Mysore J. Agric. Sci., 58 (1) : 285-294 (2024)

Assessment of Potential Seed Sources from Karnataka for the Production of Quality Planting Stock in *Santalum album* L.

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Received : October 2023
Accepted : December 2023

ABSTRACT

This study was conducted to assess and compare the potential seed sources from different regions of Karnataka with the Marayoor seed source. Seeds were collected from seven different locations of Karnataka (S_1-Bevinahally; S_2-Doranalu; S_3-Gottipura; S_4-Gungaraghatti; S_5-Muddenahally; S_6-Narasapura; S_7-Tavarekere) and S_8-Marayoor seeds were procured from Kerala Forest Research Institute. Significant variations were observed among the seed sources for most of the assessed parameters. Marayoor seed source S_8 (68.66%) displayed the highest germination. Among the Karnataka seed sources, Gottipura seed source S_3 (51.67%) recorded the higher germination percentage indicating higher probability establishment. Seed source S_3 recorded significantly highest growth parameters compared to other Karnataka seed sources throughout the study. The leaf area, leaf area ratio, leaf weight ratio, specific leaf area and specific leaf weight, were assessed and seed source S_3 recorded higher results compared to all other Karnataka sources in the study. Apart from Marayoor source, seed source S_3 showed the highest Vigour Index (1488.35) as well as the Quality Index (0.249), indicating seedlings with greater initial vigour and overall quality. Seed source S_3 also showed the lowest Sturdiness Quotient (13.58), indicating stronger and more stable seedlings. Though B:C ratio of S_1-Bevinahally seed source was high, but its nursery performance was low. By keeping nursery performance and B:C ratio in view S_3-Gottipura seed source performed best among Karnataka seed sources. These findings can contribute to the selection of suitable seed sources for sandalwood plantation and breeding programs in Karnataka, promoting the conservation and sustainable utilization of this valuable timber species.

Keywords : Seed sources, Growth parameters, Quality index, Sturdiness quotient

SANDALWOOD (*Santalum album* L.) is one of the hemi parasitic plants in the family Santalaceae and the genus *Santalum*. It is most celebrated tree species of the tropics and is often regarded as the paragon of Indian timbers. Revered for centuries for its aromatic properties, this tree species remains a symbol of economic significance, cultural heritage, and ecological importance. The significance of this species is more pronounced in the state of Karnataka, than any other state, where sandalwood's remarkable attributes have been harnessed to create a thriving industry, particularly in the production of high-quality sandal oil. A cornerstone of successful sandalwood propagation lies within its seeds, which serve as the initial point of growth for this species. However, the journey from seed to thriving seedling is heavily influenced by the source of those seeds (Shankar and Devakumar, 2018). The provenance of the parent tree, often referred to as the seed source, plays an instrumental role in shaping the attributes of subsequent generations. From germination rates to seedling vigor and growth patterns, the choice of seed source profoundly affects the trajectory of sandalwood cultivation & the broader goals of forest regeneration.

The characteristics of the seed source, encompassing its genetic makeup, adaptability to diverse environments and overall seed quality, have a cascading impact on the performance of germination and seedling growth. This nexus between genetic potential and environmental adaptation constitutes a linchpin in the broader strategy of successful sandalwood cultivation and the sustainable rejuvenation of forest ecosystem (Ananthapadmanabha, 2012). While Karnataka is having more area under sandalwood cultivation, a seed source for plantation establishment hails from the Marayoor region in Kerala. The Marayoor seed source has gained prominence due to its exceptional qualities, including rapid growth, high yields and favorable oil content (Rao *et al.,* 2007). This study assumes a significant mantle in the continuum of sandalwood conservation and cultivation. By subjecting various sandalwood seed sources from distinct regions within Karnataka to meticulous evaluation, it seeks to elucidate their performance vis-a-vis the benchmark Marayoor seed source. By evaluating germination rates, seedling growth patterns and the holistic quality of the resulting plants, this study aims to uncover novel insights into seed source viability and its intricate interplay with sandalwood propagation.

