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M Vignesh
M.Sc. Scholar, Department of Silviculture and NRM, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

M Sivaprakash
Assistant Professor, Department of Silviculture and NRM, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

A Balasubramanian
Professor, Department of Silviculture and NRM, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

M Tilak
Assistant Professor, Department of Agroforestry, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

S Radhakrishnan
Professor, Department of Silviculture and NRM, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

CN Hari Prasath
Teaching Assistant, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

KS Anjali
Ph.D., Scholar, Department of Silviculture and NRM, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

S Navaneetha Krishnan
M.Sc. Scholar, Department of Silviculture and NRM, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

Corresponding Author:
M Vignesh
M.Sc. Scholar, Department of Silviculture and NRM, Forest College and Research Institute, TNAU, Mettupalayam, Tamil Nadu, India

Effect of spacing on the growth of sandalwood (*Santalum album* L.) trees under farm conditions in Tamil Nadu, India

M Vignesh, M Sivaprakash, A Balasubramanian, M Tilak, S Radhakrishnan, CN Hari Prasath, KS Anjali and S Navaneetha Krishnan

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Abstract
This study compared the performance of *Santalum album* L. planted at five spacing treatments (2.4 X 2.4 m, 3.0 X 3.0 m, 3.6 X 3.6 m, 4.6 X 4.6 m, and 5.5 X 5.5 m) under farm condition in Tamil Nadu, India and assessed the impact of these planting densities on growth and volume of wood production. In order to determine their response, the biometric attributes of sandal such as height (m), diameter at breast height (m) and volume (m^3) of trees were measured. To assess the periodical growth variation, biometrics were studied at the level of three age classes (0-5 years, 5-10 years and 10-15 years) and biometrics were compared among the age classes. The results revealed that the spacing treatments of 3.0 X 3.0 m and 3.6 X 3.6 m were found better for planting of *Santalum album* with more growth biometrics and maximum volume of wood followed by 4.6 X 4.6 m, 5.5 X 5.5 m and 2.4 X 2.4 m spacing. Based on the study results, 3.0 X 3.0 m and 3.6 X 3.6 m spacing can be recommended as suitable spacing for cultivating sandal on farmlands.

Keywords: Age class, growth, sandalwood, spacing, Tamil Nadu, volume

1. Introduction
East Indian sandalwood (*Santalum album* L.) is one of the pioneer tree species indigenous to peninsular India (Shukla *et al*., 2016) [1], well known for its aromatic heartwood and pleasant oil around the world. It is also known as the “Dollar earning parasite", which belongs to the family Santalaceae. Thus, highly-priced heartwood and oil fetch higher income to the farming community. It is widely used for cultural, ritual, pharmaceutical and perfumery purposes. Sandal distributed all over India with 9,600 sq. km (Gairola *et al*., 2008) [2], however 90% concentrated natural population found in the southern part of India, particularly in Karnataka (5245 km^2) and Tamil Nadu (3045 km^2) (Chittapur, 2021) [3].
Having huge global annual demand of 5000-6000 MT (metric tonne) for heartwood and 100–120 MT for sandal heartwood oil (Subasinghe, 2013) [4] sandal cultivation has great scope in near future. In Tamil Nadu, due to supporting legal provisions now sandal can be cultivated under private lands. At present, 20,725 ha of sandal plantations were recorded under farm conditions in India, most of the plantations occur in southern states particularly Karnataka, Tamil Nadu and Kerala (Viswanath & Chakraborty, 2022) [5]. Increasingly growers show interest to cultivate sandal in their farmlands (Kukreti & Rawat, 2021) [6], thus the lack of proper recommendation of spacing may mislead sandal farmers to miss their assured productivity. With this background, the present study intended to assess the growth performance of sandal tree under different spacing treatments under field conditions.

2. Materials and Methods
The present study was carried out in sandal plantations grown under farm conditions in Tamil Nadu, India. Mainly to quantify the growth of *S. album* under five different spacing regimes at three different age classes. For this study, an extensive survey was conducted across Tamil Nadu and 18 sandal plantations were selected as experimental sites. Sandal plantations were grouped into spacing treatments under respective age classes (0-5, 5-10 and 10-15 years). This experiment was laid out in Randomized Block Design (RBD) with five spacing treatments (2.4 X 2.4 m, 3.0 X 3.0 m, 3.6 X 3.6 m, 4.6 X 4.6 m, and 5.5 X 5.5 m) and four replications each, these were observed with respective three age classes.

