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Profile of natural stands of *Santalum album* L. in the Pondicherry region, India

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Abstract

The enumeration of sandal and its habitats, soil type, girth, height, status of reproduction and associated plants were studied within the Pondicherry region in India. A total of 463 mature sandal trees (girth at breast height (gbh) \geq 10 cm) and 360 sapling trees (<10 cm gbh) were recorded from 10 different locations, 5 habitats and 4 soil types. The analyses of growth (girth and height), reproduction and associates were compared with different soil types. Generally clay with limestone and sandy soils had substantially greater numbers of sandal trees than clay and red earth soils. *Azadirachta*, *Glycosmis*, *Morinda* and *Phoenix* were the most predominant associated species across all soil types.

Introduction

Santalum album is a small evergreen tree that naturally occurs in India in areas from sea level to 1800m altitude in areas with a rainfall of between 600 – 1600mm with a distinct dry season. It grows in a range of soil types but generally performs in soils that are slightly acidic to neutral, well drained and moderately fertile. Sandalwood in India attains a height of 12 -13 m and a stem girth up to 2.5m with slender drooping as well as erect branching habit. The sandal tree can attain sexual maturity from 2-3 years after germination. It is a partial root parasite, which can host over 300 species of

plants from grasses to other sandal, but shows different growth patterns with different host species (Nagaveni and Vijayalakshmi, 2003).

In India *Santalum album* is distributed in the dry scrub forest of Salem, Mysore, Coorg, Coimbatore, Nilgiris and Thiruvannamalai. It is also found in Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhyapradesh, Maharashtra and Tamilnadu. Kadamban and Balachandran (2005) reported the presence of natural sandal in the Coromandal coastal plains of Pondicherry and Tamilnadu and the aim of this study

was to undertake a broad inventory of sandalwood and its associated species in this area.

Materials and Methods

A survey of the sandalwood resources in the Pondicherry region was undertaken over a period of one year during April 2005 to March 2006. The region is 292 km² in area, and is bounded by Cuddalore and Villupuram districts of Tamilnadu (north, west & south) and Bay of Bengal to the east. The maximum daily temperature ranges between 28 and 32° C during the sunny days and the average relative humidity is 80 %. It receives around 800 mm rain mainly from the north-east monsoon during September to December and has a distinct dry season typically from May to August. The region consists of the broad soil types of pure sandy, alluvial, loam, black cotton, red earth-laterites, clay and clay with lime stone. The survey was conducted in all the villages of Pondicherry region but the presence of Sandal trees were recorded in only 10 of the 264 villages, which were Abishegapakkam, Edayarpalayam, Jipmer, Madhikrishnapuram, Moolakulam, Pillyarkuppam, Poornankuppam, Pondicherry town, Sedrapet and Thavalakuppam.

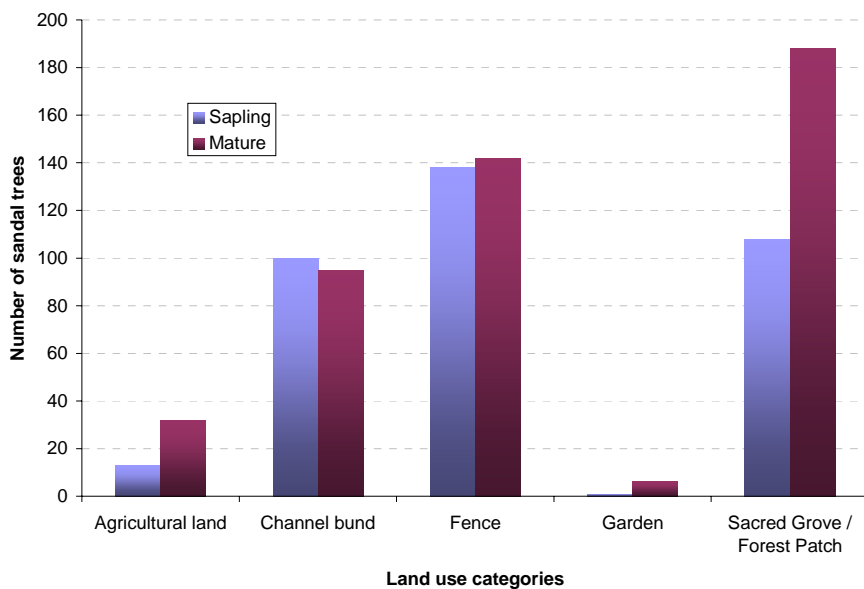


Figure 1. Number of sapling and mature sandal trees located within each land use category of the Pondicherry region.