Material and Methods

Seeds were collected from seven different locations of Karnataka during October-November 2021 (Table 1) and Marayoor seeds were procured from Kerala Forest Seed Centre a division of Kerala Forest Research Institute. After collection, fresh fruit weight was measured and fruits were soaked in water for depulping. Depulped seeds were shade dried and pretreated with 1000 ppm GA_3 for 24 hours. The evaluation was conducted in a nursery setting to provide controlled environmental conditions and eliminate potential variations due to site-specific factors. Standard nursery bed of 10m×1m was prepared and 100 pretreated seeds per replication were sowed. Nursery beds were watered regularly until the germination was completed.

Daily germination counts were recorded until germination was completed. The percentage, mean daily germination (MDG), the peak value of germination (PV) was calculated. The germination value (GV), an index combining speed and completeness of germination was calculated using the formula suggested by Czabator (1962): GV = Final Mean daily germination (MDG) x Peak Value of germination. The mean daily germination is calculated as the cumulative per cent of full seed germination at

Table 1

Geographical information of seed sources

Location	Range	Latititude	Longitude	Altitude (m)	Ann. rainfall (mm)	Avg. Temp.(^{0}C)	Soil types
S_1-Bevinahally	Tondebhavi	13.505598 N	77.486271 E	755	747	28	Clay loam
S_2-Doranalu	Tarikere	13.679082 N	75.834471 E	680	914	24	Red sandy loam,
S_3-Gottipura	Hoskote	13.0997540 N	77.8449375 E	875	857	25	*Red loamy and lateritic soil*
S_4-Gungaraghatti	Dharwad	15.5271742 N	74.9437982 E	720	786	28	Well drained loamy sand over gravel
S_5-Muddenahally	Chikkaballapur	13.403345 N	77.690987 E	993	808	28	Red loamy
S_6-Narsapura	Kushtagi	15.625631 N	76.154781 E	639	172	31	Black clayey soil
S_7-Tavarekere	Sira	13.797152 N	76.804344 E	802	638	28	Clalyey soil
S_8-Marayoor	Idukki	10.16345 N	77.24580 E	989	983	98	Red Loam & Lateritic soil

the end of germination test, divided by the number of days from sowing to the end of the test. Peak Value of germination denotes the speed of germination, which is the maximum mean daily germination, recorded at any time during the period of test. Along with germination parameters electrical conductivity and biochemical assay of seeds was done. To measure the electrical conductivity, the leachate after soaking was filtered. Five ml of the leachate was diluted to final volume of 25 ml with distilled water and the electrical conductivity was determined using a conductivity meter. The total carbohydrate content of seeds was estimated following the Anthrone reagent method (Yemm and Wills, 1954), protein by Lowry's method (Lowry *et al.,* 1951) and crude fat content by Soxhlet extraction (Kenned and Unrau, 1949).

After Biochemical assay seeds were sown in nursery bed. The emerged seedlings were then transplanted to polythene bags filled with the medium Soil: Sand: Farm Yard Manure in a ratio of 2:1:1 and kept in the shade house. The growth and biomass attributes were recorded upto 180 DAT (Days after Transplanting). Seedling growth attributes *viz.,* seedling height (shoot length + root length), collar diameter, number of leaves, root: shoot ratio, biomass production and the leaf parameters like Leaf area, LAR (Leaf Area Ratio), LWR (Leaf Weight Ratio), SLA (Specific Leaf Area) and SLW (Specific Leaf Weight) was computed for the period from 30 to 180 days. At the end of the experiment vigour index and quality parameters like seedling quality index, sturdiness quotient and bio volume index were recorded. Vigour index was calculated using the formula (Abdul Baki,1973).

