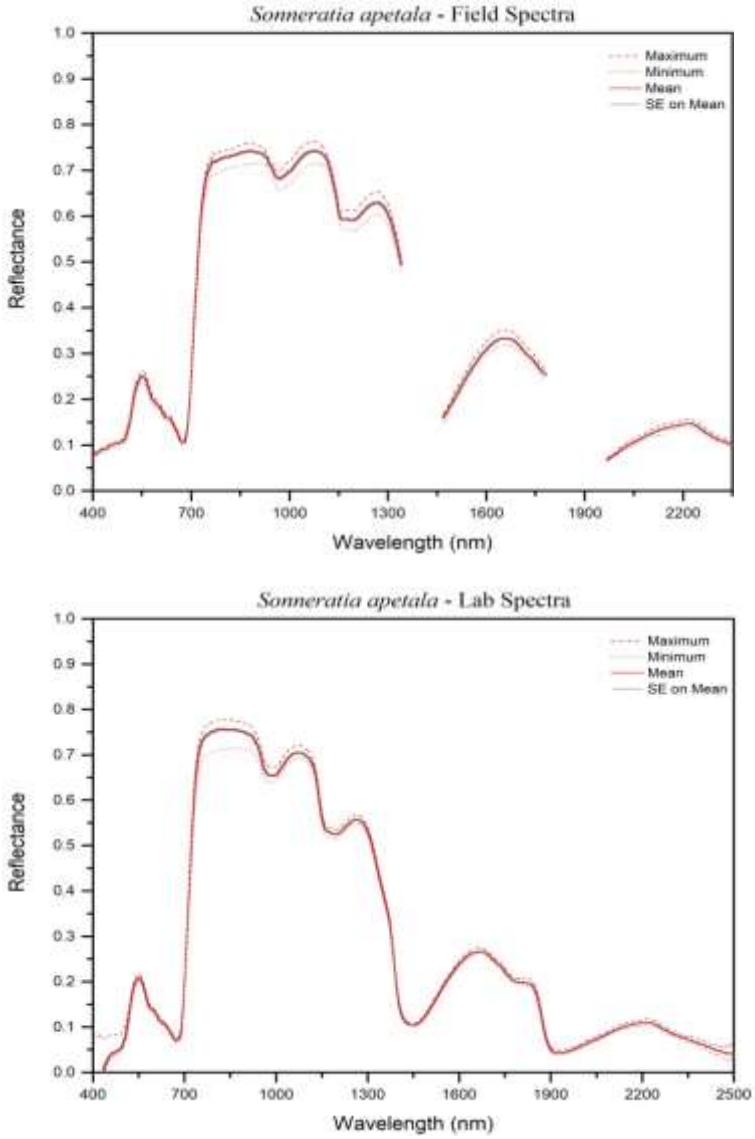




5.22. *Sonneratia apetala.* Buch Ham.

