Original Research Article

Characterization of Fruit, Seed traits and Seedling growth performance of different Seed sources of *Calophylluminophyllum*

ABSTRACT

Calophylluminophyllum is an oil-bearing tree species with seeds containing 50-70 per cent oil, mainly used for non-edible purposes. Belonging to the Clusiaceae family, it is commonly known as Undi in Kannada. This littoral tropical tree grows above the high-tide mark along coastlines and is frequently found on sandy beaches. Its prominence has increased due to high demand as biofuel and commercialization. The study aimed to examine the fruit and seed traits from various sources and the impact of seed source variation on germination and seedling growth of *Calophylluminophyllum*. Experiments were conducted at the College of Forestry, Sirsi, with fruits collected from seven different regions from coastal taluks of Uttara Kannada district, Karnataka. Data on fruit, seed, and plant parameters were recorded. Results revealed that seeds from the Ramangindi region in Kumta taluk exhibited superior germination, fruit and seed traits, as well as growth vigor and biomass accumulation compared to other sources. In contrast, seeds from the Eco-Beach region were the least superior. Therefore, seeds from Ramangindi area may be used for producing quality planting material and further plantion programmes of *Calophylluminophyllum.*

Keywords: Seed source**,** *Calophylluminophyllum*, Germination percentage, Seed length, Seed width

INTRODUCTION

Calophylluminophyllum, commonly known as Alexandrian laurel or “Undi” in Kannada, belongs to the Clusiaceae family and thrives in tropical coastal regions above the high tide mark. It is predominantly found on sandy beaches across East Africa, Southern India, Malaysia and Australia (Chinthu*et al*., 2023). The tree is slow-growing, often reaching heights of 8-20 meters, with a broad, irregular crown. Its flowers are small and white, typically blooming twice a year in late spring and autumn.The seeds of *C. inophyllum* are notable for their high oil content, ranging from 50-73 (%), making the species significant for biofuel production (Ramanadane*et al.,*2007). Oil is commonly called Tamanu oil, is primarily used for medicinal purposes and cosmetics, believed to aid in tissue regeneration. The oil also serves industrial uses, including varnish production and soap manufacturing (Novod,2008).

The wood of *C. inophyllum* is highly valued for its durability and versatility. Historically, it was used by Pacific Islanders to construct canoes and more recently for furniture, railway sleepers, and plywood. It is also sought after for its ability to endure harsh environments. Additionally, the wood is utilized in boat building due to its fine texture and strength (Chinthu*et al*., 2023).The timber is slightly heavier, stronger and more durable than that of other Calophyllum species. The wood is often fine

textured and the grain is more interlocked. Sapwood is yellow-brown with a pink tinge and is well defined from the heartwood, which is red-brown, pink-brown or orange-brown. The density is 560-800 kg/cubic m at 15 (%) mc, with an energy value of about 19,100 kJ/kg.

Tannins are commonly present, especially in the bark (11.9%) but often also in the leaves. A decoction of the bark is sometimes used to toughen and dye fishing nets. The seed oil and the latex have occasionally been used in dyeing batik cloth in Java. In traditional medicine, various parts of the tree serve numerous purposes. The bark, rich in tannins, can be used as an astringent, while the leaves are utilized in treatments for eye inflammations and skin conditions. In some regions, the oil extracted from the seeds is applied to treat rheumatism and ulcers. Moreover, the latex and sap of the tree are poisonous and have been historically used to create poison arrows (Pawar and Patil, 2020).

C. inophyllum is also known for its role in environmental conservation. The tree is planted for shade and acts as an efficient coastal protector, stabilizing sandy soils. Its ornamental value makes it popular for roadside planting in India (Chinthu*et al*., 2023).

The objective of the work is to study the characteristics of fruit and seed traits of different seed sources and effect of seed source variation on germination and seedling growth attributes of *Calopylluminophyllum,* which can be found abundantly in the study area.

Materials and Methods

The present study was carried out at the College of Forestry, Sirsi, located at 14°26'N latitude, 75°50'E longitude and 619 meters above mean sea level. The area experiences an average annual rainfall of 1069 mm, predominantly between June and September, with temperatures ranging from 15°C to 35°C. Seeds were collected from various coastal locations in the Uttara Kannada district (Table 1). Ripened fruits from each source were measured for pod traits, including pod length, breadth, thickness and weight. The seeds were then extracted from the pods and evaluated for seed traits such as length, breadth, thickness and weight. Seeds from each source were sown in nursery beds and germination and seedling parameters were measured at 30 and 60 days after sowing (DAS).