The sandal trees and their recruitments were recorded under 5 minor land use patterns from these villages.

- (1) agricultural land - area under cultivation,
- (2) channel bund - outlet of the tank bunds from the river and the drainage from the farm land
- (3) fence - a live fence surrounding a field or garden
- (4) garden – a garden / park developed and maintained privately or by the government
- (5) sacred grove / forest patch – a patch of vegetation close to the habitation area ranging from 0.1 to 100 acre conserved by faith and belief system of the people

During the survey trees with a girth at breast height (GBH) of ≥ 10 cm were assessed for their habit, girth, height and reproductive phenology (presence or absence of either flowers or fruits). The vegetation habitats and soil types were also recorded for each sandal tree. Trees of less than 10cm GBH were defined as ‘saplings’ and considered in the estimates of natural recruitment. Woody perennial species occurring within a 1m radius of the sandal were identified, but for trees with few associated species the nearest three plants (not more than two meters away from the plant) were identified.

Results

A total of 463 ‘mature’ (gbh ≥ 10 cm) sandal trees and 360 ‘sapling’ (gbh < 10 cm) trees were recorded across the 10 different locations in the Pondicherry region. Sandal trees were found to grow in a range of soil types such as sandy, clay, clay with limestone and red earth, but approximately 71 % of the trees surveyed were found in clay with limestone. When stratified in to the 5 different land type, trees were most commonly found in forest patches (296) fence (280) and channel bunds (195), while very few trees were located in agricultural (45) and garden (7) areas (Figure 1).

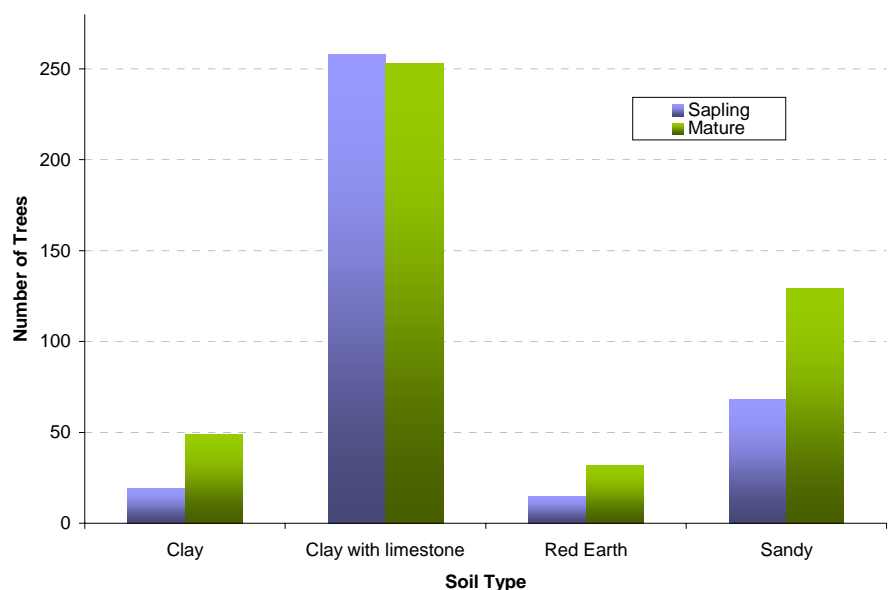


Figure 2. Number of sapling and mature sandal trees identified in the different soil types of the Pondicherry region.

The ‘sapling’ trees range in height from 30 to 150 cm and girth (gbh) from one to nine cm. Among these 360 sapling trees 7 plants were observed with flowers. A total of 258 sapling trees were recorded from clay with lime stone alone which is substantially greater than those recorded in sandy (68), clay (19) and red earth (15). Comparable sandal numbers and proportions were found within each soil type for both saplings (< 10 cm GBH) and mature (≥ 10 cm GBH) trees (Figure 2).

The ‘mature’ trees ranged in height from 1.5 to 8 m and girth (gbh) from 10 to 55 cm. Among these 463 mature trees 118 plants were observed with flowers and fruits and most of these trees had a height of between 3.5 and 6 m. Trees of all heights were found to have signs of reproduction (i.e. flowers and fruits), but those ranging from 3.5 – 6 m had substantially greater numbers than both taller (6.5-8 m) and shorter (1.5-3 m) trees (Figure 3). The number of trees with signs of reproduction was substantially greater in clay limestone (54) and sandy (46) than those in clay (13) and red earth (5) soils.