Family: *Sonneratiaceae*

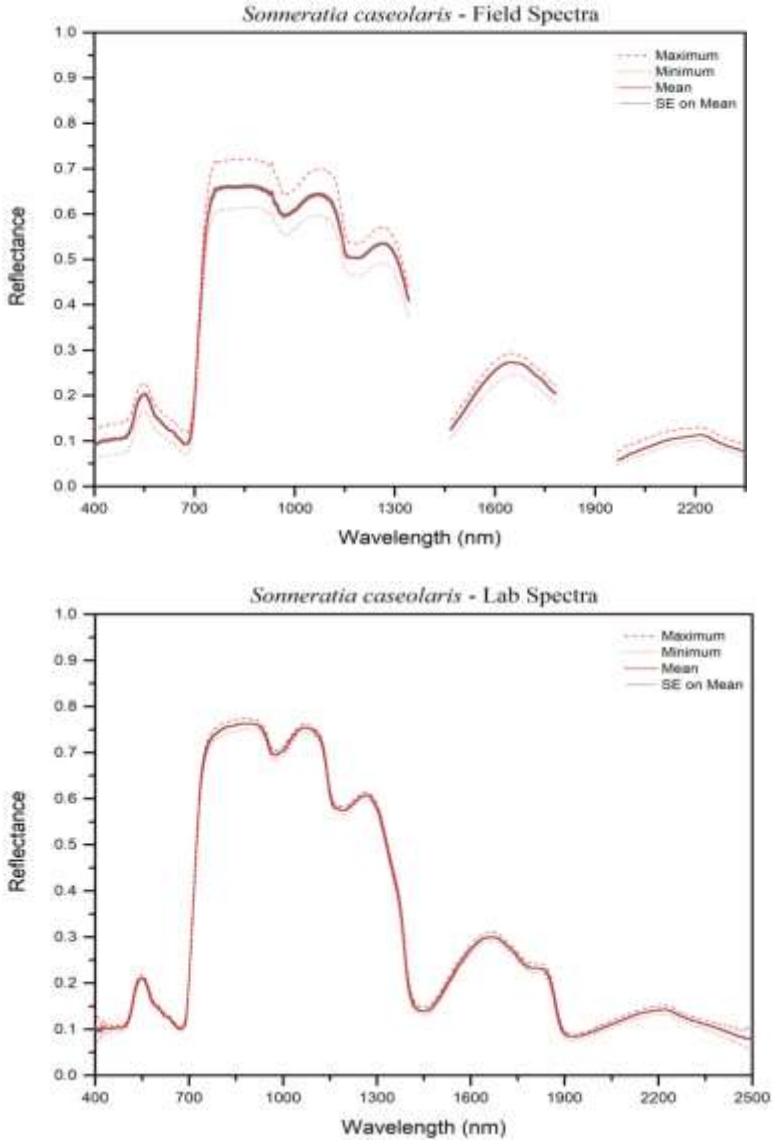
Local/Common name: Keruan



5.23. *Sonneratia caseolaris.* (L.) Engler.

Family: *Sonneratiaceae*

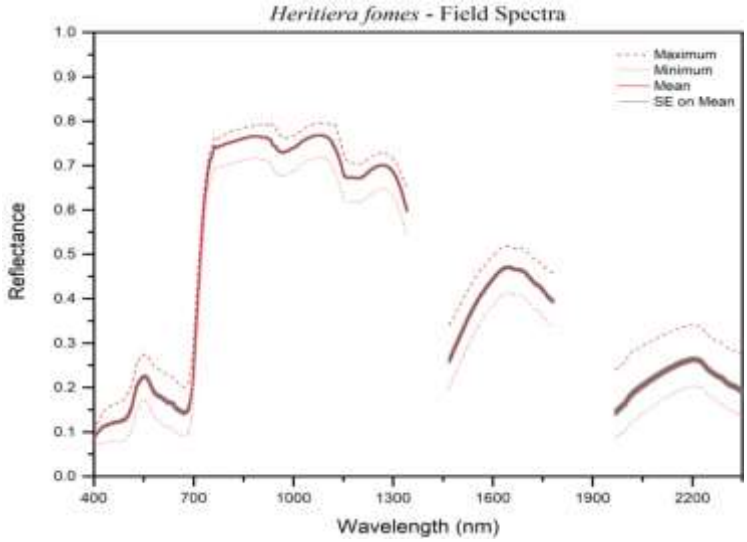
Local/Common name: Orua

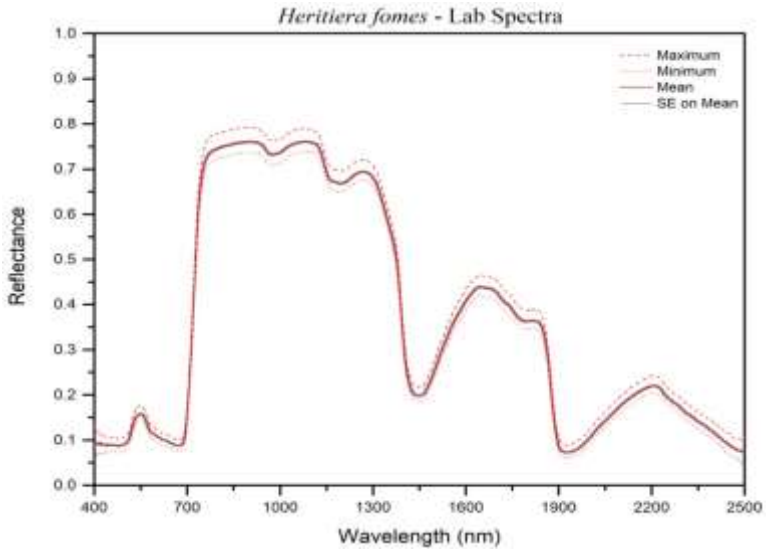


5.24. *Heritiera fomes.* Buch, Ham.

