



## Variability Studies for Seed and Seedling Traits in *Calophyllum Inophyllum* (L.) at South India

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### ABSTRACT

The present investigation was carried out at Forest College and Research Institute, Mettupalayam, Tamilnadu to identify the best half sibs of *Calophyllum inophyllum* across its natural distribution of south India for further collection of seeds for afforestation or breeding purpose. The seeds were collected from different climatic zones of south India. Seeds were measured for its length, width, Pod length, Width and then sown in nursery to study the variation in germination and initial growth parameters viz., germination percent, germination value, peak value, mean daily germination of seedlings. Seeds collected from Western Ghats of Karnataka were superior compared to seeds from other parts in all the traits considered for the study. These seed sources can be further screened for tree improvement traits considering their immense value in yielding bio diesel.

### 1. Introduction

*Calophyllum inophyllum* is a multipurpose tree belonging to the family Clusiaceae, commonly known as mangosteen family. This plant has multiple origins including East Africa, India, South East Asia, Australia, and the South Pacific. *Calophyllum inophyllum* is known by various names around the world. Shows different vernacular names of *Calophyllum inophyllum* in some selected countries of the world. Shows the distribution map of *Calophyllum inophyllum* around the world. As can be seen this tree is widely available in India, South East Asia and Australia. It grows in areas with an annual rain of 1000–5000 mm at altitudes from 0 to 200 m. *Calophyllum inophyllum* is allow-branching and slow-growing tree with two distinct flowering periods of late spring and late autumn. But sometimes its flowering may occur throughout the year. *Calophyllum inophyllum* grows best in sandy, well drained soils. However it tolerates clays, calcareous, and rocky soils. The tree supports a dense canopy of glossy, elliptical, shiny and tough leaves, fragrant white flowers, and large round nuts. Its size typically ranges between 8 and 20 m (25–65 ft) tall at maturity, sometimes reaching up to 35 m (115ft). The growth rate of the tree is 1m (3.3ft) in height per year on good sites.

Its leaves are heavy and glossy, 10–20 cm (4–8 inch) long and 6–9 cm (2.4–3.6 inch) wide, light green when young and dark green when older. Fruits are spherical drupes and arranged in clusters. The fruit is reported to be pinkish-green at first. However, it turns later to be bright green and when ripe, it turns dark grey- brown and wrinkled. The tree yield is 100–200 fruits/kg. In each fruit, one large brown seed 2–4 cm (0.8–1.6in.) India meter is found. The trees yield 3000–10,000 seeds /tree/ season. The seed is surrounded by a shell and a thin layer of pulp of 3–5 mm. *Calophyllum inophyllum* Oil is non-edible and dark green. Traditionally, its oil has been used as a medicine, soap, lamp oil, hair grease and cosmetic in different parts of the world. Recently, *Calophyllum inophyllum* has been proposed as a source of biodiesel.

### 2. Materials and methods

The present study was under taken during the year 2014-15 at Forest College and Research Institute (Mettupalayam), Coimbatore. Which is situated at 11°19'N latitude and 77°56'E longitude and an altitude of 350 m above MSL. The average annual rainfall is 945 mm, most of which is received between June to September. The temperature varies from 15 to 34.9 °C.

The extensive survey was under taken across three different state and one union territory of India. A distance of at least 200 mts was maintained between two trees and at least 25 kms between two seed sources. The individual tree was identified based on their phenotypical characteristics and the individual tree identity was also maintained. Seeds were extracted from 100 pods after sun drying for ten days for assessment of seed characteristics. Further same seeds were used for assessing germination and seedling characters. Seed parameters such as seed length, seed width, seed thickness, seed volume and 100 seed weight were recorded for each seed source. The experiment was laid out in completely randomized design with five replications of 100 seeds each. The seeds were sown in the standard nursery bed and regular watering was done. Observations on daily germination were recorded up to 31 days from date of sowing. Germination percentage, peak value, mean daily germination, germination rate and germination value were recorded for each seed source. Data collected was analysed statistically using Mstatc program.

$$\text{Germination per cent} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

Number of seeds sown  
 Germination value (GV) = PV X MDG, where, PV- Peak Value of germination.

$$\text{MDG- Mean Daily Germination} = \frac{\text{Total germination per cent}}{\text{Total number of days}}$$

$$\text{Peak Value} = \frac{\text{Final germination per cent}}{\text{Number of days that took to reach Peak Germination}}$$