A total of 79 species including both dicot and monocots were recorded as associate / host with the sandal plants in this study (Appendix 1). They represent 41 families and 76 genera with various habits climber (13), shrub (26) and trees (40). Six species within each of the Mimosaceae and

Soil Type	Main Associated Species
Clay	<i>Azadirachta</i>
	<i>Morinda</i>
	<i>Lantana</i>
Clay with lime stone	<i>Azadirachta</i>
	<i>Glycosmis</i>
	<i>Phoenix</i>
Red earth	<i>Azadirachta</i>
	<i>Morinda</i>
	<i>Phoenix</i>
Sandy	<i>Azadirachta</i>
	<i>Cocos & Lantana</i>
	<i>Morinda & Phoenix</i>

Table 1. Common associated species for sandalwood with a height of ≥ 5 m

Rubiaceae families were identified; Arecaceae and Verbenaceae each had 4 species. *Areca catechu*, *Borassus flabellifer*, *Cocos nucifera* and *Phoenix pusilla* of Arecaceae; *Pandanus tectorius* of Pandanaceae; *Bambusa arundinacea* of Poaceae are the woody monocots recorded from the study. *Cerus pterogonous* and *Opuntia stricta* of Cactaceae are also recorded. Weedy and wildy growing plants such as *Azadirachta indica* (34), *Borassus flabellifer* (12), *Glycosmis mauritiana* (28), *Lantana camera* (14), *Morinda coreia* (22) and *Phoenix pusilla* (22) were frequently associated.

Azadirachta indica (Meliaceae) was the most common associated species identified 105 of the 463 mature sandal trees measured across all soil types. *Morinda coreia* (Rubiaceae) was a common associated species for sandal occurring in clay and red earth soils; *Glycosmis mauritiana* (Rutaceae) was found commonly with sandal occurring in clay with lime stone and *Phoenix pusilla* (Arecaceae) was commonly recorded in red earth and clay with limestone. *Lantana camera* (Verbenaceae), *Cocos nucifera* (Arecaceae) and *Carissa spinarum* (Apocynaceae) were also regularly recorded with the sandal trees assessed (Table 1).

The total number of observations for

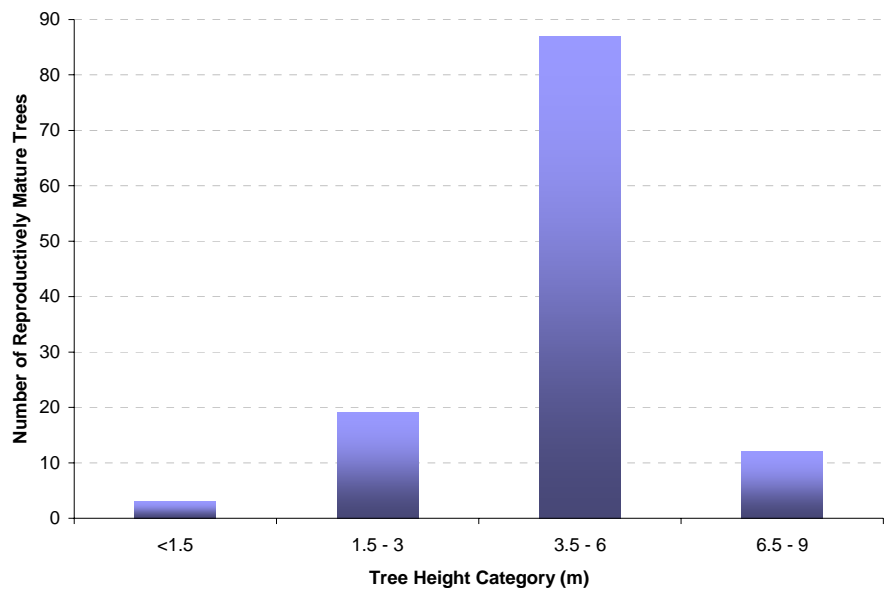


Figure 3. The number of trees with signs of reproduction (i.e. flowers or fruits) stratified into tree height classes.

all associated species declined with increasing girth class, i.e. the representation of the individuals was very poor with the girth range between 31 and 55 cm (figure 4). A higher number of associated plants were recorded for sandalwood up to 6 m height than above 6m (Table 2). The low number of matured trees in this region is indicative of a high level of disturbance. During the survey, root suckering was observed in quite a few places indicating the sign of cutting and excavating the trunk and roots of large valuable trees. The mean proportion of sandal trees with flowers and fruits (30.6%)

was comparable between the predominant associated species indicating that they have very little effect on sandalwood reproduction.