2.1 Collection of data

The growth biometrics of tree height, diameter at breast height (DBH) were measured by using Distance laser meter (Leica DISTO^{TM} D810), and then volume of standing tree was calculated by using the following Chaturvedi & Khanna (1982) (Formula 1).

$$\text{Volume of tree } (m^3) = \pi r^2 h \quad (1)$$

Where (r) radius, and (h) height of the tree.

2.2 Statistical analysis

The experimental databases collected were statistically analysed under Randomised Block design. Whereas the treatment results were significant, the critical differences were worked out at five per cent probability level ($p< 0.05$) (Gupta, 2002) [7].

3. Results and Discussion

3.1 Growth performance of *Santalum album* at the age class of 0 to 5 years

The result revealed that at the age class of 0 to 5 years sandal with the maximum height (4.62 m) and DBH (Diameter at breast height) (0.07 m) was recorded under wider spacing (5.5 X 5.5 m) and the maximum tree volume (0.017 m^3/tree) was registered under 3.6 X 3.6 m spacing (Table 1). While considering total volume per hectare (m^3/ha) the maximum total volume of 12.98 m^3/ha was observed under 3.6 X 3.6 m spacing followed by the spacing of 3.0 X 3.0 m (12.56 m^3/ha), 2.4 X 2.4 m (9.39 m^3/ha), 5.5 X 5.5 m (8.41 m^3/ha) and 4.6 X 4.6 m (6.78 m^3/ha).

Table 1: Influence of spacing on growth biometry of *Santalum album* at age class of 0 to 5 years under farmlands.

Spacing (m)	Height (m)	DBH (m)	Tree volume (m^3/tree)	Total volume (m^3/ha)
2.4 X 2.4	3.56	0.044	0.005	9.392
3.0 X 3.0	3.87	0.061	0.011	12.559
3.6 X 3.6	4.50	0.069	0.017	12.984
4.6 X 4.6	4.46	0.064	0.014	6.783
5.5 X 5.5	4.62	0.070	0.018	8.406
Mean	4.20	0.062	0.013	10.025
S.Ed	0.0413	0.0009	0.0004	0.2396
CD (0.05)	0.0908	0.0021	0.0010	0.5272

3.2 Growth performance of *Santalum album* at age class of 5 to 10 years

Based on the results the maximum height (5.07 m) and maximum tree volume (0.061 m^3/tree) were observed under 3.6 X 3.6 m spacing and the maximum DBH (0.128 m) was registered under wider spacing (5.5 X 5.5m) (Table 2). While considering total volume per hectare (m^3/ha) the maximum volume of 47.24 m^3/ha was recorded under 3.6 X 3.6 m spacing followed by the spacing of 3.0 X 3.0 m (41.97 m^3/ha), 2.4 X 2.4 m (34.21 m^3/ha), 5.5 X 5.5 m (28.23 m^3/ha) and 4.6 X 4.6 m (23.69 m^3/ha) of *S. album* under farmlands.

Table 2: Influence of spacing on growth biometry of *Santalum album* at age class of 5 to 10 years under farmlands.

Spacing (m)	Height (m)	DBH (m)	Tree volume (m^3/tree)	Total volume (m^3/ha)
2.4 X 2.4	4.98	0.071	0.020	34.211
3.0 X 3.0	4.63	0.102	0.038	41.966
3.6 X 3.6	5.07	0.124	0.061	47.243
4.6 X 4.6	4.43	0.120	0.050	23.686
5.5 X 5.5	4.64	0.128	0.060	28.227
Mean	4.749	0.109	0.046	35.067
S.Ed	0.0239	0.0021	0.0015	0.8636
CD (0.05)	0.0526	0.0046	0.0034	1.8999