#### Estimation of oil content using Soxhlet method

For estimating oil, the seeds were depulped, the kernels dried at 50°C for 16 hrs and allowed to cool in a desiccator. Five grams of seeds were pulverized to a fine powder in a porcelain mortar. Ground samples were placed in a filter paper and fastened in such a way to prevent escape of the meal and then carefully transferred to an extraction thimble. The thimble was then placed in a Soxhlet extractor to which sufficient quantity of solvent petroleum ether (40 - 60°C) was added and heated until eleven siphonings were completed. The oil content was recorded by evaporating the petroleum ether at 60°C. The entire extraction process was carried out in

Soxhlet extractor according to AOAC (1970). The percentage of oil content was then calculated by using the formula.

$$\text{Oil per cent} = \frac{\text{Oil weight (g)}}{\text{Sample weight (g)}} \times 100$$

**Table.1** *Calophyllum inophyllum* seed source collection from different places in South India

Source	Latitude	Longitude	Altitude
<b>Tamilnadu</b>			
FCRICI 1 (Vedaranyam)	10°22'N	79°51'E	14
FCRICI 2 (Nagapattinam)	10°45'N	79°49'E	5
FCRICI 3 (Velankanni)	10°41'N	79°50'E	21
FCRICI 4 (Thiruvavur)	10°45'N	79°37'E	38
FCRICI 5 (Pudhucherry)	11°54'N	79°47'E	25
FCRICI 6 (Tindivanam)	12°13'N	79°39'E	140
FCRICI 7 (Cuddalore)	11°44'N	79°42'E	35
FCRICI 8 (Nagercoil)	08°09'N	77°22'E	148
FCRICI 9 (Pechiparai)	08°26'N	77°18'E	326
FCRICI10(Mettupalayam)	11°19'N	76°58'E	1036
FCRICI 11 (Thiruchencode)	11°22'N	77°53'E	1405
FCRICI 12 (Coimbatore I)	10°59'N	76°54'E	1307
FCRICI 13 (Coimbatore II)	10°57'N	76°55'E	1373
<b>Karnataka</b>			
FCRICI 14 (Honnavaara)	14°15'N	74°26'E	43
FCRICI 15 (Hubli)	15°22'N	75°04'E	2127
FCRICI 16 (Sirsi)	14°39'N	74°52'E	2049
FCRICI 17 (Bhatkal)	13°59'N	74°31'E	51
FCRICI 18 (Kumta)	14°26'N	74°23'E	114
FCRICI 19 (Udupi)	13°20'N	74°43'E	49
FCRICI 20 (Mangalore)	12°54'N	74°51'E	79
FCRICI 21 (Talugoppa)	14°12'N	74°54'E	1961
FCRICI 22 (Shimoga)	13°53'N	75°33'E	1922
FCRICI 23 (Sagar)	14°09'N	75°00'E	1982
FCRICI 24 (Tumkur)	13°20'N	76°09'E	2974
FCRICI 25 (Mandiya)	12°29'N	76°54'E	2210
FCRICI 26 (Mysore)	12°22'N	76°40'E	2299
<b>Kerala</b>			
FCRICI 27 (Tiruvandrum)	8°29'N	76°59'E	81
FCRICI 28 (Thirissur)	10°29'N	76°17'E	161
FCRICI 29 (Kottayam)	9°33'N	76°32'E	21
FCRICI 30 (Upala)	12°41'N	79°54'E	35