Vigour index = Germination percentage x Total dry weight

The seedling quality index was calculated as (Dickson *et al.,* 1960).

$$\text{Quality index} = \frac{\text{Total dry weight of seedlings (g)}}{\dfrac{\text{Height of seedlings (cm)}}{\text{Diameter of seedlings (mm)}} + \dfrac{\text{Shoot dry weight (g)}}{\text{Root dry weight (g)}}}$$

The sturdiness quotient was calculated as per the formula given below (Ritchie, 1985) :

$$\text{Sturdiness Quotient} = \frac{\text{Height of seedlings (cm)}}{\text{Collar diameter of seedlings (mm)}}$$

Bio Volume index (BVI) was arrived by using the formula (Hatchel, 1985 and Manavalan, 1990)

B.V. I. = [Collar diameter (Cm) ^{2} x Height (cm)]

All the statistical analyses were conducted in Agricolae and ICAR Goa WASP 2.0 software.

Results and Discussion

The present study aimed to identify potential seed sources from Karnataka for the production of high-quality planting stock of *Santalum album* L. The results revealed significant variations among the seed sources for almost all the assessed parameters. Table 2 shows the results of the influence of seed source on various initial seed quality parameters in *Santalum album* L. Significant differences were found in 100 Fruit weight, ranging from 60.54 g (S_5) to 68.51 g (S_3). However, no significant differences were observed in 100 Seed weight, Seed length and Seed width, indicating similarity in physical quality parameters across different seed sources. The variation in fruit weight could be related to the method of seed dispersal. Plants have evolved various strategies for dispersing their seeds, such as wind dispersal, animal dispersal, or water dispersal. The weight of the fruit may be optimized to enhance the efficiency of these dispersal mechanisms (Rakesh, 2012). The Fig.1

Table 2

Influence of seed source on initial seed quality parameters in *Santalum album* (L.)

Seed Sources	100 Fruit weight (g)	100 Seed weight (g)	Seed length (mm)	Seed width (mm)
S1- Bevinahally	68.47	17.07	7.50	6.64
S2- Doranalu	65.58	16.83	7.64	6.55
S3- Gottipura	68.51	17.10	7.45	6.46
S4-Gungaraghatti	67.08	17.97	7.37	6.46
S5-Muddenahally	60.54	16.58	7.44	6.28
S6 – Narasapura	61.40	17.90	7.48	6.44
S7 – Tavarekere	61.96	16.92	7.72	6.46
S8 - Marayoor	-	17.89	7.65	6.57
SEm±	0.97	0.34	0.13	0.09
C.D. (p=0.05)	2.94	NS	NS	NS
C.V. (%)	2.58	3.45	3.06	2.44

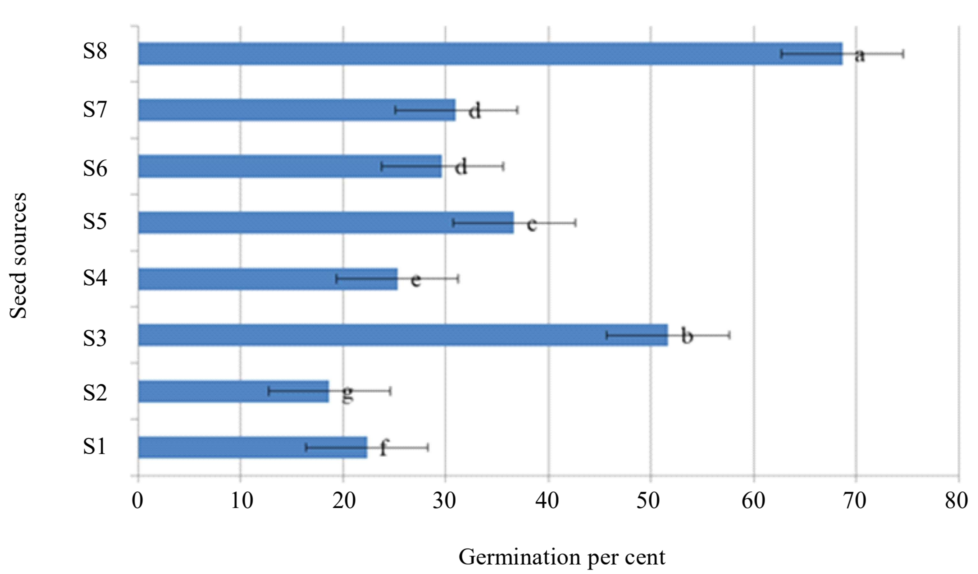

Fig. 1 : Influence of seed sources on the germination percentage of *Santalum album* (L.)