3.3 Growth performance of *Santalum album* at the age class of 10 to 15 years

The result revealed that at the age class of 10 to 15 years *S. album* with the maximum height (7.51 m) was recorded under closer spacing (2.4 X 2.4 m), the maximum DBH (0.168 m) was observed under wider spacing (5.5 X 5.5 m) and the maximum tree volume (0.145 m^3/tree) was registered under 3.6 X 3.6 m spacing (Table 3). While considering total volume per hectare (m^3/ha) the maximum volume of 111.88 m^3/ha was recorded under 3.6 X 3.6 m spacing followed by the spacing of 3.0 X 3.0 m (100.31 m^3/ha), 2.4 X 2.4 m (94.32 m^3/ha), 5.5 X 5.5 m (72.05 m^3/ha) and 4.6 X 4.6 m (54.81 m^3/ha).

Table 3: Influence of spacing on growth biometry of *Santalum album* at age class of 10 to 15 years under farmlands.

Spacing (m)	Height (m)	DBH (m)	Tree volume (m^3/tree)	Total volume (m^3/ha)
2.4 X 2.4	7.51	0.096	0.054	94.320
3.0 X 3.0	7.48	0.124	0.090	100.306
3.6 X 3.6	7.49	0.157	0.145	111.884
4.6 X 4.6	6.93	0.146	0.116	54.810
5.5 X 5.5	6.88	0.168	0.152	72.048
Mean	7.256	0.138	0.112	86.674
S.Ed	0.0291	0.0026	0.0036	2.0538
CD (0.05)	0.0641	0.0056	0.0079	4.5184

The results revealed that the growth biometrics varied significantly in all five spacing regimes. With respect to age class, 10-15 years showed the highest growth biometrics (height, DBH & volume) (Table 3). While in the spacing regime, 3.6 X 3.6 m spacing showed the maximum total volume of 111.884 m^3/ha followed by 3.0 X 3.0 m spacing (100.31 m^3/ha). The interaction between age and spacing is also significant ($p< 0.05$). Among the interaction between age class and spacing, the age class of 10-15 years at 3.6 X 3.6 m and 3.0 X 3.0 m spacing represented the highest growth biometrics and a maximum total volume.

These results indicated that spacing strongly influences the growth of the sandal tree particularly DBH. As mentioned by Nissen *et al.* (2001) [7] growth of a tree is the function of age, site quality and spacing. Spacing is considered to be an important silvicultural tool used to maximize productivity.

Cultivating sandal trees needs more care because of their partial root parasitism and competition amongst trees for above and below-ground resources. Due to this accommodating both host and parasite is a little trickier task (Chittapur, 2021) [3] and spacing also decides the utilization of existing light, moisture and nutrients (Khan & Chaudhry, 2007) [8].

The result revealed that at earlier stage, the tree height, DBH and volume of *S. album* were gradually increased from 3.0 X 3.0 m towards 5.5 X 5.5 m spacing (Table 1). Supporting the present study, a similar increment in the plant height and DBH of *Ailanthus excelsa* at different spacing under field conditions were observed by Deswal *et al.*, 2021 [9]. With respect to tree height, it invariably varies among the spacing treatments without any regular pattern the same was recorded by Faiz *et al.*, 1999 [10], Bisaria *et al.*, 1999 [11] and Khan & Chaudhry, 2007 [8]. The rate of increase in tree height is not affected by its spacing. Diameter at breast height showed the most significant values among the spacing treatments, indicated that DBH increasing with increasing spacing distance. These results are in line with the findings of Chaturvedi, 1992 [12], Bisaria *et al.*, 1999 [11] and Khan & Chaudhry, 2007 [8]. The total volume of wood was maximum at 3.6 X 3.6 m spacing (111.88 m^3/ha) followed by 3.0 X 3.0 m, 2.4 X 2.4 m, 5.5 X 5.5 m and 4.6 X 4.6 m spacing at age class of 10 to 15 years (Fig. 1). These results are in line with Singh *et al.*, 1997 [13] and Khan & Chaudhry, 2007 [8].

