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Seedling quality and growth of sandalwood in response to integrated nutrient management

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Abstract
Present investigation was carried out to study the effect of integrated nutrient management on seedling quality and growth parameter of Sandalwood seedling. Twelve treatment combinations along control were used to study seedling quality index, root length shoot length ratio, shoot root ratio along with plant height, collar diameter and number of leaves per plant. Among different treatment combinations, maximum seedling quality index (0.127), root length shoot length ratio (0.837), shoot root ratio on dry weight bases (3.013) were recorded in T_{10} (1 g NPK + Vermicompost @ 25 g/ seedling), T_6 (Azospirillum @ 10 g/seedling) and T_1 (1.0 g of NPK / Seedling), respectively. The plant height, collar diameter and number of leaves per plant were increased with Integrated Nutrient Management (INM). Maximum percentage increase in growth parameters was found in T_{10} (1 g NPK + Vermicompost @ 25 g/ seedling) at 90,120 at 150 DAT. While, minimum growth parameter was reported under control condition.

Keywords: seedling quality index, shoot root ratio, root length shoot length ratio, growth parameters

Introduction
Santalum is a genus of sixteen semi-root parasitic plants belonging to the Santalaceae family (Barrett and Fox, 1995) [1]. *Santalum album* (also known as East Indian Sandal wood or Sandal tree) is a small semi-parasitic evergreen tree with a fragrant heartwood. Because of its limited distribution, its oil is rare and valuable, and the heartwood contains santalol, which makes the wood resistant to termites, the tree is known as the "Royal Tree" (Jeeva *et al.*, 1998) [10]. It is native to India, and its range is confined to around 9600 km^2, largely in the deciduous forests of Peninsular India's Deccan region (Gairola *et al.*, 2008) [5]. Kanataka and Tamil Nadu in India account for more than 90% of the natural population of *S. album* (Dutt and Verma, 2005) [4]. The sandal tree is frequently seen as a part of the household, particularly in northern Kerala (Kumar *et al.*, 1994) [12]. *S. album* is an evergreen partial root parasite attaining 10-15 m height and 1-2 m girth at full maturity when it reaches the age of 60-80 years (Jain *et al.*, 1999) [8]. Sandalwood's high economic worth provides enough incentive for farmers to grow it on a commercial scale. However, because of pilferage and the difficulties of field establishing sandal trees in new regions, the area under the tree is rapidly dwindling. Because of a lack of knowledge about host–parasite relationships, regeneration and establishment of the sandal tree have been difficult (Surendran *et al.*, 1998) [18]. The goal of the Integrated Nutrient Management (INM) system is to maximize the usage of chemical fertilizers in conjunction with organic manures. It also optimizes all feasible organic and inorganic sources of plant nutrients required for crop development and quality in an integrated manner, relevant to each cropping system and agricultural environment in terms of ecological, social, and economic possibilities (Roy, 1986) [16]. Seedlings are not growing well due to a lack of sufficient nourishment. Sandalwood seedlings in the nursery require special nutrition. In integrated nutrient management, there are numerous sources of nutrients. Present investigation was conducted to determine the best nutrition strategy for seedlings of *S. album*.

Materials and Methods
Study area: This investigation was carried out at Net House Complex, College of Forestry (ACHF), Navsari Agricultural University, Navsari during year 2018-19.
After seed treated with 500 ppm GA_3 for 24 hours (Govind *et al*., 2021) [6], sandalwood seeds were cultivated in a sinking sand substrate. The base of the sunken sand bed was made by layering sand. Sandalwood seeds are strewn over the sand layer at a depth of 2 cm. For all of the treatments, the soil mixture was made by combining 1:1:1 sand, soil, and FYM.

A popular host plant employed was Leucaena (*Leucaena leucocephala*). In plastic bags, Leucaena seeds were planted. With particular labelling, the transplanted seedlings were placed per repeat in CRD. Phosphobacteria and Azospirillium, among the bio-fertilizers, were inoculated in polybags according to the treatments. Vermicompost was pulverised and placed in polybags according to the procedure. As per treatments, NPK was applied by chemical fertilizer. The growth and biomass of sandalwood seedlings were observed and documented. Five plants were chosen at random for taking observations of each treatment in each of the three repetitions, and the observations were recorded at monthly intervals for seedling height, collar diameter, and number of leaves per plant measure from 30 DAT to 150 DAT (Day After Transplanting). While other parameters such as root length and fresh and dry weight of the entire plant were recorded for calculating various quality parameters.

