



Studies on the floral composition in the six selected provenances of Sandal (*Santalum album* Linnaeus) of South India

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ABSTRACT : A detailed study on the floral composition in six selected provenances of sandal (*Santalum album* Linnaeus) in different localities of south India has been made during August, 2004 to September, 2006. The six sandal provenances selected for the study were Bangalore, Thangli and Mandagadde in Karnataka, Javadis and Chitteri in Tamil Nadu and Marayoor in Kerala. Around 76 floral species excluding grasses were recorded from the selected provenances of sandal. The floral composition consists of 21 species under 15 families in Bangalore, 16 species under 14 families in Thangali, 16 species under 16 families in Mandagadde, 22 species under 17 families in Chitteri and 28 species under 22 families in Javadis and 16 species under 10 families in Marayoor. The density, frequency, abundance and A/F ratio of plant species found in all the provenances were calculated.

Key words : Sandal, provenance, floral composition, South India.

INTRODUCTION

After the Rio conference every country has started showing great concern for conserving their biodiversity for its great utilitarian values. India is one of the 12 centres of the origin of cultivated plants known as the Hindustan Centre of Origin of Crops and Plant diversity. India has a very rich biological diversity which is due to the wide range of physiographic and climatic conditions. As per report about 4 to 5% of all known plant species on earth are found in India. Embracing 10 biogeographic zones and 25 distinct biotic provinces, India incorporates an exceptional range of biodiversity including all the world's major ecosystems. Next to the Himalayan mountain forests the biodiversity of the tropical forests is found only in the Southern Peninsula. Among the important tree species of India, Sandal (*Santalum album* Linn.) is indigenous to Peninsular India, which has high economic value. Sandal wood tree commonly known as Chandan is prized for its oil and heartwood. It is estimated that the annual requirements by the Indian essential oil and allied industries is about 50 tones of oil and on an average 30 to 40 tones of oil is required for export. Though sandal is distributed all over the country it grows naturally and extensively in Karnataka, Tamil Nadu and Kerala and more than 90% lies in Karnataka and Tamil Nadu. It occurs in southern dry deciduous and thorn forest types either along with other species as an "associate" or along farm bunds and fence of private holdings. It is a semi-root parasite and can parasitize over 300 species of plants representing almost all the family of plants and found in association with other trees. Its roots are partially parasitic on the roots of other plants from which their haustoria obtain their nutrient material particularly nitrogen and phosphorus. The biotic factors and pests are affecting the yield of sandal. The important host plants of sandal includes *Casuarina equisetifolia*, *Melia dubea*, *Acacia nilotica*, *Wrightia tinctoria*, *Pongamia pinnata*, *Terminalia arjuna*, *T. alata*, *Dalbergia sissoo*, *Cassia siamia*,

Bauhinia biloba etc., in its natural habitats. Review of literature reveals that no consolidated account is available on the floral composition of sandal dominated ecosystem. Therefore, the present study made a modest attempt to study associated vegetation and their interaction with sandal in six selected sandal provenances of South India.

MATERIAL AND METHODS

A detailed study on the floral composition in six selected provenances of sandal (*Santalum album* Linnaeus) in different localities of south India has been made during August, 2004 to September, 2006. For this purpose six provenances of sandal from south India were selected. They were Bangalore, Thangli and Mandagadde in Karnataka, Javadis and Chitteri in Tamil Nadu and Marayoor in Kerala. The survey was conducted two times in a year representing summer and winter season. Blocks of the size 50 x 50 ft in five replications were marked in all the selected sandal provenances for sampling. From each block vegetation samples were collected and in the lab herbarium were prepared. The common vegetation were identified in the field and other species were got identified with the help of literature and by the experts of IWST and ATREE, Bangalore. The identified floral sample herbariums were deposited at the Wood Biodegradation Division of Institute of Wood Science and Technology (ICFRE), Bangalore.