Family: *Sterculiaceae*

Local/Common name: Bada Sundari

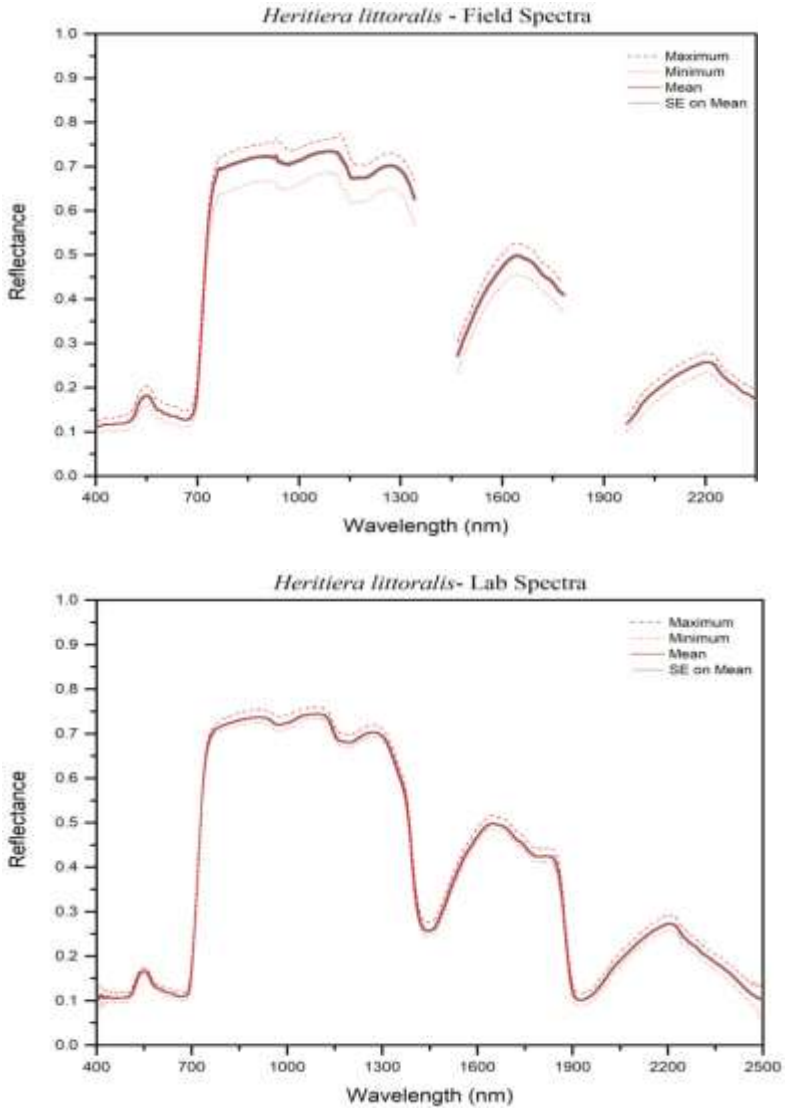




5.25. *Heritiera littoralis.* Dryand.