Discussion

Good sandal stands in India are found in mixed deciduous forests, open scrub forest, among the bushes of *Lantana* and *Bambusa* and around the margins of cultivated fields (Cameron 1894; Troup 1921; Bourdillon 1937; Kristensen 1960; Sinha 1967). Recently, Kadamban and Balachandran (2005) reported the occurrence of natural *Santalum album* on the coastal

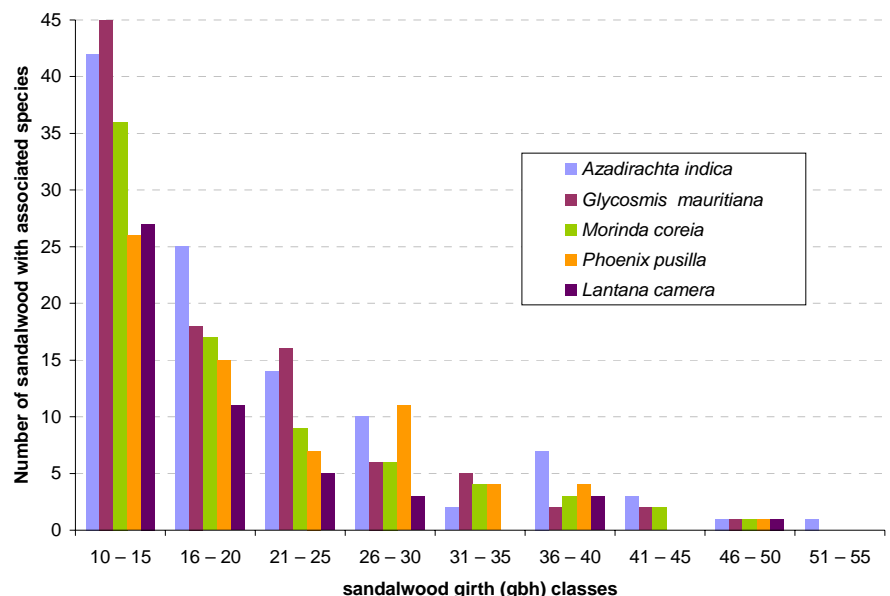


Figure 4. The number of sandalwood associated with the main putative host species identified.

Height (m)	<i>Azadirachta</i>	<i>Glycosmis</i>	<i>Morinda</i>	<i>Phoenix</i>	<i>Lantana</i>
	<i>indica</i>	<i>mauritiana</i>	<i>coreia</i>	<i>pusilla</i>	<i>camera</i>
0 to 2	14	9	14	6	9
2.5 to 4	53	46	38	39	29
4.5 to 6	31	33	23	22	12
6.5 to 8	7	7	3	1	0
Total	105	95	78	68	50

Table 2. Frequency of predominant associated species for each sandal height class

plains of Pondicherry region, Cuddalore and Villupuram districts of Tamilnadu. In this study, sandal was recorded in five different land use categories of the Pondicherry region such as sacred groves / remnant forest patches (296), fence (280), channel bunds (195), agricultural (45) and garden (both government and private) (7) areas (Figure 1). Most sandalwood trees were found in the sacred groves/remnant forest patches, fence and channel bunds areas. This finding may be related to the lower level of disturbance in these areas when compared with agricultural and garden areas where there are active and continuous disturbances by human and cattle. This is further supported by the relatively high proportions of trees located in undisturbed areas within each of these land use categories (Figure 5).

Normally, the growth of sandal is vigorous and luxuriant on rich and fairly moist soil, such as garden loams and on well drained deep alluvium along the river banks, but the heart wood from these trees is deficient in oil. The trees grown on poor soil particularly on stony or gravelly soil, red ferruginous loam overlying, metamorphic rocks, chiefly gneiss and calcareous situations do not attain such large dimensions, but produce more highly scented wood, giving a better yield of oil (Cameron 1894; Troup 1921; Gamble 1922; Street 1928).