shows the influence of seed sources on germination percentages of *Santalum album* L. The germination percentage varied among the seed sources, ranging from 18.67 per cent (S_2) to 68.66 per cent (S_8). Seed source S_8 displayed the highest germination percentage (68.66%) followed by seed source S_3. This indicates that seeds from this source have a higher probability of successful germination and early establishment when compared to other sources. On the other hand, seed sources S_2 and S_1 showed relatively lower germination percentages of 18.67 per cent and 22.33 per cent, respectively. These sources might have seeds with lower viability; potentially due to factors such as poor seed quality or storage conditions. The low germination percentages from these sources warrant caution when considering them for planting or reforestation projects, as they may result in lower plant establishment success (Jagadish *et al.*, 2008). Table 3 presents the results of the influence of seed source on germination attributes of *Santalum album*. The germination attributes measured include Time Taken to Initiate

TABLE 3

Influence of seed source on germination attributes of *Santalum album* (L.)

Seed Sources	TTIG	TTCG	MDG	PV	GV
S1 - Bevinahally	23.00	81.33	0.28	0.39	0.11
S2 - Doranalu	31.00	86.33	0.22	0.25	0.05
S3 - Gottipura	19.33	57.67	0.90	1.05	0.94
S4 - Gungaraghatti	20.67	69.33	0.37	0.40	0.14
S5 - Muddenahally	21.33	63.67	0.58	0.58	0.33
S6 - Narasapura	24.00	61.00	0.49	0.40	0.20
S7 - Tavarekere	20.00	62.67	0.49	0.53	0.26
S8 - Marayoor	16.67	51.67	1.33	1.86	2.47
S.Em ±	0.77	0.99	0.02	0.03	0.04
C.D. (p = 0.05)	2.34	2.98	0.07	0.09	0.11
C.V. (%)	6.08	2.56	6.46	7.82	1.17

Germination (TTIG), Time Taken to Complete Germination (TTCG), Mean Daily Germination (MDG), Peak Value of Germination (PV) and Germination Value (GV). Germination attributes in sandal varied among seed sources. Marayoor (S_8) showed early germination (TTIG = 20.67 days) followed by Gottipura (S_3). Mean Daily Germination was highest in (Marayoor S_8) 1.33 and lowest in (Bevinahally S_2) 0.22. Peak Value of Germination was highest in (Marayoor S_8) 1.86 and lowest in Doranalu (0.22). Germination Value was highest in Marayoor (S_8) (GV = 2.47) and lowest in Doranalu (S_2) (GV = 0.05). Significant differences were observed among the seed sources for all germination attributes.

Variations in electrical conductivity and biochemical composition among different sandal seed sources are presented in Table 4. Negative correlation was observed between EC and germination percentage (Fig. 2). Electrical conductivity ranged from 0.50 dS cm^{-1} (S_8) to 0.88 dS cm^{-1} (S_2), indicating differences in the cell membrane system degradation. Total carbohydrates varied from 1.01 mg g^{-1} (S_2) to 1.63

TABLE 4

Changes in the electrical conductivity and biochemical composition of sandal seeds with respect to different seed sources