Family: *Sterculiaceae*

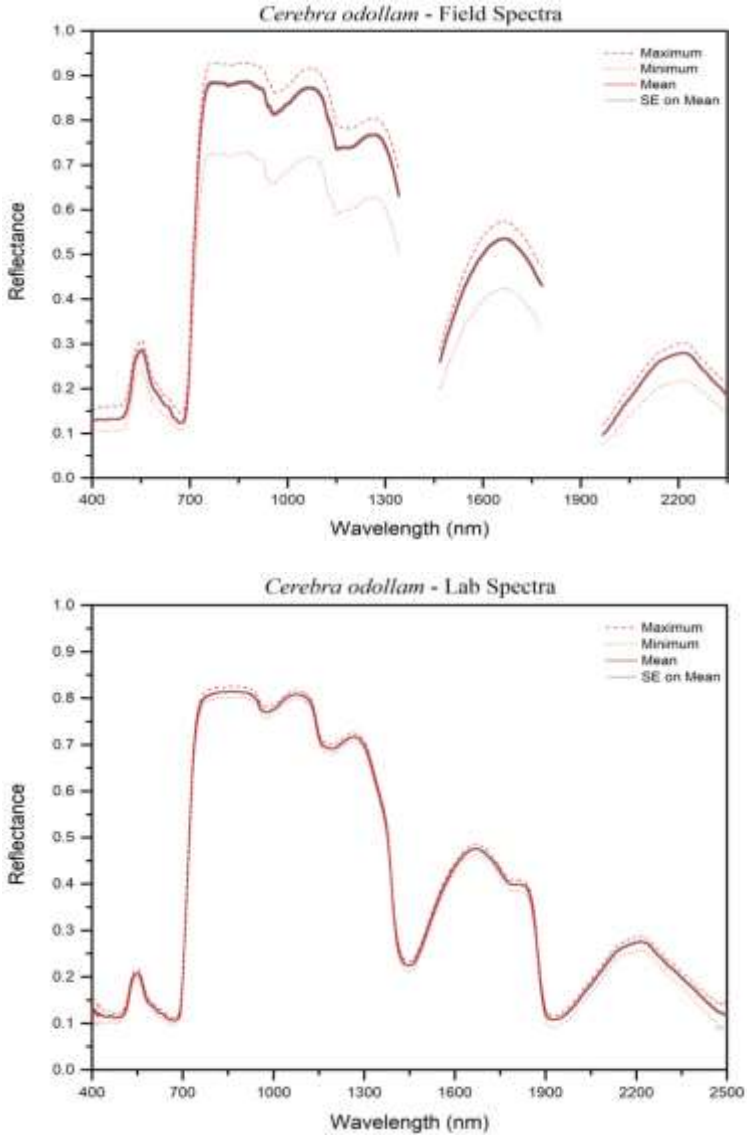
Local/Common name: Dhala Sundari



5.26. *Cerebra odollam*

Family: *Apocynaceae*

Local/Common name: Paniamba

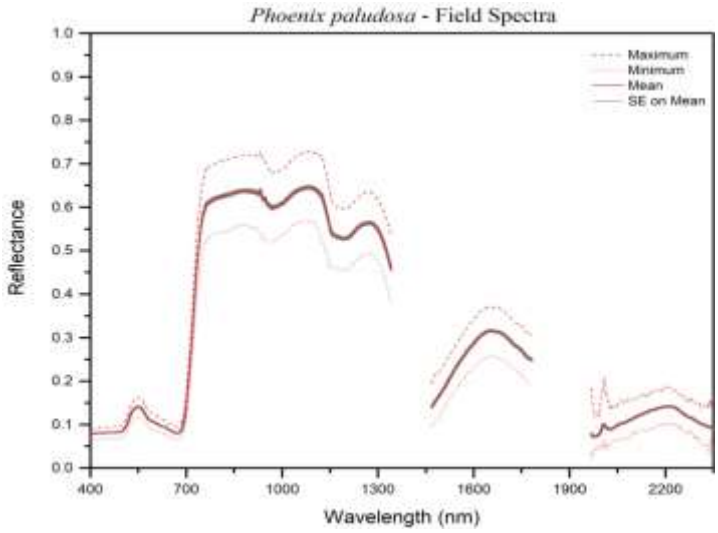


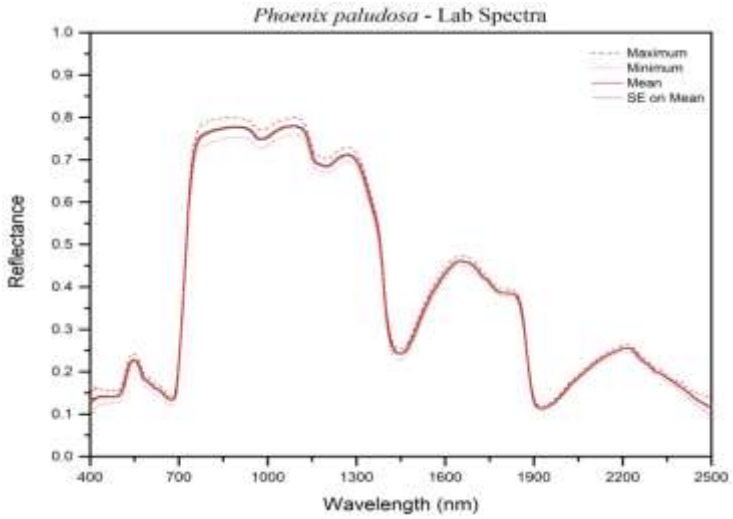
5.27. *Phoenix paludosa* Roxb.