On the coastal plains of Pondicherry the results of Kadamban and Balachandran (2005) and the present study revealed that a greater number of sandal plants were found high in clay with lime stone rather than sandy soil (Figure 2). A substantial proportion of the individuals occurring in red earth (58.82 %), clay (45.71 %) and sandy soil (54.54 %) had a girth of ≥ 20 cm, indicating that these soils are suitable for the production of commercially

sized trees. While a reduced proportion of large trees ($gbh \geq 20$ cm) were found growing in clay with lime stone (37.75 %) substantially larger numbers of mature and juvenile trees were found in this soil type (258 and 252 respectively) than the remaining soil types; sandy (68 and 130), clay (19 and 47) and red earth (15 and 34) (Figure 2).

In Karnataka, Tamilnadu and Kerala Rangaswamy *et al.* (1986) observed that sandal was most prevalent on red loam soils. The result of this study, indicate that sandal is most prevalent on clay with limestone in Pondicherry. Parthasarathi *et al.* (1973) observed that the soil was non-calcareous in many areas where spike disease was prevalent. No incidence of spike disease or insects infestation was recorded during this study in Pondicherry region where 71 % of the sandal trees occur in calcareous soils, which loosely supports the above statement.

The sandal and host tree relationship

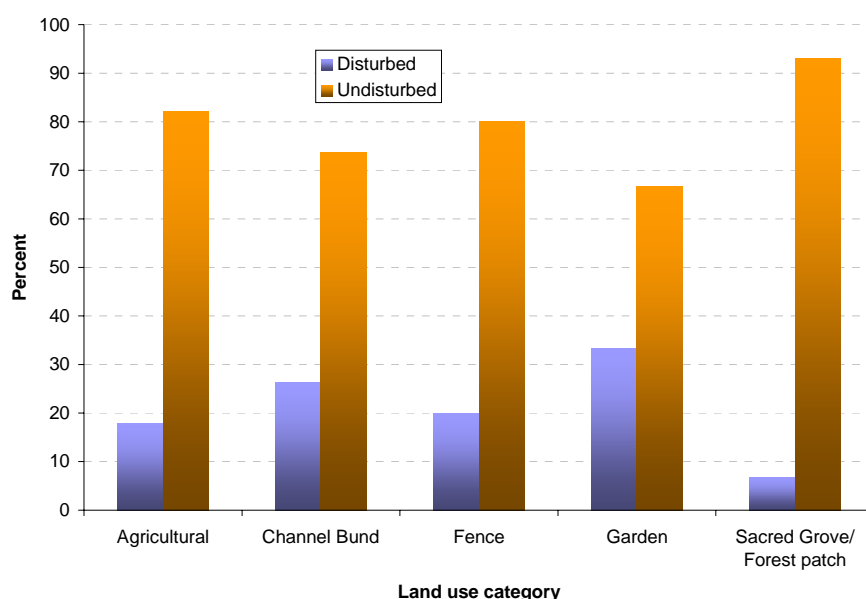


Figure 5: Relative proportion of sandalwood observed growing in disturbed and undisturbed areas within each land use category.

has been reported to influence sandalwood growth, reproduction, formation of heart wood and resistance to spike disease and insect pests (Scott 1871; Rama Rao 1911; Troup 1921). In mixed and dry deciduous forest plants like *Terminalia*, *Lagerstroemia*, *Anogeissus*, *Dalbergia*, *Pongamia*, *Albizia* and *Acacia* etc. are commonly associated with sandal (Ananthapadmanabha *et al.*, 1988). Sandal trees growing with *Azadirachta*, *Ruta*, *Bambusa*, *Dalbergia*, *Erythroxylum*, *Semecarpus*, *Strychnos* and *Ziziphus* are considered to be resistant to spike disease (Srinivasan *et al.* 1992). In contrast sandal trees growing with *Acacia farnesiana*, *Cajanus cajan*, *Lantana camera* and *Pongamia pinnata* are apparently very susceptible (Srinivasan *et al.* 1992). In this study, it is clear that the spike disease was not yet recorded along the coastal plains of Pondicherry, but further investigation is required to determine the environmental and biological factors that may limit its incursion and spread in this area.