Fruits from each locality were treated as separate treatments, labelled T_1 to T_7. Observations on pod and seed parameters were made before sowing the seeds in nursery beds. The experiment was designed using a Factorial Completely Randomized Design (CRD) with three replications and seven treatments. As a pre-sowing treatment, the fruits were soaked in water overnight.

Table 1. Locations of seed collection.

Treatments	Name of locality	Taluk	NL	EL
T_1	Ramangindi	Kumta	14° 21′ 40″ 13	74° 24′ 24″ 33
T_2	Apsarakonda	Honnavar	14° 23′ 50″ 65	74° 44′ 59″ 36
T_3	Dhareshwar	Honnavar	14° 38′ 28″ 22	74° 40′ 27″ 27
T_4	Kasarkod	Honnavar	14° 26′ 30″ 87	74° 43′ 15″ 22
T_5	Ankola	Ankola	14° 63′ 58″ 15	74° 28′ 52″ 23
T_6	Eco-beach	Honnavar	14° 26′ 06″ 57	74° 43′ 28″ 75
T_7	Karki	Honnavar	14° 30′ 70″ 11	74° 43′ 51″ 26

Parameters recorded

Germination Percentage:

$$\text{Germination (\%)} = \frac{\text{Number of seed germinated}}{\text{Number of seed sown}} \times 100$$

Seedling traits:

After completion of germination, observation was taken on seedling parameters. The seedling from each replication were selected in different category *i.e*. one seedling from each category. The following observations were recorded from three randomly selected sample plants in each category.

Shoot length (cm): The height of the shoot was measured from ground level to growing tip and expressed in centimetres.

Root length (cm): The root length was measured from collar region to the tip of main root and expressed in centimetres.

Number of leaves per seedling: Total number of leaves was counted from each each replication and average number of leaves per seedling was recorded.

Shoot dry weight per seedling:

The dry weight was assured by destructive sampling threeseedlings from each category were selected for every observation. The plant was uprooted from nursery bed and shoot were separated, the fresh weight was taken and average fresh weight per seedling was recorded. The samples were oven dried at 60-80^{o}C for 48 hours and shoot dry weight per seedlings were recorded in grams.

Root dry weight per seedling:

Root dry weight was assessed by destructive sampling of three seedlings from each replication. The plant was uprooted from nursery bed and roots were separated and washed thoroughly with tap water. The average fresh weight was recorded per seedling. The samples were oven dried at 60-80^{o}C for 48 hours and root dry weights per seedlings were recorded in grams.

Collar diameter:

Collar diameter was measured slightly above ground level and was expressed in mm

Seedling height:

Seedling height was measured from ground level to the tip of leaves and was expressed in cm.

Shoot to root Ratio:

$$\text{Shoot to root Ratio} = \frac{\text{Shoot length}}{\text{Root length}}$$

Seedling Biomass:

Seedling Biomass was recorded replicate wiseand average fresh weight per seedling was reported. The samples were oven dried at 60 ℃- 80 ℃ for 48 hours and dry weight was recorded per seedling in grams.

Statistical analysis: Collected data was subjected to statistical analysis and ANOVA table was constructed. Values of minimum, maximum, mean, standard deviation, standard error of mean and critical difference at 1% P were given in tabular form and detailed inference is described below.

Results and Discussion

The natural regeneration of plant species through seeds relies on seed production, germination capacity and the successful establishment of seedlings. Seeds from healthy, well-formed trees offer greater assurance that the resulting plants will exhibit good form, higher survival rates and better resistance to stress. A tree species may cover a vast geographical range and thrive in diverse environment with varying climate and topography. These populations, adapted to different local conditions, are referred to as provenances. Understanding the adaptability of a species' populations is crucial for forest restoration, especially as global warming and environmental changes disrupt natural forests (Ledig and Kitzmiller, 1992).

Provenance trials compare seeds from various climatic conditions to assess seed quality. These trials are a key step in tree species improvement, providing essential knowledge of genetic and environmental variations. Provenance trials allow for direct genetic comparisons among seed sources grown in multiple "common gardens" and help to quantify the impact of changing climates on wood production (Kitzmiller, 2005). A significant decision in forest management is selecting the appropriate seed sources for reforestation to ensure successful outcomes (Shu *et al*., 2012). This can be supported by seed zone and seed transfer guidelines, which reduce the risk of planting poorly adapted trees (Hamann *et al*., 2000). Morphological variation in seed characteristics across natural populations is valuable for tree improvement programs, as seed quality influences seedling performance, growth, and biomass allocation. Generally, germination variation among species is linked to the altitude, longitude and latitude of seed origin (Singh *et al*., 2004; Saikia *et al*., 2009).