Seed Sources	Seed Sources	Electrical conductivity (dS cm^{-1})	Total carbohydrate (mg g^{-1})	Total protein (mg g^{-1})	Crude fat (%)
S1- Bevinahally	S_1	0.83	1.03	0.041	44.53
S2- Doranalu	S_2	0.88	1.01	0.042	43.89
S3- Gottipura	S_3	0.52	1.61	0.073	51.14
S4-Gungaraghatti	S_4	0.80	1.23	0.048	44.95
S5-Muddenahally	S_5	0.68	1.42	0.051	48.21
S6 – Narasapura	S_6	0.73	1.23	0.049	45.02
S7 – Tavarekere	S_7	0.71	1.35	0.051	45.19
S8 - Marayoor	S_8	0.50	1.63	0.074	53.22
SEm±	SEm±	0.01	0.01	0.001	0.23
C.D. (p=0.05)	CD (p=0.05)	0.02	0.02	0.003	0.69
C.V. (%)	CV (%)	1.95	1.05	2.953	0.84

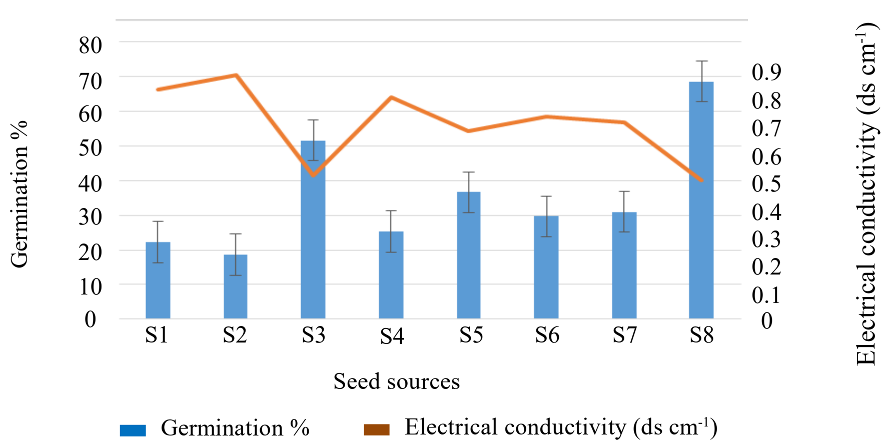

Fig. 2 : Relationship between germination percentage and electrical conductivity of sandal in different seed sources

mg g^{-1} (S_8), Total protein from 0.041 mg g^{-1} (S_1) to 0.074 mg g^{-1} (S_8), and Crude fat from 43.89 per cent (S_2) to 53.22 per cent (S_8). Gottipura seed source (S_3) recorded the highest crude fat (51.14%), followed by Muddenahally (S_5). Significant differences were observed among the treatments for all parameters. Seeds with lower EC values (S_8) typically exhibit better cell membrane integrity, indicating lower leakage of ions and solutes. This could result from factors like optimal seed maturity at harvest, efficient seed hydration and reduced exposure to stressors such as high temperatures or pathogenic infections as reported by Jijeesh *et al.* (2022). The variations in total carbohydrate, total protein and crude fat content among different seed sources are indicative of genetic diversity and metabolic differences. Genetic variability can influence the synthesis and accumulation of biochemical compounds within the seeds (Polaiah *et al.,* 2020 and Mohapatra & Anil, 2022).

Comprehensive analysis of growth parameters across various seed sources (S_1 to S_8) is shown in Table 5. The study evaluates height, collar diameter, number of leaves, total dry weight and root-to-shoot ratio as indicators of growth performance. The results reveal significant variations among the seed sources, highlighting the potential influence of genetic traits and environmental factors. Notably, S_3 and S_8 exhibit superior height, with 28.82 cm and 29.92 cm respectively, while S_2 demonstrates the shortest height at 19.92 cm. Collar diameter variation ranges from 1.153 mm (S_2) to 2.730 mm (S_8). Source S_3 boasts the highest leaf count (25.05), while S_2 displays the fewest (18.08). These findings underscore the favorable growth attributes of the Gottipura (S_3) and Marayoor sources. Moreover, S_8 demonstrates the highest total dry weight (0.826 gm) and root-to-shoot ratio (0.77), reflecting significant biomass production and root system dominance. Genetic diversity and environmental influences are proposed as contributors to shoot length disparities (Xiaojin *et al.,* 2011). S_3 consistently excels, potentially due to advantageous genetic traits, whereas S_1, S_2 and S_6 show slightly diminished shoot growth, likely due to specific genetic traits or environmental adaptations.