Family: *Arecaceae*

Local/Common name: Hental

English name: Sea date

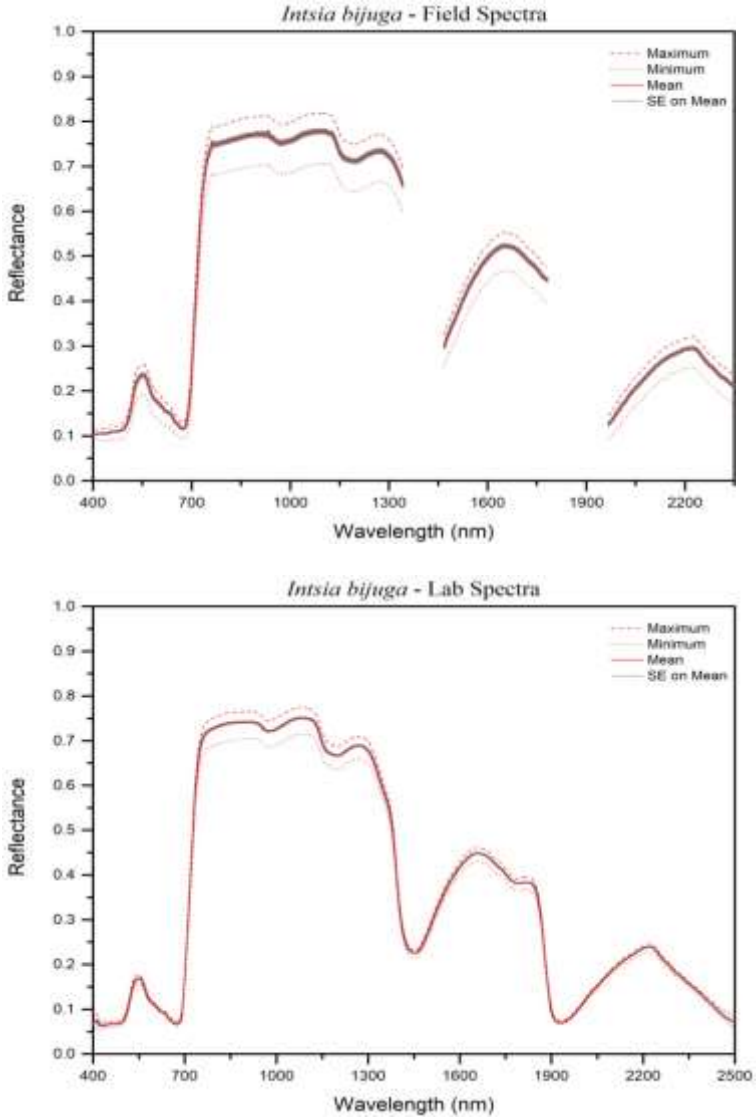




5.28. *Intsia bijuga* (Colebr.) Kunt.