Seed source variation on fruit and seed traits

The data depicted in the table 2 represents the effect of seed sources on fruit parameters of *Callophylluminophyllum.* Among the seven different seed sourcesAnkola (T_5) exhibited the highest fruit length of 3.13 cm, followed by Apsarakonda (3.08 cm), with Dhareshwar and Karki showing similar lengths of 3.02 cm. The shortest fruit length was observed in the Kasarkod region at 2.53 cm. In terms of fruit width, T_2 (Apsarakonda) was the highest at 2.69 cm, followed by T_7 (Karki) at 2.62 cm, and T_1 (Ramangindi) at 2.60 cm, while the lowest width was recorded at T_6 (Eco-Beach) with 2.32 cm. T_1 (Ramangindi) had the highest fruit weight at 7.57 gm, followed by T_3 (Dhareshwar) with 6.49 gm and T_2 (Apsarakonda) with 6.45 gm. The lowest fruit weight was observed in T_6 (Eco-Beach) at 4.58 gm.

Kasarkod (T_4) showed the greatest seed length at 2.12 cm, followed by Ramangindi (T_1) at 2.07 cm, Apsarakonda (T_2) at 1.99 cm, and Ankola (T_5) with the least at 1.90 cm. For seed width, Kasarkod (T_4) was superior at 1.91 cm, followed by Ramangindi (T_1) at 1.87 cm, and Karki (T_7) at 1.79 cm, with Ankola (T_5) showing the lowest width at 1.66 cm. The highest seed weight was recorded in Ramangindi (T_1) at 4.28 gm, followed by T_2 (Apsarakonda) at 4.13 gm, and T_4 (Kasarkod) at 3.89 gm, with the lowest seed weight in T_3 (Dhareshwar) at 2.68 gm (Table 3).

Seeds are unique in natural regeneration and propagation because seeds constitute unique genetic composition resulting from mixing parental genetic materials, which result in genetic variation of the offspring that enhances the ecological adaptability of species. Therefore, understanding intra and inter population variation for reproductive traits would be essential for popularization of species. This also helps in further selection and improvement of species for commercial traits to obtain higher yield. It is also reported that seed germination and seedling vigour are affected by seed size and other factors like dormancy, moisture, *etc.* the bigger sized seeds of *C.inophyllum*produces quick, uniform and maximum germination as well as vigorous seedling and higher dry biomass as compared to those of medium and small sized seeds. Genetic quality seeds are essential for production of quality seedlings in large quantities (Shreekumar and Gunaga, 2017).

Warringa*et al*. (1998) attributed the factors contributing to early development of inflorescence and partitioning of assimilates at anthesis to the variations in seed size. Schmidt (2001) had opined that the seeds exhibit variation in size but this is neither due to the less accumulation of reserve food material nor earlier abscission of seeds. Environmental influences during the development of the seeds combined with genetic variability are reported to cause variations in seed dimensions.Jijeesh and Sudhakara(2013) reported that the larger seed size gives a better germination. The higher germination of the seeds might be due to the variation in seed biochemical components which increases with seed weight.

Seed source variation on Germination and seedling attributes

The data depicted in table 4 represent the effect of seed sources on germination percentage of *Callophylluminophyllum.*At 30 DAS (Days After Sowing), there was minimal germination, as

Calophylluminophyllum typically requires 40-50 days to germinate. Ramangindi (T_1) exhibited the highest germination rate at 5.33 per cent, followed by T_3 and T_7 at 2 per cent, T_2 and T_6 at 1.33 (%), with the lowest germination rate observed in T_4 and T_5 at 0.66 (%). At 60 DAS, T_1 (Ramangindi) again demonstrated superiority with a germination rate of 48.66 per centand T_6 (Eco-Beach) with the lowest rate of 28 per cent.

Effect of seed sources on seedling parameters of *Callophylluminophyllum* is represented in table 5. Seedling parameters like root length, shoot length, shoot to root ratio, number of leaves and collar diameter were measured at 60 days after sowing (DAS) due to insufficient growth at 30 DAS, as germination had only just begun and no significant shoot or root growth was measurable. Root length was recorded from the base of the stem to the root tip, with T_1 (Ramangindi) showing the greatest length at 9.38 cm, followed by T_5 (Ankola) at 9.03 cm, T_2 (Apsarakonda) at 8.60 cm and T_6 (Eco-Beach) with the shortest root length of 7.09 cm. Shoot length was measured from the base of the stem to the tip of the shoot. The highest shoot length was observed in T_5 (Ankola) at 12.29 cm, followed by T_7 (Karki) at 12.13 cm, T_1 (Ramangindi) at 11.75 cm, and T_6 (Eco-Beach) at the lowest with 8.81 cm.