Table 6 examines the influence of diverse seed sources on leaf parameters of *Santalum album* L. seedlings over a 180-day period post-transplantation (DAT). Leaf area, leaf area ratio (LAR), leaf weight ratio (LWR), specific leaf area (SLA) and specific

TABLE 5

Comparative analysis of seed source on the growth attributes of *Santalum album* L. seedlings up to180 days after transplanting

Seed Sources	Seed Sources	Height (cm)	Collar diameter (mm)	No. of leaves	Total dry weight(g)	Root : Shoot
S1- Bevinahally	S_1	21.62	1.337	20.04	0.325	0.71
S2- Doranalu	S_2	19.92	1.153	18.08	0.276	0.71
S3- Gottipura	S_3	28.82	2.523	25.05	0.769	0.74
S4-Gungaraghatti	S_4	22.92	1.520	19.41	0.337	0.72
S5-Muddenahally	S_5	24.78	1.630	21.72	0.354	0.58
S6 – Narasapura	S_6	21.41	1.260	19.98	0.361	0.68
S7 – Tavarekere	S_7	22.29	1.427	19.04	0.353	0.65
S8 - Marayoor	S_8	29.92	2.730	24.33	0.826	0.77
SEm±	SEm±	0.33	0.020	0.22	0.006	0.02
C.D. (p=0.05)	CD (p=0.05)	0.99	0.062	0.65	0.019	0.05
C.V. (%)	CV (%)	2.37	2.426	1.77	2.408	4.16

TABLE 6

Influence of different seed sources on leaf parameters of *Santalum album* L. seedlings up to 180 DAT

Seed Sources	Leaf Parameters									
	Leaf area cm^2		LAR $cm^2 g^1$		LWR $g kg^{-1}$		SLA $cm^2 mg^{-1}$		SLW $g cm^{-2}$	
	30 DAT	180 DAT	30 DAT	180 DAT	30 DAT	180 DAT	30 DAT	180 DAT	30 DAT	180 DAT
S_1	7.09	8.49	39.47	26.13	0.30	0.28	132.28	92.98	0.008	0.011
S_2	6.35	7.69	43.54	27.92	0.29	0.30	152.22	93.81	0.007	0.011
S_3	10.08	12.93	20.62	16.83	0.56	0.57	36.80	29.79	0.027	0.034
S_4	7.09	8.04	37.57	23.85	0.33	0.30	114.92	80.71	0.009	0.012
S_5	7.58	9.06	35.95	25.65	0.34	0.32	105.83	81.77	0.009	0.012
S_6	8.03	8.84	42.81	24.50	0.33	0.26	130.29	95.35	0.008	0.010
S_7	8.08	9.72	38.25	27.55	0.33	0.28	115.44	99.04	0.009	0.010
S_8	10.11	12.40	20.90	15.02	0.55	0.58	38.19	26.08	0.026	0.038
SEm±	0.10	0.16	0.76	0.44	0.02	0.01	1.89	1.97	0.000	0.001
CD (p=0.05)	0.29	0.48	2.31	1.32	0.04	0.02	5.70	5.95	0.001	0.002
CV (%)	2.09	2.88	3.79	3.24	6.73	3.89	3.16	4.55	3.804	6.083