Treatment Details

Treatment	Treatment Details
T_0	Soil : Sand : FYM (1:1:1)
T_1	1.0 g of NPK / Seedling
T_2	2.0 g of NPK / Seedling
T_3	Vermicompost @ 25 g / seedling
T_4	Vermicompost @ 50 g / seedling
T_5	Azospirillum @ 5 g/seedling
T_6	Azospirillum @ 10 g/seedling
T_7	Phosphobacteria @ 5 g/seedling
T_8	Phosphobacteria @ 10 g/seedling
T_9	Azospirillum @ 5 g/seedling + Phosphobacteria @ 5 g/seedling
T_{10}	1.0 g of NPK / Seedling + Vermicompost @ 25 g / seedling
T_{11}	Vermicompost @ 25 g / seedling + Azospirillum @ 5 g/seedling
T_{12}	Vermicompost @ 25 g / seedling + Phosphobacteria @ 5 g/seedling

Further, root length shoot length ratio, shoot root ratio was measured by using below formula.

Root length (RL) to shoot length (SL) ratio:
The RL /SL (Length bases) was calculated using formula as given below

$$RL/SL = \frac{\text{Root length (cm)}}{\text{Shoot Length (cm)}}$$

Shoot to root ratio (Dry weight eight bases):
The shoot: root was calculated using formula as under:

$$\text{Shoot: Root} = \frac{\text{Shoot dry weight (g)}}{\text{Root dry weight (g)}}$$

Seedling quality index was measure by formula given by (Dickson *et al*., 1960) [3]. The variance technique, as developed by Panse and Sukhatme (1987) [14], was used to statistically analyze the various parameters.

Result and Discussion

Finding from research revealed that root length shoot length ratio was recorded maximum (0.837) in T_6 (Azospirillum @ 10 g/seedling) which is followed by T_5, T_3, T_4, T_7, T_8 and T_9. (Fig. 1). While, minimum was found in T_1 (1.0 g of NPK / Seedling). A high RL/SL value indicates low foliage development therefore negatively influence the photosynthetic process. Nagaveni *et al.* (1997) [13] observed that the root region of Sandal had more nitrogen-fixing bacteria and VAM fungi however, addition of VAM to the rhizosphere of both Sandal and host boosted growth and biomass, especially in the root system.

Maximum shoot root ratio (3.013) was found highest in treatment T_1 (1.0 g of NPK / Seedling) which was followed by T_2 (2.74). While, minimum was recorded in T_3 (1.163) (Fig. 2). Further, seedling quality index was observed maximum (0.127) in T_{10} (Fig. 3). While, minimum (0.05) was recorded in control condition. Seedling Quality Index (SQI) is considered a promising integrated measure of morphological traits and used as good indicator for assessment of seedling quality as it computes the robustness and biomass distribution of seedlings as compared to individual growth parameters like shoot length, collar diameter etc. (Binotto *et al.*, 2010) [2]. Normally higher the value of SQI, better is the ability of the seedling to survival and establish in the field condition. Further, *Dalbergia sissoo* seedlings showed maximum SQI of 3.76 under the influence of Bio-fertilizers + N: P: K fertilizers (Jaishankar *et al.*, 2013) [9].