The shoot-to-root ratio, which indicates the balance between shoot and root growth. The highest shoot-to-root ratiowas observed in T_7 (Karki) at 1.63, followed by T_3 (Dhareshwar) at 1.41, T_5 (Ankola) at 1.37 and T_2 (Apsarakonda) with the lowest ratio of 1.24. The number of leaves, an indicator of plant vigor and health, was greatest in T_1 (Ramangindi) with an average of 5 leaves per plant, T_6 (Eco-Beach) with the least at 3.33 leaves.

Collar diameter was measured 3 cm above theground level using Vernier caliper, results showed that T_7 (Karki) had the largest collar diameter of 3.16 mm andsmallest diameter of 2.43 mm was found in Ankola (T_5).

The superior performance of seeds from the Ramangindi region, in terms of both germination percentage and seedling growth, likely reflects the genetic adaptations of these seeds to the specific environmental conditions of that area. The better performance in Ramangindi might be due to genetic adaptations that enhance stress resistance or optimize nutrient utilization in this region. Similarly Zerbib (2007) reported that Provenance trials often show that seed populations adapted to local conditions perform better than those from other regions, particularly in response to climatic factors such as temperature, rainfall and soil type.

Similar results were also reported 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.SimilarlyPalanikumaran*et al*.(2015) reported that he size and shape of seeds is variable depending on the structure and form of the ovary and environmental conditions under which plant is growing.

Conclusion

The seed source variation is the major factor that affects the quality and quantity of growth and vigour of *Callophylluminophyllum*. The experimental results conclude that the seeds from Ramangindi region of Kumta taluk showed the superior characteristics in germination of seed and fruit characteristics and also the growth vigour of over the seeds of other regions of Uttara Kannada district. While seeds from Eco-Beach region is the least superior among other seven regions. Among the selected regions the seed sources from Ramangindi performed better hence, seeds from these areas can be used for further plantation programmes, raising quality planting materials in large quantity for further afforestation programme of *Callophylluminophyllum.*

Table 2. Effect of seed sources on Fruit parameters of *Callophylluminophyllum*

Seed source	Fruit length(cm)	Fruit width(cm)	Fruit weight(gm)
Ramangindi (T_1)	2.94	2.60	7.57
Apsarkonda (T_2)	3.08	2.69	6.45
Dhareshwar (T_3)	3.02	2.57	6.49
Kasarkod (T_4)	2.53	2.51	5.54
Ankola (T_5)	3.13	2.46	5.99
Eco-Beach (T_6)	2.97	2.32	4.58
Karki (T_7)	3.02	2.62	5.79
C.D (0.01%)	1.01	0.81	4.98
SEm (±)	0.23	0.18	1.15

Table 3. Effect of seed sources on seed parameters of *Callophylluminophyllum*

Seed source	Seed length(cm)	Seed width(cm)	Seed weight(gm)
Ramangindi (T_1)	2.07	1.87	4.28
Apsarkonda (T_2)	1.99	1.79	4.13
Dhareshwar (T_3)	1.98	1.78	2.68
Kasarkod (T_4)	2.12	1.91	3.89
Ankola (T_5)	1.90	1.66	3.75
Eco-Beach (T_6)	1.96	1.78	3.54
Karki (T_7)	1.98	1.79	3.44
C.D (0.01%)	0.55	0.37	2.00
SEm (±)	0.12	0.08	0.46

Table 4. Effect of seed sources on germination percentage of *Callophylluminophyllum*

Seed source	30 DAS (%)	60 DAS (%)
Ramangindi (T_1)	5.33	48.66
Apsarkonda (T_2)	1.33	33.33
Dhareshwar (T_3)	2.00	37.33
Kasarkod (T_4)	0.66	28.66
Ankola (T_5)	0.66	41.33
Eco-Beach (T_6)	1.33	28
Karki (T_7)	2.00	30
C.D (0.01%)	5.92	22.62
SEm (±)	1.37	5.23

Table 5. Effect of seed sources on seedling parameters (60DAS) of *Callophylluminophyllum*

Seed source	Root length (cm)	Shoot length (cm)	Shoot to root ratio	No. of leaves	Collar diameter (mm)
Ramangindi (T_1)	9.38	11.75	1.26	5.00	2.88
Apsarkonda (T_2)	8.60	10.60	1.24	4.00	2.60
Dhareshwar (T_3)	7.20	10.10	1.41	4.33	2.72
Kasarkod (T_4)	8.19	9.74	1.26	3.67	2.57
Ankola (T_5)	9.03	12.29	1.37	4.33	2.43
Eco-Beach (T_6)	7.09	8.81	1.29	3.33	2.60
Karki (T_7)	7.69	12.13	1.63	4.00	3.16
C.D (0.01%)	3.93	5.10	0.83	2.07	0.72
SEm (±)	0.91	1.18	0.19	0.47	0.16

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