Family: *Caesalpiniaceae*

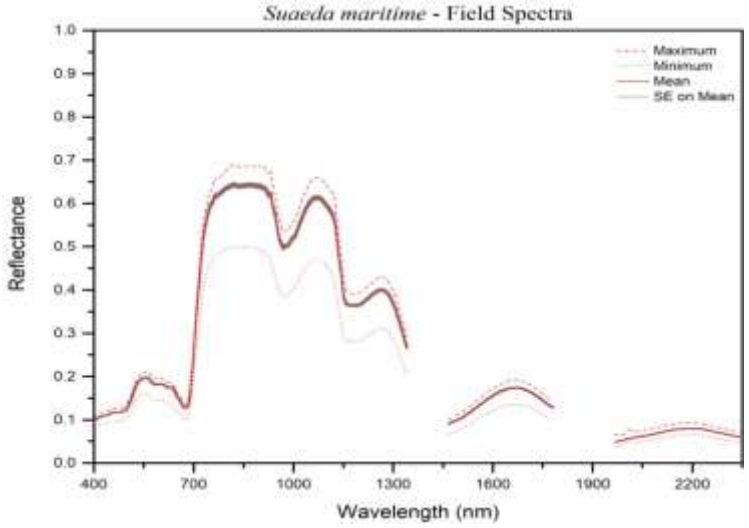
Local/Common name: Maasitha

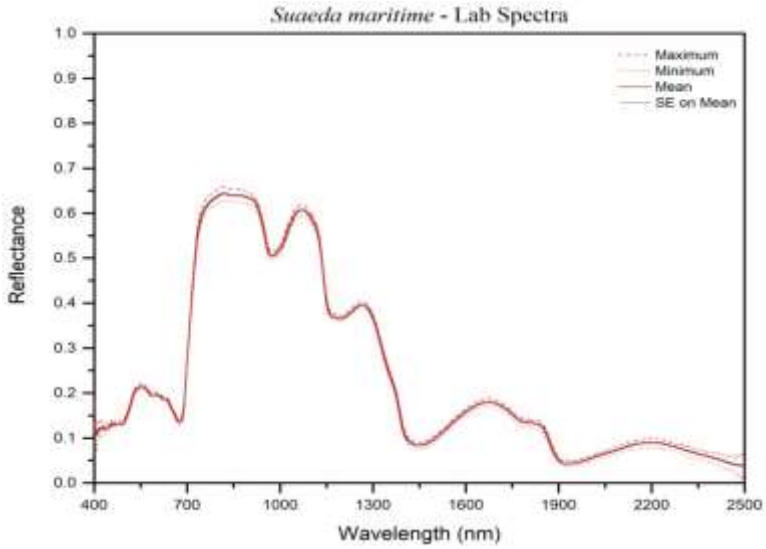


5.29. *Suaeda maritime*. Dumort

Family: *Chenopodiaceae*

Local/Common name: Giria Saga



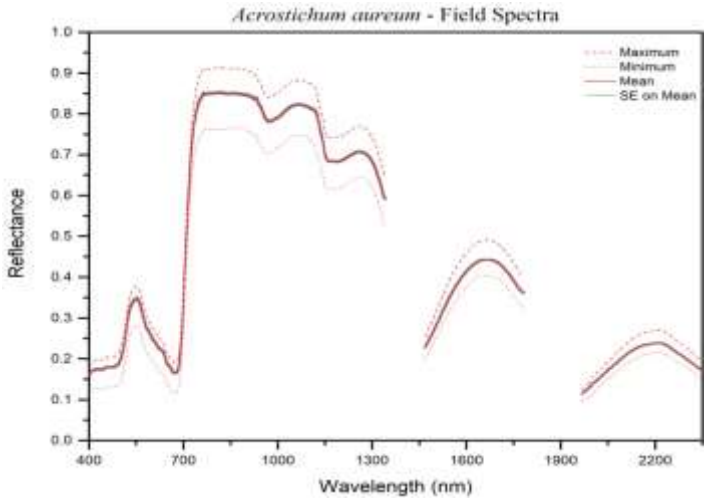


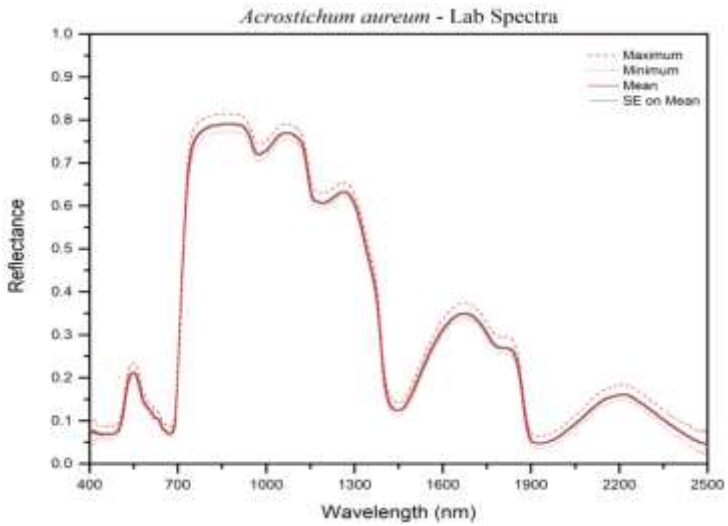
5.30. *Acrostichum aureum* Linnaeus, 1758