Azadirachta indica, *Glycosmis mauritiana*, *Lantana camera*, *Morinda pubescens* and *Phoenix pusilla* are the main sandal associates of this study region (Table 1). Troup (1921) stated that *Lantana camera* is readily parasitized by the sandal tree. *Carissa*, *Cereus*, *Cocos* and *Pamburus* are the other common associates. The numbers of sandalwood individuals were less in between the heights of 6.5 and

8 m and the girths 31 to 55 cm (Figure 4). This may be due to the influence of disturbance, distribution of individuals in different habitats and soil types. Further study of the relationships between soil, altitude, growth and reproduction with common associate and the haustorial connections will help to improve our understanding of these factors in sandalwood growth and productivity.

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Appendix

Sl.No.	Botanical Name	Family Name	Tamil Name	Habit
1	Acacia nilotica (L.) Del.	Mimosaceae	Karuvel	Tree
2	Alangium salviifolium (L.f.) Wangerin	Alangiaceae	Azhingil	Tree
3	Albizia lebbek (L.) Benth.	Mimosaceae	Vagai	Tree
4	Allophylus cobbe auct. Non Raeusch.	Sapindaceae	Siruvalli	Shrub
5	Annona squamosa L.	Annonaceae	Seetapazham	Tree
6	Areca catechu L.	Arecaceae	Pakku maram	Tree
7	Asparagus racemosus Willd.	Asparagaceae	Thannirvittan kizhangu	Climber
8	Azadirachta indica Adr. Juss.	Meliaceae	Vembu	Tree
9	Azima tetraantha Lam.	Acanthaceae	Mullangan	Shrub
10	Bambusa bambos (L.) Voss	Poaceae	Moongil	Tree
11	Barleria prionitis L.	Acanthaceae	Kattukanagambaram	Subshrub
12	Borassus flabellifer L.	Palmaceae	Pannai maram	Tree
13	Breynia vitis-idaea (Burm.f.) C.Fisher	Euphorbiaceae	Manipullandi	Shrub
14	Butea monosperma (Lam.)Taubert	Fabaceae	Poorasu	Tree
15	Cadaba fruticosa (L.)Druce	Capparaceae	Vizhudhi	Shrub
16	Capparis brevispina DC.	Capparaceae	Aathandai	Shrub
17	Capparis zeylanica L.	Capparaceae	Suduthoratti	Climber
18	Carissa spinarum L.	Apocynaceae	Siru kala	Shrub
19	Carmona retusa (Vahl) Masam.	Boraginaceae	kurangu vettrilai	Shrub
20	Cassine glauca (Rottb.) Kuntze	Celastraceae	Kanniramaram	Tree
21	Casuarina equisetifolia Forster & Forster .f.	Casuarinaceae	Savukku	Tree
22	Ceiba pentandra (L.) Gaertner var.pentandra	Bombacaceae	Ilavam	Tree
23	Cephalandra indica Naudin	Cucurbitaceae	Kovai	Climber