RESULTS AND DISCUSSION

A detailed study on the floral composition in six selected provenances of sandal (*Santalum album* Linnaeus) in south India has been made during August, 2004 to September, 2006. The areas of study/the six selected Sandal Provenances in South India details recorded as in Table-1.

Table 1 : Details of six selected Sandal Provenances in South India.

Potential Sandal provenance	Forest division and state	Latitude and longitude	Altitude (m)	Mean annual rainfall (mm)	Temp. Max/min (°C)	Soil type	pH	TSS Mhos/Cm
Bangalore	Bangalore	12°58'N	1000	850	36.8/12.2	Red loam	6.3 – 6.5	251.1 m mhos
Thangli	Chickmagalur, Karnataka	13°40'N	766	1500	44.0/10.5	Red load and alluvium	7.5 – 7.8 alkaline	2.3 m mhos
Mandagadde	Shimoga, Karnataka	13°9'N 75°40'E	650	2000	38.1/13.0	Red loam	5.5 – 5.8 Acidic	317.0 μ mhos
Chitteri	Harur, Tamil Nadu	12°0' N 78°7'E	1050	1000	35.2/8.2	Red sandy load	6.0 – 6.3 Acidic	327.3 μ mhos
Javadis	Tirupattur, Tamil Nadu	12°3' N 78°7'E	930	1200	38.0	Red loam	6.6 – 6.7 Acidic	432.5 m mhos
Mayayoor	Munnar, Kerala	10°1'N 77°1'E	1000	1450	36.0/10.0	Black clay	6.2° 6.7 Acidic	362.0 mhos

The floral composition in all the selected provenances of sandal including trees, shrubs except grasses were identified and documented. Around 76 floral species excluding grasses were recorded from the selected provenances of sandal. The floral composition consists of 21 species under 15 families in Bangalore (Table-2), 16

species under 14 families in Thangali (Table-3), 16 species under 16 families in Mandagadde (Table-4), 22 species under 17 families in Chitteri (Table-5) and 28 species under 22 families in Javadis (Table-6) and 16 species under 10 families in Marayoor (Table-7).

Table 2 : Floral composition of Bangalore Sandal Provenance (Karnataka).

S.No.	Plant species	Family	Type of flora	Density	Frequency	Abundance	A/F ratio
1.	<i>Annona squamosa</i> Linn.	Annonaceae	T	0.4	0.4	1.0	2.5
2.	<i>Artocarpus heterophyllus</i> Lam.	Moraceae	T	0.4	0.2	1.0	5.0
3.	<i>Bambusa</i> sp.	Poaceae	T	0.2	0.2	1.0	5.0
4.	<i>Broussonetia papyrifera</i> Vent.	Moraceae	S	0.4	0.6	3.3	5.5
5.	<i>Caryota urens</i> Linn.	Palmae	S	0.4	0.4	1.0	7.0
6.	<i>Casurina equisetifolia</i> Forster & Forster	Casurinaceae	T	0.8	0.8	08	12.5
7.	<i>Coffea arabica</i> Linn.	Rubiaceae	S	2.2	0.4	5.5	13.7
8.	<i>Coffea robusta</i> Linn.	Rubiaceae	S	0.2	0.2	1.0	5.0
9.	<i>Delonix regia</i> R. Hook.	Leguminosae	T	0.2	0.6	3.3	5.5
10.	<i>Eucalyptus</i> sp.	Myrtaceae	T	0.2	0.2	1.0	5.0
11.	<i>Ficus glomerata</i> Roxb.	Moraceae	T	0.2	0.2	1.0	5.0
12.	<i>Gliricidia sepium</i> (Jacq.) Kanthex.	Papilionaceae	S	1.4	0.6	2.3	3.8
13.	<i>Grevillia robusta</i> A. Cunn.	Protreaceae	T	0.2	0.2	1.0	5.0
14.	<i>Lantana camara</i> Linn.	Verbenaceae	S	0.4	0.2	2.0	10.0
15.	<i>Leucaena leucocephala</i> (Lam.)	Leguminosae	T	0.6	0.2	3.0	15.0
16.	<i>Pongamia pinnata</i> (Linn.)	Papilionaceae	T	1.2	0.4	3.0	7.5
17.	<i>Santalum album</i> Linn.	Santalaceae	T	18.0	1.0	18.0	18.0
18.	<i>Spathodea companulata</i> Beauv.	Bignoniaceae	T	0.6	0.4	1.5	3.7
19.	<i>Tamarindus indica</i> Linn.	Caesalpiniaceae	T	0.2	0.2	1.0	5.0
20.	<i>Ziziphus oenoplea</i> (Linn.)	Rhamnaceae	S	0.1	0.2	5.0	25.0
21.	<i>Ziziphus</i> sp.	Rhamnaceae	T	1.6	0.4	4.0	10.0