Family: *Pteridaceae*

Local/Common name: Kharkhari

English name: Mangrove fern

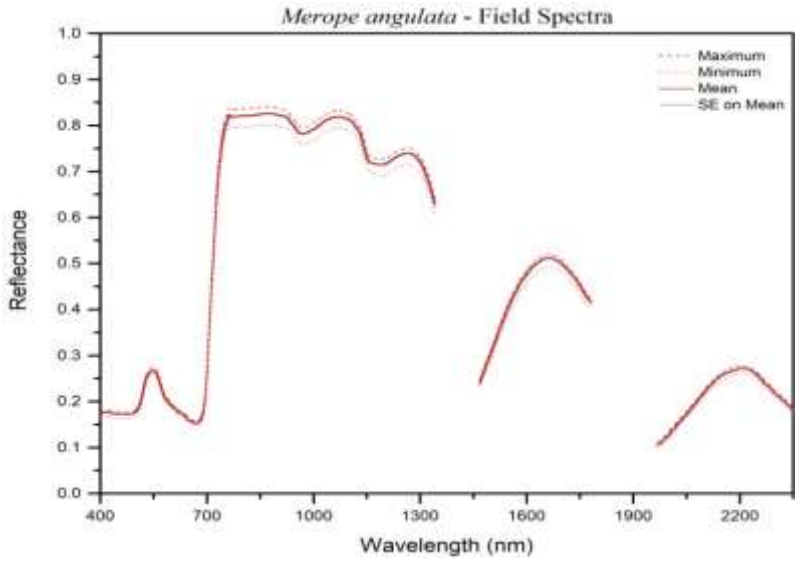


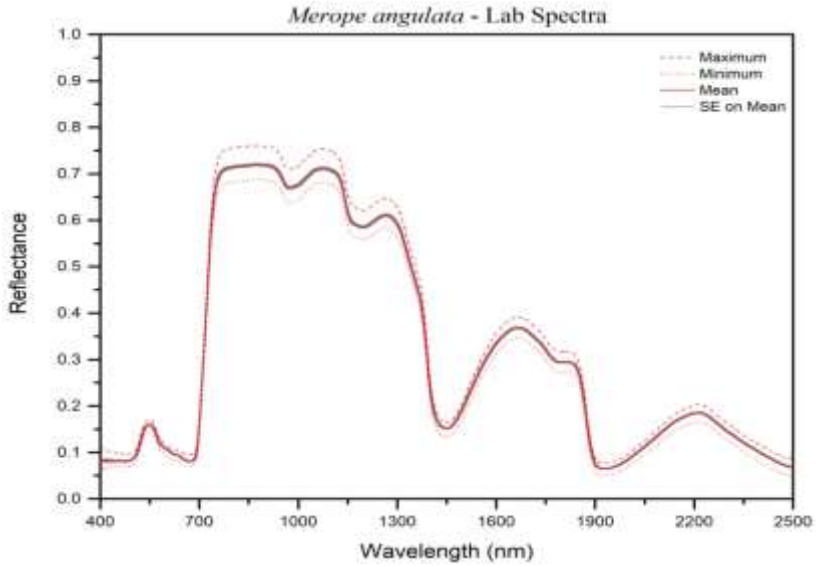


5.31. *Merope angulata* (Willd) Swingle

Family: *Rutaceae*

Local/Common name: Bana lembu

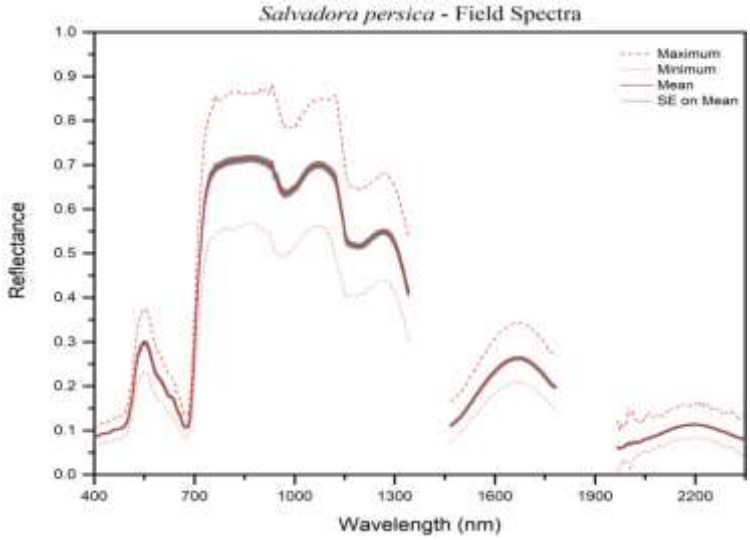


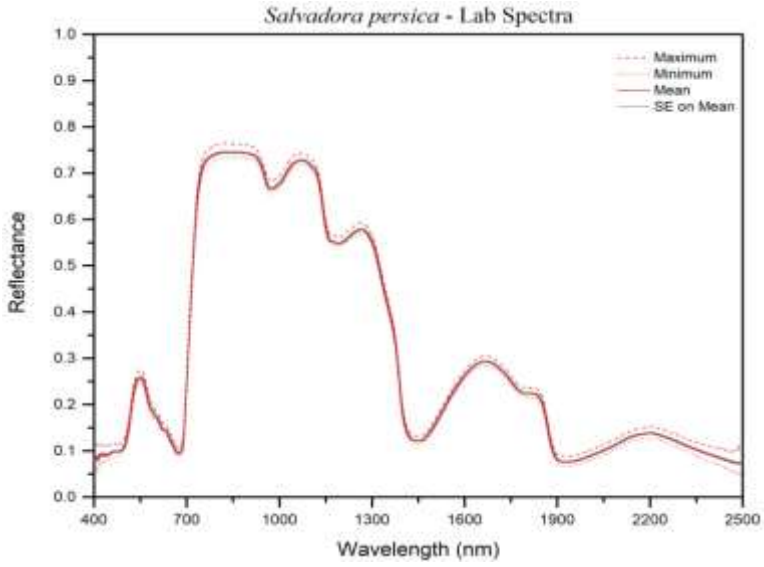