leaf weight (SLW) were assessed at 30 DAT and 180 DAT to track parameter changes over time. Notable variations in leaf parameters were observed among the treatments, implying genetic, physiological and environmental influences. Seed source S_3 demonstrated the highest leaf area at both time points (10.08 cm^2 and 12.93 cm^2 at 30 DAT and 180 DAT, respectively), while S_2 displayed the smallest leaf area initially (6.35 cm^2). LAR highlighted resource utilization efficiencies with S_2 having the highest LAR (43.54 $cm^2 g^{-1}$ and 27.92 $cm^2 g^{-1}$ at 30 DAT and 180 DAT, respectively) and S_3 having the lowest at both times. LWR indicated allocation strategies, where S_8 invested most in leaf biomass (0.58 g kg^{-1} and 0.55 g kg^{-1} at 30 DAT and 180 DAT, respectively) and S_3 allocated the least. SLA demonstrated leaf thickness and density variations with S_3 having the highest values (36.80 $cm^2 mg^{-1}$ and 29.79 $cm^2 mg^{-1}$ at 30 DAT and 180 DAT, respectively) and S_8 displaying the lowest. Source S_8 exhibited the highest SLW (0.038 g cm^{-2} and 0.026 g cm^{-2} at 30 DAT and 180 DAT, respectively). The dynamic interplay of genetic traits, physiological adaptations and environmental factors contributed to the observed leaf parameter variations among seed sources, ultimately influencing cultivation and breeding decisions (Rocha *et al.,* 2014).

Insights into the ramifications of distinct seed sources on the vigour index (VI), vigour index II (VI II), Dickson quality index (DQI), sturdiness quotient (SQ), and bio volume index (BVI) of Sandal seedlings are discussed in Table 7. A strong relationship was observed between vigour index and germination percentage (Fig. 3). The highest VI value (1488.35) was recorded by seed source S_3, indicating robust initial vigour, while the lowest (372.66) pertains to S_2, signifying limited vigour. Sources S_3 and S_8 consistently exhibit elevated vigour across parameters. The highest VI II value (24.07) emerges from S_8, contrasting with the lowest (3.63) from S_2. Marayoor source S_8 showed highest DQI value (0.258), showcasing superior overall seedling quality, while S_1 scores the lowest (0.084), denoting diminished quality. S_3 and S_8 maintain significantly higher quality than other sources. In sturdiness assessment, S_1 reports the highest SQ value (19.03), suggesting fragility, while S_3 records the lowest (13.58), implying robustness. Noteworthy SQ differences prevail with S_3 and S_8 presenting lowered sturdiness relative to S_1. Exploring growth, S_8 commands the highest BVI value

TABLE 7

Influence of different seed sources on Vigour index and quality parameters of *Santalum album* L. seedlings

Seed Sources	Seed Sources	VI I(Vigour Index)	VI II(Vigour Index)	DQI(Dickson Quality Index)	SQ (Sturdiness quotient)	BVI (Bio Volume Index)
S1 - Bevinahally	S_1	483.03	5.22	0.084	19.03	0.279
S2 - Doranalu	S_2	372.66	3.63	0.086	17.28	0.266
S3 - Gottipura	S_3	1488.35	17.26	0.249	13.58	1.300
S4 - Gungaraghatti	S_4	580.31	6.02	0.101	17.36	0.400
S5 - Muddenahally	S_5	908.98	8.89	0.096	18.63	0.439
S6 - Narasapura	S_6	635.04	7.95	0.091	16.99	0.340
S7 - Tavarekere	S_7	690.74	7.88	0.095	18.17	0.336
S8 - Marayoor	S_8	2054.49	24.07	0.258	14.05	1.358
SEm±	SEm±	25.85	0.59	0.002	0.21	0.023
C.D. (p=0.05)	CD (p=0.05)	78.17	1.80	0.007	0.63	0.068
C.V. (%)	CV (%)	4.97	10.17	2.990	2.13	6.644