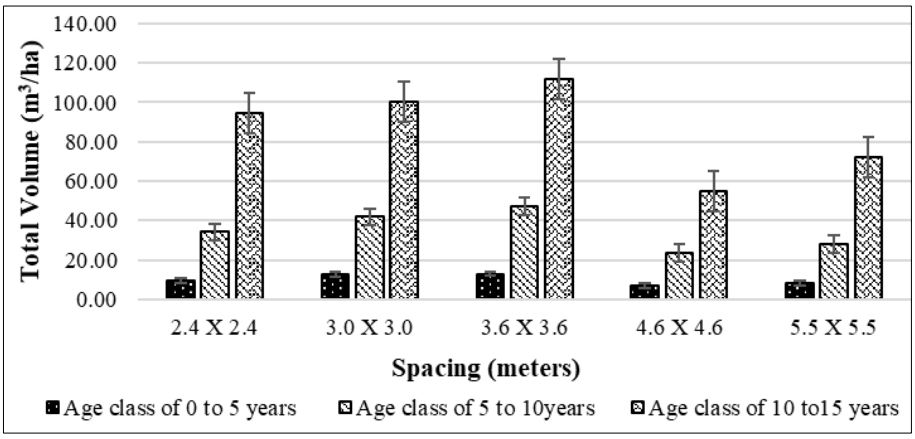

Fig 1: Impact of spacing on *Santalum album* total volume per hectare with three age classes

5. Conclusion

As a queen of essential oil, commercial cultivation of *Santalum album* is a profitable venture through the proper execution of important silviculture operations such as spacing. Among all the spacing treatments, better growth performance and maximum total volume were observed with 3.6 X 3.6 m and 3.0 X 3.0 m spacing. Thus, it may be concluded that 3.0 X 3.0 m and 3.6 X 3.6 m spacing were found better for sandal cultivation on farmlands.

6. Reference

1. Shukla P, Singh B, Saini A, Haldar S, Singh J. A new population of *Santalum album* L. (sandalwood) from Agali Forest Range, Kerala, India. Current Science. 2016 Jan 25;110(2):148.
2. Gairola S, Aggarwal PS, Ravikumar GS. Status of production and marketing of sandalwood (*Santalum album* L.). InProc. national seminar on conservation, improvement, cultivation and management of sandal. Institute of Wood Science and Technology, Bangalore, 2008, 1-8.
3. Chittapur BM. Sandalwood plantations-points to ponder. Current Science (00113891). 2021 Apr 10;120(7).
4. Subasinghe SM. Sandalwood research: a global perspective, 2013.
5. Viswanath S, Chakraborty S. Indian Sandalwood Cultivation Prospects in India. In Indian Sandalwood. Springer, Singapore, 2022, 281-292.
6. Kukreti A, Rawat L. Sandalwood Species Significantly Associated with Culture and Heritage of India, 2021.
7. Nissen TM, Midmore DJ, Keeler AG. Biophysical and economic tradeoffs of intercropping timber with food crops in the Philippine uplands. Agricultural systems. 2001 Jan 1;67(1):49-69.
8. Khan GS, Chaudhry AK. Effect of spacing and plant density on the growth of poplar (*Populus deltoides*) trees under agro-forestry system. Pak. J Agri. Sci. 2007;44(2):321-7.
9. Deswal RP, Kaushik N, Jat MK, Ranawat JS. Growth performance of *Ailanthus excelsa* based agroforestry system under different planting spacing in arid region of Haryana, 2021.
10. Faiz M, Singh RP, Singh K. Growth and biomass production by *Populus deltoides* under agroforestry in Tarai of Kumaun region, UP. Indian Forester. 1996;122(7):631-6.
11. Bisaria AK, Solanki KR, Newaj AR, Tiwari R. Effect of tree densities and environmental factors on *Hardwickia binata* and companion crops in Agrisilviculture. J. Trop. For. 1999 Apr;15(2):93-102.
12. Chaturvedi AN. Optimum rotation of harvest for poplars in farmlands under agroforestry. Indian forester. 1992 Feb 1;118(2):81-8.
13. Singh G, Singh NT, Dagar JC, Singh H, Sharma VP. An evaluation of agriculture, forestry and agroforestry practices in a moderately alkali soil in north-western India. Agroforestry systems. 1997 Jun;37(3):279-95.