Table 3 : Floral composition of Thangali Sandal Provenance (Karnataka).

S.No.	Plant species	Family	Type of flora	Density	Frequency	Abundance	A/F ratio
1.	<i>Santalum album</i> Linn.	Santalaceae	T	13.4	1.0	13.4	13.40
2.	<i>Prosopis juliflora</i> (Sw.)	Leguminasae	T	2.6	0.8	3.25	4.06
3.	<i>Tamarindus indica</i> Linn.	Caesalpiniaceae	T	0.1	0.6	1.66	2.76
4.	<i>Feronia elephantum</i> Corr.	Rutaceae	T	0.4	0.2	1.00	5.00
5.	<i>Phoenix sylvestris</i> (Linn.)	Aracaceae	S	2.2	0.6	3.66	6.10
6.	<i>Eucalyptus</i> sp.	Myrtaceae	T	2.2	0.4	3.66	9.15
7.	<i>Leucaena leucocephala</i> (Lam.)	Leguminasae	T	5.2	0.4	13.00	32.5
8.	<i>Acacia monoacantha</i> (Willd.)	Mimosaceae	T	1.2	0.6	2.00	3.33
9.	<i>Cordia wallintona</i>	Cordiaceae	T	0.4	0.2	1.00	5.00
10.	<i>Ziziphus jujuba</i> Lamk.	Rhamnaceae	T	0.2	0.2	1.00	5.00
11.	<i>Streblus aspera</i> Lour	Moraceae	T	0.2	0.2	1.00	5.00
12.	<i>Carrisa</i> sp.	Apocynaceae	S	0.4	0.2	1.00	5.00
13.	<i>Acacia nilotica</i> (Linn.)	Mimosaceae	T	0.2	0.2	1.00	5.00
14.	<i>Agave</i> sp.	Amaryllidaceae	S	2.0	0.2	10.00	50.00
15.	<i>Annona squamosa</i> Linn.	Annonaceae	T	0.6	0.4	1.5	3.75
16.	<i>Parthenium hysterophorus</i> Linn.	Compositae	H	12.2	0.8	16.00	20.00

Table 4 : Floral composition of Mandagadde Sandal Provenance (Karnataka).

S.No.	Plant species	Family	Type of flora	Density	Frequency	Abundance	A/F ratio
1.	<i>Santalum album</i> Linn.	Santalaceae	T	12.8	1.0	12.8	12.8
2.	<i>Tectona grandis</i> L.f.	Verbanaceae	T	11	0.8	13.75	17.8
3.	<i>Sapindus laurifolius</i> Vahl.	Sapindaceae	T	0.4	0.4	1.00	2.50
4.	<i>Bambusa</i> sp.	Graminae	T	4.2	0.8	5.25	6.56
5.	<i>Syzygium cumini</i> (Linn.)	Myrtaceae	T	0.6	0.2	1.00	5.00
6.	<i>Terminalia ponculata</i> Roxb.	Combretaceae	T	6.8	1.0	6.8	6.8
7.	<i>Trema orientalis</i> Linn.	Ulmaceae	T	1.4	0.6	2.33	3.80
8.	<i>Strychnos nux-vomica</i> Linn.	Loganiaceae	T	2.2	0.6	2.75	4.58
9.	<i>Erythroxylon</i> sp.	Erythroxylaceae	T	1.0	0.4	2.50	6.25
10.	<i>Ficus glomerata</i> Roxb.	Moraceae	T	0.2	0.2	1.00	5.00
11.	<i>Psychotria</i> sp.	Rubiaceae	S	1.4	0.8	1.75	2.18
12.	<i>Ziziphus jujuba</i> Lamk.	Rhamnaceae	T	0.8	0.6	1.33	2.21
13.	<i>Cassia tora</i> Linn.	Caesalpiniaceae	S	0.3	0.4	9.50	18.75
14.	<i>Lantana camera</i> Linn.	Verbenaceae	S	0.2	0.6	3.33	5.55
15.	<i>Ficus benghalensis</i> Linn.	Mimosaceae	T	0.8	0.4	2.00	5.00
16.	<i>Tecoma stans</i> (Linn.)	Bignoniaceae	S	0.4	0.4	1.00	2.56