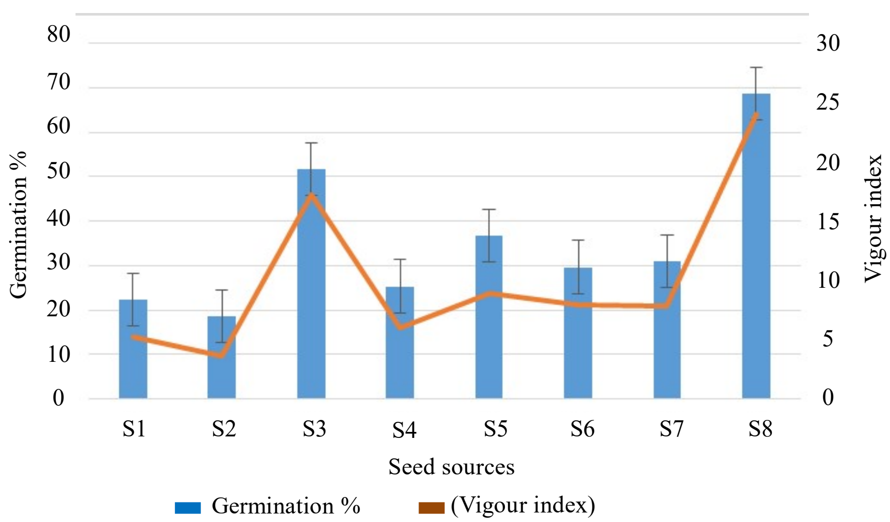

Fig. 3 : Relationship between germination percentage and vigour index of sandal in different seed sources

(1.358), reflecting extensive volume and growth, as S_2 exhibits the lowest (0.266), symbolizing limited expansion. BVI distinctions are pronounced, notably for S_3, S_4, S_5 and S_8. These findings collectively highlight the pivotal role of seed sources in shaping vigour, quality, sturdiness and growth attributes of *Santalum album* seedlings.The variations in vigour and quality parameters might reflect differences in physiological responses to stress, light availability, and water availability among seed sources. Some sources might have physiological mechanisms that confer better stress tolerance and growth under specific conditions (Baiyeri and Mbah, 2006). The process of selecting parent plants for seed production can greatly influence seedling quality. Seed sources that are chosen based on desired traits, such as vigour and quality, are likely to yield seedlings with corresponding attributes. Seed source S_8 producing

TABLE 8

Benefit-cost ratio of sandal seedlings raised from different seed sources up to 180 days in nursery

Inputs and Outputs	Seed Sources							
	S1	S2	S3	S4	S5	S6	S7	S8
Total sum of production costs per seedling (Rs.)	19.10	21.21	19.98	23.11	19.81	23.76	19.99	33.45
Total sum of receipts per seedling (Rs.)	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
B:C ratio	1.83	1.66	1.75	1.51	1.77	1.47	1.75	1.05

seedlings with high vigour and quality values might be the result of careful selection and breeding for these traits. Differences in environmental conditions where the parent plants were grown and where the seeds were collected can impact seedling vigour and quality. Variations in climate, soil type, and other local factors can affect seedling performance. Seed sources adapted to specific environmental conditions may exhibit higher vigour under similar conditions. The selection of seed sources, exemplified by S_3 and S_8, bears substantial implications for the success and productivity of sandalwood plantations.

The analysis of the benefit-cost ratio for sandalwood seedlings raised from different seed sources, encompassing a growth period of 180 days in the nursery, reveals distinct levels of economic viability (Table 8). Among the analyzed seed sources, S_1-Bevinahally with a B:C ratio of 1.83, suggesting a promising financial return of 1.83 rupees for every one rupee invested in seedling production. Similarly, S_3-Gottipura and S_5-Muddenahally also exhibit strong economic viability with B:C ratios of 1.75 and 1.77 respectively, emphasizing the potential for profitable returns. But S_8 presents a B:C ratio of 1.05, indicating a marginal return on investment, urging a closer examination to optimize the economic feasibility of seedling production. By comparing B:C ratio with germination performance, seedling characters and quality indices of seed sources (S_2-Gottipura) seed source proved to be potential enough to use as seed source for future plantation activities.

The findings of the study provides valuable insights for selecting suitable seed sources for enhancing the production of superior planting stock of *Santalum album* in Karnataka, thus contributing to the conservation and sustainable utilization of this valuable timber species. The implications of these results and their potential applications for sandalwood plantation management and genetic improvement programs are of paramount importance. This study emphasizes the importance of informed seed source selection for successful sandalwood plantation establishment, promoting higher yields and overall productivity.

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