Sl.No.	Botanical Name	Family Name	Tamil Name	Habit
24	<i>Cereus pterogonus</i> Lemaire	Cactaceae	Rayel chappati	Shrub
25	<i>Cissus quadrangularis</i> L.	Vitaceae	Pirandai	Climber
26	<i>Cocos nucifera</i> L.	Arecaceae	Thennai maram	Tree
27	<i>Cordia dichotoma</i> Forster f.	Boraginaceae	Narivizhi	Tree
28	<i>Diospyros melonoxylon</i> Roxb.	Ebenaceae	Beedi ilai	Tree
29	<i>Derris scandens</i> (Roxb.) Benth.	Fabaceae	Thegil	Climber
30	<i>Ehertia pubescens</i> Benth.	Boraginaceae	Aadali	Tree
31	<i>Enterolobium saman</i> (Jacq.) Prain	Mimosaceae	Thungumoonji	Tree
32	<i>Eucalyptus</i> sp.	Myrtaceae	Thaila maram	Tree
33	<i>Ficus benghalensis</i>	Moraceae	Aala maram	Tree
34	<i>Ficus hispida</i> L.f.	Moraceae	Pee atthi	Shrub
35	<i>Glycosmis mauritiana</i> (Lam.) Yuich.Tanaka	Rutaceae	Koonji maram	Shrub
36	<i>Glyricidia sepium</i> (Jacq.) Walp	Fabaceae	Vivasaya thagarai	Tree
37	<i>Ixora pavetta</i> Andrews	Rubiaceae	Koran	Tree
38	<i>Jatropha gossypifolia</i> L.	Euphorbiaceae	Kattamanakku	Shrub
39	<i>Justicia adhatoda</i> L.	Acanthaceae	Adhathodai	Shrub
40	<i>Lannea coromandelica</i> (Houtt.)Merr.	Anacardiaceae	Odiya maram	Tree
41	<i>Lantana camera</i> L.	Verbenaceae	Unni chedi	Shrub
42	<i>Lepisanthes tetraphylla</i> (Vahl) Radlk.	Sapindaceae	Kugamathi	Tree
43	<i>Leptadenia reticulata</i> (Retz.) Wight & Arn.	Asclepiadaceae	Palakkodi	Climber
44	<i>Leucaena leucocephala</i> (Lam.) de Wit	Mimosaceae	Savunadal	Tree
45	<i>Madhuca longifolia</i> (J.Koenig) Macbr.	Sapotaceae	Illuppai	Tree
46	<i>Mangifera indica</i> L.	Anacardiaceae	Maa maram	Tree
47	<i>Maytenus emarginata</i> (Willd.) Ding Hou	Celastraceae	Chottai kala	Shrub
48	<i>Memecylon umbellatum</i> Burm.f.	Melastomataceae	Kasan	Shrub
49	<i>Morinda coreia</i> Buch.-Ham.	Rubiaceae	Nuna maram	Tree
50	<i>Moringa oleifera</i> Lam.	Moringaceae	Murunga maram	Tree
51	<i>Olex scandens</i> Roxb.	Olacaceae	Kadal ranji	Climber
52	<i>Opuntia dillenii</i> (Ker Gawler) Haw.	Cactaceae	Chappattikalli	Shrub
53	<i>Pamburus missionis</i> (Wight) Swingle	Rutaceae	Kattu narathai	Tree
54	<i>Pandanus odoratissimus</i> L.f.	Pandanaceae	Thazhai maram	Shrub
55	<i>Pavetta indica</i> L.	Rubiaceae	Paavattai	Shrub
56	<i>Phoenix pusilla</i> Roxb.	Palmaceae	Etcha maram	Tree
57	<i>Pimenta dioica</i> (L.) Merr.	Myrtaceae		Tree
58	<i>Pithecellobium dulce</i> (Roxb.)Benth.	Mimosaceae	Kooduka pulli	Tree
59	<i>Plumbago zeylanica</i> L.	Plumbaginaceae	Cithiramulam	Shrub
60	<i>Polyalthia suberosa</i> (Roxb.) Thwaites	Annonaceae		Shrub
61	<i>Premna latifolia</i> Roxb.	Verbenaceae	Munnai	Tree
62	<i>Prosopis juliflora</i> (Sw.)DC.	Mimosaceae	Vela maram	Tree
63	<i>Psidium guajava</i> L.	Myrtaceae	Koyya maram	Tree
64	<i>Psilanthus wightianus</i> (Wight & Arn.) J.Leroy	Rubiaceae	Vaedan	Shrub
65	<i>Psydrax dicoccos</i> Gaertner	Rubiaceae	Nazhuvai	Tree
66	<i>Randia dumetorum</i> (Retz.)Poiret	Rubiaceae	Madukkarai	Shrub
67	<i>Reissantia indica</i> (Willd.(N.Halle	Celastraceae	Odangkodi	Climber
68	<i>Scutia myrtina</i> (Burm.f.) Kurz.	Rhamnaceae	Kokkimullu	Shrub
69	<i>Securiniga leucopyrus</i> (Willd.) Baillon	Euphorbiaceae	Vellai poola	Shrub
70	<i>Streblus asper</i> Lour.	Moraceae	Kutti pala	Tree
71	<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	Naval maram	Tree
72	<i>Tamarindus indica</i> L.	Caesalpiniaceae	Puliya maram	Tree
73	<i>Tectona grandis</i> L.f.	Verbenaceae	Thekka maram	Tree
74	<i>Thespesia populnea</i> (L.) Sol.ex Correa	Malvaceae	Poovarasu	Tree
75	<i>Tiliacora acuminata</i> (Lam.) Miers	Menispermaceae	Kattukodi	Climber
76	<i>Tinospora cordifolia</i> (Willd.) Hook.f. & Thomson	Menispermaceae	Seendhil	Climber
77	<i>Toddalia asiatica</i> (L.) Lam.	Rutaceae	Milagaranai	Shrub
78	<i>Vitex negundo</i> L.	Verbenaceae	Notchi	Tree
79	<i>Zizyphus oenophilia</i> (L.) Miller	Rhamnaceae	Surai mullu	Climber