Table 5 : Floral composition of Chitteri Sandal Provenance (Tamil Nadu).

S.No.	Plant species	Family	Type of flora	Density	Frequency	Abundance	A/F ratio
1.	<i>Santalum album</i> Linn.	Santalaceae	T	16.6	1.0	16.60	16.60
2.	<i>Cassia hirsuta</i> Lam.	Caesalpiniaceae	S	4.8	0.6	8.00	1.33
3.	<i>Cassia fistula</i> Linn.	Caesalpiniaceae	S	3.8	0.4	9.50	23.75
4.	<i>Bambusa bambusa</i>	Poaceae	T	1.2	0.4	3.00	7.50
5.	<i>Ziziphus oenoplea</i> (Linn.)	Rhamnaceae	T	0.8	0.6	3.00	2.21
6.	<i>Albizia lebbek</i> (L.)Willd.	Mimosaceae	T	0.2	0.6	1.00	1.66
7.	<i>Spathodea companulata</i> Beauv.	Bignoniaceae	T	0.2	0.2	1.00	5.00
8.	<i>Chromolaena odorata</i> (Linn.)	Asteraceae	H	30	0.4	75.00	187.50
9.	<i>Lantana camara</i> Linn.	Verbenaceae	S	30	0.8	37.50	46.87
10.	<i>Ficus glomerata</i> Roxb.	Caesalpiniaceae	T	0.4	0.2	1.00	5.00
11.	<i>Erythroxylon monogynum</i> Roxb.	Erythroxylaceae	T	0.8	0.2	1.00	5.00
12.	<i>Clausena dentata</i> Oliv.	Rutaceae	T	4.6	0.6	7.66	12.76
13.	<i>Syzygium cumini</i> (Linn.)	Myrtaceae	T	0.4	0.2	1.00	5.00
14.	<i>Leucaena leucocephala</i> Lam.	Caesalpiniaceae	T	0.6	0.4	1.50	3.75
15.	<i>Anogeissus latifolia</i> Wall.	Combretaceae	T	4.4	0.8	5.55	6.93

S.No.	Plant species	Family	Type of flora	Density	Frequency	Abundance	A/F ratio
16.	<i>Dodonaea viscosa</i> (Linn.)	Sapindaceae	S	5.0	1.0	30.00	37.50
17.	<i>Randia dumetorum</i> (Retz.)	Rubiaceae	T	2.4	0.4	37.50	9.37
18.	<i>Chloroxylon swietenia</i> DC.	Meliaceae	S	2.4	0.4	6.00	15.00
19.	<i>Maba buxifolia</i> Rottb.	Ebenaceae	S	0.8	0.2	75.00	375.00
20.	<i>Canthium dicoccum</i> (Gaertn)	Rubiaceae	T	0.8	0.4	1.00	2.50
21.	<i>Pterolobium indicum</i> A. Rich	Fabaceae	T	0.6	0.4	1.00	2.50
22.	<i>Tarema asiatica</i>	Rubiaceae	S	11.46	0.4	11.40	27.50

Table 6 : Composition of Javadis (Kavalur) Sandal Provenance (Tamil Nadu).