**Table 2.** Seed characteristics as influenced by various place in South India

Seed source	Pod length (mm)	Pod width (mm)	Seed length (mm)	Seed width (mm)	100 Seed weight (g)
FCRICI 1 (Vedaranyam)	29.13	22.38	19.50	18.76	102.13
FCRICI 2 (Nagapattinam)	34.39*	25.18	21.34	20.66*	146.10*
FCRICI 3 (Velankanni)	30.64	26.92	19.10	17.54	107.09
FCRICI 4 (Thiruvavur)	24.96	25.61	21.34	20.38*	124.19*
FCRICI 5 (Pudhucherry)	30.27	24.06	21.90	19.68*	100.17
FCRICI 6 (Tindivanam)	29.86	25.67	20.99	14.77	108.27
FCRICI 7 (Cuddalore)	29.75	24.51	21.34	15.11	102.02
FCRICI 8 (Nagercoil)	29.39	25.03	20.81	13.89	111.24
FCRICI 9 (Pechiparai)	33.77*	23.38	20.42	17.91	133.30*
FCRICI10(Mettupalayam)	29.56	22.06	21.56	14.99	96.30
FCRICI 11 (Thiruchencode)	24.30	24.31	20.05	14.53	89.20
FCRICI 12 (Coimbatore I)	28.97	23.88	20.36	13.26	128.30*
FCRICI 13 (Coimbatore II)	27.56	25.97	20.06	14.26	68.08
FCRICI 14 (Honnava)	39.57*	34.44*	27.15*	23.50*	164.27*
FCRICI 15 (Hubli)	25.07	25.65	18.77	13.31	134.07*
FCRICI 16 (Sirsi)	26.51	24.08	18.99	14.38	125.32*
FCRICI 17 (Bhatkal)	28.61	24.07	17.71	12.44	96.13
FCRICI 18 (Kumta)	30.75	25.25	21.98	13.49	134.04*
FCRICI 19 (Udupi)	28.32	23.15	21.74	15.05	127.17*
FCRICI 20 (Mangalore)	26.20	29.10*	21.48	12.85	125.26*
FCRICI 21 (Talugoppa)	27.68	25.08	20.07	12.81	117.15
FCRICI 22 (Shimoga)	28.42	24.04	20.99	14.12	131.09*
FCRICI 23 (Sagar)	34.65*	23.02	21.31	12.89	120.12*
FCRICI 24 (Tumkur)	33.35*	28.14	22.27	21.44*	115.33
FCRICI 25 (Mandiya)	29.94	26.81	25.29*	21.92*	120.27*
FCRICI 26 (Mysore)	27.73	27.00	23.13	15.09	126.16*
FCRICI 27 (Tiruvandrum)	26.93	25.64	21.60	14.49	119.15*
FCRICI 28 (Thirissur)	34.15*	24.69	20.72	14.88	121.16*
FCRICI 29 (Kottayam)	29.01	25.76	18.87	14.21	126.15*
FCRICI 30 (Upala)	25.38	25.88	22.13	15.51	134.25*
<b>Mean</b>	<b>29.49</b>	<b>25.36</b>	<b>21.10</b>	<b>15.94</b>	<b>118.45</b>

*SEd* = 1.895 1.516 1.478 1.624 0.125  
**CD (0.05)** = 3.794 3.035 2.960 3.252 0.250

**Table 3.** Seed germination attributes in different place in South India

Seed source	Germination percent	Germination value	Peak value	Mean daily germination	Oil %
FCRICI 1 (Vedaranyam)	63.00	4.41	2.30	1.92	44.9
FCRICI 2 (Nagapattinam)	68.00	4.71*	2.85*	1.69	58.3
FCRICI 3 (Velankanni)	61.67	3.68	1.92	1.93	47.8
FCRICI 4 (Thiruvavur)	56.67	3.87	2.18	1.79	42.6
FCRICI 5 (Pudhucherry)	58.00	3.32	2.09	1.59	49.6
FCRICI 6 (Tindivanam)	58.00	3.32	1.98	1.67	41.0
FCRICI 7 (Cuddalore)	59.33	3.07	1.93	1.59	38.2
FCRICI 8 (Nagercoil)	68.33	3.80	2.17	1.74	52.4
FCRICI 9 (Pechiparai)	64.00	4.45	2.55	1.56	57.4
FCRICI10(Mettupalayam)	59.67	3.10	1.97	1.57	45.8
FCRICI 11 (Thiruchencode)	54.00	3.64	2.06	1.77	44.4
FCRICI 12 (Coimbatore I)	64.67	3.50	2.04	1.70	43.7
FCRICI 13 (Coimbatore II)	58.33	3.48	2.20	1.57	50.6
FCRICI 14 (Honnavaara)	78.00*	5.11*	3.06*	1.79	64.6*
FCRICI 15 (Hubli)	56.00	3.64	2.31	1.56	39.3
FCRICI 16 (Sirsi)	53.00	3.63	1.99	1.83	44.8
FCRICI 17 (Bhatkal)	54.67	3.25	1.92	1.68	51.4
FCRICI 18 (Kumta)	59.00	3.48	2.02	1.73	45.5
FCRICI 19 (Udupi)	55.67	2.88	1.98	1.43	43.5
FCRICI 20 (Mangalore)	46.67	2.54	1.77	1.44	43.0
FCRICI 21 (Talugoppa)	54.67	2.53	1.68	1.51	43.6
FCRICI 22 (Shimoga)	52.33	3.26	1.89	1.72	46.3
FCRICI 23 (Sagar)	56.00	3.62	1.98	1.82	48.2
FCRICI 24 (Tumkur)	56.00	2.63	1.68	1.73	37.9
FCRICI 25 (Mandiya)	52.00	2.96	1.87	1.66	48.3
FCRICI 26 (Mysore)	55.67	2.90	2.09	1.40	35.7
FCRICI 27 (Tiruvandrum)	57.33	2.24	1.70	1.33	47.7
FCRICI 28 (Thirissur)	54.67	2.72	1.98	1.52	44.4
FCRICI 29 (Kottayam)	57.33	2.63	1.74	1.53	44.7
FCRICI 30 (Upala)	54.33	3.29	2.06	1.58	46.3
<b>Mean</b>	<b>58.23</b>	<b>3.39</b>	<b>2.06</b>	<b>1.64</b>	<b>46.4</b>