5.32. *Salvadora persica* L.

Family: *Salvadoraceae*

Local/Common name: Miriga

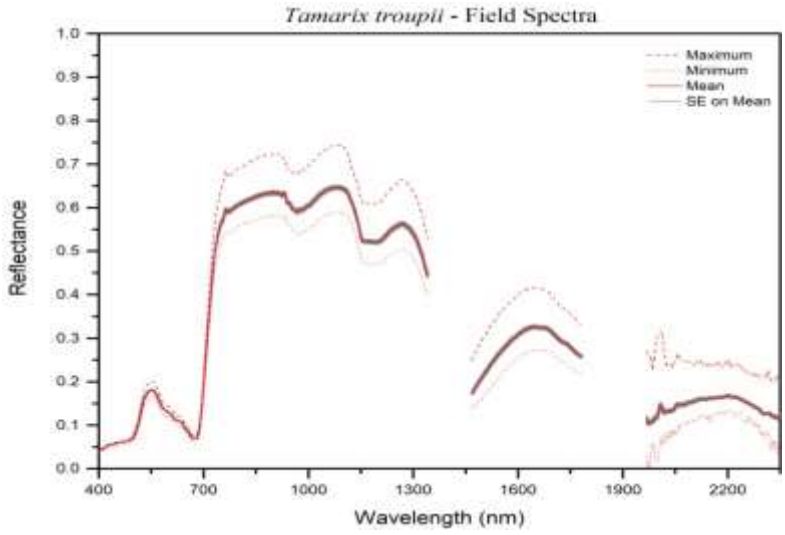


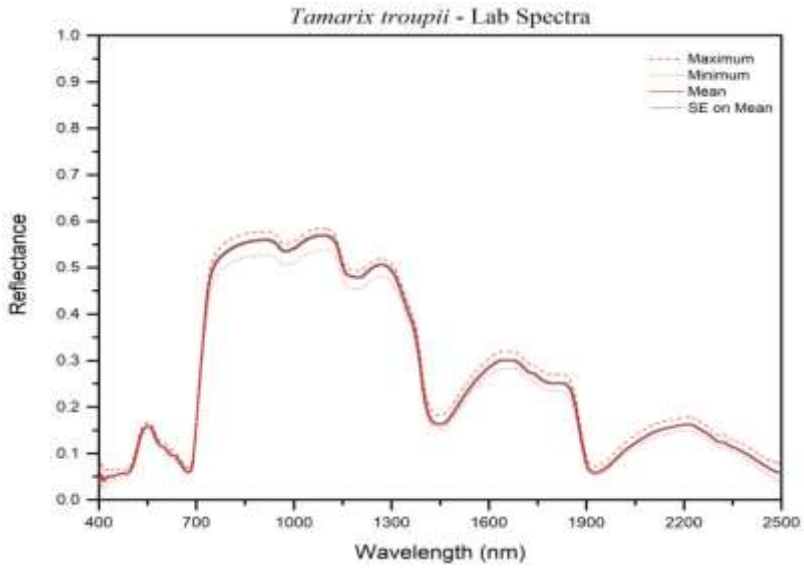


5.33. *Tamarix troupii* Hole

Family: *Tamaricaceae*

Local/Common name: Jagula





5.34. *Brownlowia tersa* Benth

Family: *Tiliaceae*

Local/Common name: Lati Sundari