S.No.	Plant species	Family	Type of flora	Density	Frequency	Abundance	A/F ratio
1.	<i>Santalum album</i> Linn.	Santalaceae	T	21.8	1.0	21.80	21.80
2.	<i>Delonix regia</i> (Boj.)	Leguminasae	T	0.2	0.2	1.00	5.00
3.	<i>Tecoma</i> sp.	Bignoniaceae	T	0.2	0.2	1.00	5.00
4.	<i>Annona squamosa</i>	Annonaceae	T	1.6	0.8	2.66	3.32
5.	<i>Melia azadirach</i> Linn.	Meliaceae	T	1.6	0.2	2.00	10.00
6.	<i>Tectona grandis</i> L.F.	Verbenaceae	T	0.4	0.2	1.00	5.00
7.	<i>Pongamia pinnata</i> (Linn.)	Papilionaceae	T	0.6	0.2	1.00	5.00
8.	<i>Chromolena odorata</i> (Linn.)	Asteraceae	H	30	0.4	75.00	187.50
9.	<i>Parthenium hysterophorus</i> Linn.	Compositae	H	20	0.4	50	120.00
10.	<i>Prososis juliflora</i> (Sw.)	Leguminasae	T	1.2	0.2	1.00	5.00
11.	<i>Bambusa</i> sp.	Graminae	T	0.2	0.2	1.00	5.00
12.	<i>Sida acuta</i> Burm.f.	Bombacaceae	H	2	0.2	1.00	5.00
13.	<i>Phyllanthus niruri</i> Linn.	Ephorbiaceae	H	1.8	0.2	10.00	50.00
14.	<i>Vernonia</i> sp.	Compositae	H	3	0.2	9.00	45.00
15.	<i>Ziziphus oenoplea</i> (Linn.)	Rhamnaceae	T	8.4	0.6	15.00	25.00
16.	<i>Randia dumetorum</i> Lam.	Rubiaceae	S	3	0.2	15.00	75.00
17.	<i>Lantana camara</i> Linn.	Verbenaceae	S	30	0.8	37.50	46.82
18.	<i>Capparis sepiaria</i> Linn.	Capparidaceae	S	4	0.4	10.00	25.00
19.	<i>Azadirachta indica</i> (A. Juss.)	Meliaceae	T	0.6	0.6	1.00	1.66
20.	<i>Zyziphus</i> sp.	Rhamnaceae	T	1	0.6	1.66	2.76
21.	<i>Chloroxylon swietenia</i> DC.	Meliaceae	S	0.2	0.2	0.2	1.00
22.	<i>Dodonaea viscosa</i> (Linn.)	Sapindaceae	S	6.4	0.6	6.4	10.66
23.	<i>Cassia auriculata</i> Linn.	Caesalpinaceae	S	6.2	0.6	0.8	10.33
24.	<i>Eucalyptus</i> sp.	Myrtaceae	T	0.8	0.2	0.6	1.00
25.	<i>Erythroxylon monogynum</i> Roxb.	Erythroxyloaceae	T	0.6	0.8	1.0	0.75
26.	<i>Acacia leucophloea</i> (Roxb.) Willd.	Mimosaceae	T	1.0	0.2	12.8	5.00
27.	<i>Commelina benghalensis</i> Linn.	Commelinaceae	H	12.8	1.00	4.6	12.80
28.	<i>Siegesbeckia orientalis</i> Linn.	Asteraceae	H	4.6	0.8	4.6	5.75

Table 7 : Floral composition of Marayoor Sandal Provenance (Kerala).