*SEd* = 8.880      0.596      0.305      0.170      6.133  
*CD (0.05)* = 17.77      1.193      0.610      0.341      12.27

**Table 4.** Genotypic correlation of seed and seedling attributes of *Calophyllum inophyllum* in South India (\*\* Significant at 1 % level; \* Significant at 5 % level)

Characters	Pod length	Pod width	Seed length	Seed width	Seed weight	Germination percent	Germination value	Peak value	MDG	Oil %
<b>Pod length</b>	1.000	0.396*	0.566**	0.547**	0.405*	2.403**	0.663**	0.803**	0.533**	0.853**
<b>Pod width</b>		1.000	0.822**	0.525**	0.480**	1.274**	0.196	0.450**	0.067	0.389*
<b>Seed length</b>			1.000	0.753**	0.530**	1.520**	0.283	0.576**	-0.124	0.408*
<b>Seed width</b>				1.000	0.295	1.639**	0.557**	0.704**	0.498**	0.639**
<b>Seed wt</b>					1.000	0.928**	0.365*	0.575**	-0.076	0.373*
<b>G.percent</b>						1.000	1.758**	2.179**	-0.700	2.793**
<b>G.value</b>							1.000	0.991**	0.607**	1.217**
<b>Peak value</b>								1.000	0.346	1.336**
<b>MDG</b>									1.000	0.639**
<b>Oil %</b>										1.000

**Table 5.** Phenotypic correlation of seed and seedling attributes of *Calophyllum inophyllum* in South India (\*\* Significant at 1 % level; \* Significant at 5 % level)

Characters	Pod length	Pod width	Seed length	Seed width	Seed weight	Germination percent	Germination value	Peak value	MDG	Oil %
<b>Pod length</b>	1.000	0.230	0.343*	0.406*	0.325*	0.226	0.198	0.236	0.074	0.370*
<b>Pod width</b>		1.000	0.389*	0.326*	0.357*	0.048	0.065	0.165	-0.053	0.150
<b>Seed length</b>			1.000	0.438**	0.344*	0.027	0.005	0.137	-0.090	0.171
<b>Seed width</b>				1.000	0.243	0.173	0.375*	0.342*	0.229	0.195
<b>Seed wt</b>					1.000	0.164	0.210	0.296	-0.030	0.187
<b>G.percent</b>						1.000	0.552**	0.511**	0.459**	0.269
<b>G.value</b>							1.000	0.848**	0.638**	0.318*
<b>Peak value</b>								1.000	0.232	0.339*
<b>MDG</b>									1.000	0.060
<b>Oil %</b>										1.000