S.No.	Plant species	Family	Type of flora	Density	Frequency	Abundance	A/F ratio
1.	<i>Santalum album</i> Linn.	Santalaceae	T	21.4	1.0	21.4	21.40
2.	<i>Clausena dentata</i> Oliv.	Rutaceae	S	25	1.0	25.00	25.00
3.	<i>Lantana camera</i> Linn.	Verbenaceae	S	16	0.8	20	25.00
4.	<i>Cassia fistula</i> Linn.	Caesalpinaceae	T	02	0.2	10.00	50.00
5.	<i>Canthium dicoccum</i> (Gaertn)	Rubiaceae	S	1.2	0.4	6.00	15.00
6.	<i>Mangifera indica</i> Linn.	Anacardiaceae	T	0.4	0.4	1.00	2.50
7.	<i>Cassia</i> sp.	Caesalpinaceae	H	13.6	1.0	13.60	13.60
8.	<i>Mallotus philippinensis</i> Muell.	Euphorbiaceae	S	02	0.6	3.33	5.55
9.	<i>Atlanta racemosa</i>	Rutaceae	T	2.8	1.0	2.80	2.80
10.	<i>Sida rhomboidea</i> Roxb.	Malvaceae	H	06	0.6	10.00	16.66
11.	<i>Cassia tora</i> Linn.	Caesalpinaceae	S	02	0.4	5.00	12.50
12.	<i>Spathodea companulata</i> Beauv.	Bignoniaceae	T	0.2	0.2	1.00	5.00
13.	<i>Tectona grandis</i> L.F.	Verbanaceae	T	01	0.2	5.00	25.00
14.	<i>Litsea deccanensis</i> Gamble	Lauraceae	T	1.4	0.6	2.33	3.83
15.	<i>Emblica officinalis</i> Gaertn.	Euphorbiaceae	T	0.6	0.4	1.55	3.87
16.	<i>Hibiscus feculence</i>	Malvaceae	H	0.6	0.2	3.00	15.00

Where: T= Tree, S = Shrub and H= Herb

In all the six selected sandal provenances density, frequency, abundance and A/F ratio of plant species were recorded as given below.

(a) **Density** : In all the selected provenances, sandal tree has recorded highest density compared to all other species. Among the provenances Javadis and Marayoor have recorded highest sandal density of 21.8 and 21.4, respectively followed by Bangalore (18) and Chitteri (16). Mandagadde and Thangali provenances have recorded less density of 12.8 and 13.4 respectively.

(b) **Frequency** : It's evident from frequency data of flora that sandal exhibits highest frequency (1 or 100%) than any other species.

(c) **Abundance** : Abundance for all the species has been calculated and from the data it is evident that in all provenances, sandal showed the abundance value same as that of density. With this it is clear that as all the provenances are sandal dominated and homogenous with sandal it is represented in all sample plots.

(d) **A/F ratio**: The abundance to frequency ratio indicated the distribution pattern of species. In general distribution of sandal was continuous and recorded highest A/F ratio among all the tree species in all the provenances except Mandagadde, where in *Tectona grandis* was recorded more than that of sandal.

The study reveals that in all the six selected sandal provenances, there is rich floral diversity of different plant species and all species grows well in association. It is recorded that sandal trees which grow in association with other floral species, the growth and survival rate of sandal tree is high as compared to the isolated sandal tree. Further as now-a-days efforts were made to grow sandal throughout India, but the survival rate, growth, wood quality, oil contents of sandal tree were recorded very low as compared to sandal growing in its natural habitat of South India, so there is need of more emphasis on scientific studies of soil quality, climate changes, associated vegetation, pests, experimental trials etc. before selecting new habitat for sandal.

Srinivasan et al., 1992 has documented the brief studies on all aspects of Sandal and also recorded association of sandal with other plant species. Sharma et al., 2009 has recorded 82 different plant species in and around Dholbaha dam, Punjab. The various workers all over the world has conducted their studies on the diversity of flora,

documented their work and discovered new species. By doing all efforts, still there is continuous decline in our existing plant species due to developmental activities, increase of population and destruction of habitats etc. Therefore, the efforts are required all over the globe for the conservation of existing natural or artificial habitats, is the only method for survival of biodiversity.

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