### 3. Results and Discussion

Data from the Table. 2 revealed that seed traits for all seed sources showed significant differences. The seeds collected from Honnavara region were longest, thickest and had higher mass as well as seed volume compared to all other seed sources. Seed length amongst various seed sources varied from 17.71 mm to 27.15 mm, seed width from 12.44 mm to 23.50 mm. Pod length and pod width varied from 25.07 mm to 39.57 mm and 22.06 mm to 34.44 mm respectively. The 100 seed weight ranged between 68.08 g to 133.30 g. These variations may be due to the fact that, this species grows over a wide range of climatic conditions as well as soil types and altitudes. Similar findings were revealed by Sudhir Kumar (2003) in *Jatropha curcas* and Vasanth Reddy *et al.* (2007) in *Pongamia pinnata*. Analysis of variance (ANOVA) revealed that the results were statistically significant for all the germination attributes (Table. 3). Overall germination per cent was on/or above the 50 per cent. Maximum germination per cent was found in Honnavara region (78.00 %), owing to higher mean daily germination (1.79), Germination value (5.11) and peak value of germination (3.06). It was followed by Nagapattinam region (68.00 %) and Pechiparai region (81.67 %) seed sources. Whereas, minimum germination per cent was recorded on Dharapuram region (64.00 %). The size and shape of seeds is variable depending on the structure and form of the ovary and environmental conditions under which plant is growing. It is evident from the result that seeds from Honnavara region was found to be superior with respect to germination percentage. This is in line with study made by Dwivedi (1993) in *Azadirachta indica* and Devagiri *et al.* (1998) in *Dalbergia sissoo*. They found that the variation observed in the seed characters may be attributed to adverse environment and differences in their distribution range this in turn affect the germination of seeds. Seedlings of Honnavara region higher oil content (64.6 %). It was followed by Nagapattinam (58.30%) and Pechiparai region (57.30 %).

#### *Genotypic correlation*

Pod length (0.853), Pod width (0.389), Seed length (0.408), seed width(0.639) Seed weight (0.373), Germination percent (2.793), Germination value (1.217),

Peak value (1.336) and Mean daily germination (0.639) showed positive significant correlation with oil content (Tables 4).

#### *Phenotypic correlation*

Pod length (0.370), Germination value (0.318), Peak value (0.339) showed positive but significant correlation with oil content. Pod width (0.150), seed length (0.171), seed width (0.195), Seed weight (0.187), Germination percent (0.269), Mean daily germination (0.060), showed positive but non-significant correlation with oil content (Tables 5 and 6).

A highly significant and positive correlation existed between Pod length (0.370), Germination value (0.318), Peak value (0.339). Significant correlation among various seed germination and seedling traits suggests that test weight may prove to be important criteria in selection of geographic seed sources for raising stock for bulk commercial plantations. This study identifies two best sources for *Calophyllum inophyllum* L based upon seed and seedling traits for those place of Honnavara and Nagergoil which were sampled. On a short term basis, breeding zones may be set up in these environmentally homogeneous areas. However, this may be preliminary as only seedling traits have been considered. Hence, seed source screening provides a great opportunity to the tree breeder to screen and capture natural variation for success of afforestation, besides providing information on the raw material for breeding and evolving improved planting stock within a seed source.

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## References

- Devagiri, GM, Dhiman, RC Thapiyal, R. C. and S Nautiyal (1998). Seed source variation in pod and seed traits of *Dalbergia sissoo*. Ann. For., 6: 148 -155.
- Dwivedi, AP (1993). National level of Neem Seed source trials at Jodhpur. Syst. Ecol. Contrib. 5(7):20-34.
- Geethanjali, K., Balasubramanian, A. and Paramathma, M., 2003, Seed technological studies in *Jatropha Curcus*. Nation. Workshop *Jatropha Other Perennial Oil Seed Species*, 5<sup>th</sup> to 8<sup>th</sup> August 2003, Bharathiya Agro-Industries Federation of India (BAIF), Pune, pp.31-33.
- George Jenne, M, Dasthgiri, Prathiban, K and Judesudhagar (2003). Variability studies in seed and seedling attributes in Mahauva (*Madhuca latifolia*). Indian For., 129 (4): 509-516.
- Sniezko, RA and HTL Stewart (1989). Range wise seed sources variation in growth and nutrition of *Acacia albida* seedlings propagated in Zimbabwe. For. Ecol. Mgmt., 27: 179 -197.
- Sudhir Kumar, 2003, Effect of seed size on germination and seedling traits of *Jatropha curcas*. Nation. Workshop *Jatropha Other Perennial Oil Seed Species*, 5<sup>th</sup> to 8<sup>th</sup> Aug. 2003, Bharathiya Agro-Industries Federation of India (BAIF), Pune, pp. 5-7.
- Vasanth Reddy, K.N., Pradeep Kumar, H., Siddraju, C.M., Rajesh P. Gunga, Madiwalar, S.L. and Patil, S.K., 2007, Seed source variation for seed and seedling traits in *Pongamia pinnata* (L.) Pierre; An important biofuel yielding tree species. My For., 43(1):61-68.
- Zobel, B and JJ Talbert (1984). Applied Forest Tree Improvement. John Wiley and Sons, New York, pp. 75 -116.