Plant height and collar diameter was also observed during study period. At 30 and 60 DAT, plant height and collar diameter were not significantly affected by INM treatments. At 90, 120 and 150 DAT maximum plant height and collar diameter (18.75, 21.65, 25.85 cm and 2.50, 2.69, 3.06 mm, respectively) was recorded in T_{10} (Table 1 & 2). While, minimum plant height and collar diameter was recorded under control for all month. A combined application of 1.0 g of NPK / Seedling + Vermicompost @ 25 g / seedling (T_{10}) reported maximum percent increase over control in plant height (23.46, 26.44 and 35.12%) and collar diameter (30.21, 29.95 and 34.21%) at 90, 120 and 150 DAT, respectively. The highest number of leaves per plant was observed in treatment T_{10} (19.47, 20.73 and 17.93, respectively at 90,120 and 150 DAT) which was statistically at par with T_2, T_1, T_{12} and T_{11} (*i.e.*, 19.07, 18.87, 18.60 and 18.07, respectively) at 90 DAT; T_2, T_1, T_{12}, T_{11}, T_4 and T_3 (*i.e.* 20.43, 20.33, 20.13, 19.80, 19.67 and 19.33, respectively) at 120 DAT; T_2 and T_1 (17.03 and 16.80, respectively) at 150 DAT (Table 3). The minimum number of leaves per plant was found in treatment T_0 (Control) at 90,120 and 150 DAT. At 150 DAT number of leaves was decreased compare to 120 DAT. Percent increase in number of leaves per plant over control was more in T_{10} (1.0 g of NPK / Seedling + Vermicompost @ 25 g / seedling) at 90, 120 and 150 DAT.

Different INM treatments had a positive effect on plant height and collar diameter. This could be owing to the rapid release of nutrients caused by the application of inorganic fertilizers

(NPK), followed by the slow and continual release of nutrients caused by vermicompost, all of which contribute to an increase in micronutrient release. Because nitrogen plays a direct function in the production of proteins, it is vital for boosting seedling height. It's also a component of chlorophyll, which is the photosynthesis's major absorber of light energy. This could have resulted in greater photosynthetic production and distribution into the root and shoot portions, resulting in increased plant height, collar diameter and number of leaves. Similar findings were observed by Husen and Pal (2004) [7] in *Tectona grandis* and Singh *et al.* (2003) [17] in Sapota. According to Korwar *et al.* (2005) [11], various sources of nutrients, such as organic and inorganic sources of nutrients, boosted the growth of Aonla. Govind *et al.* (2021) [6] reported maximum plant height, collar diameter and number of leaves per plant in NPK with vermicompost in Sandalwood seedling. Biofertilizers applied to seedlings at the nursery stage considerably improved the growth characteristics of *Gmelina arborea* seedlings, such as seedling height, collar diameter, and number of leaves per plant, as compared to uninoculated seedlings (Rashmiprava *et al.*, 2018) [15].

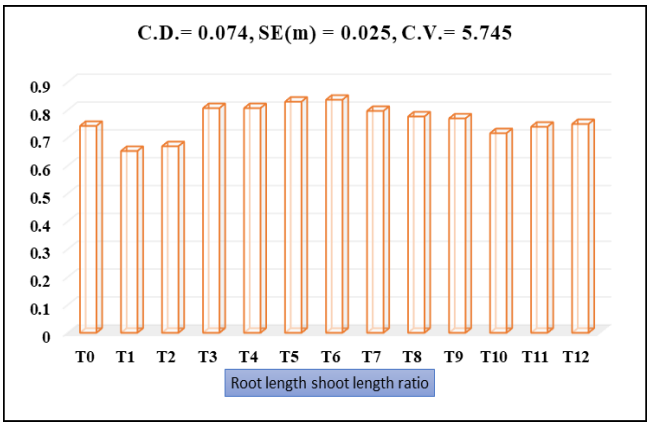

Fig 1: Root length shoot length ratio as affected by different INM treatments

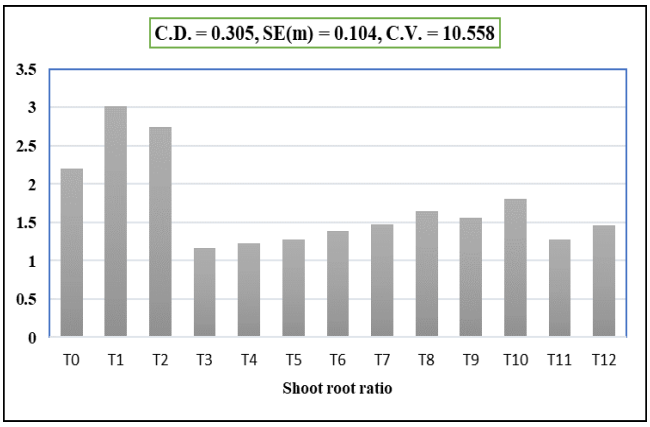

Fig 2: Shoot root ratio as affected by different INM treatments

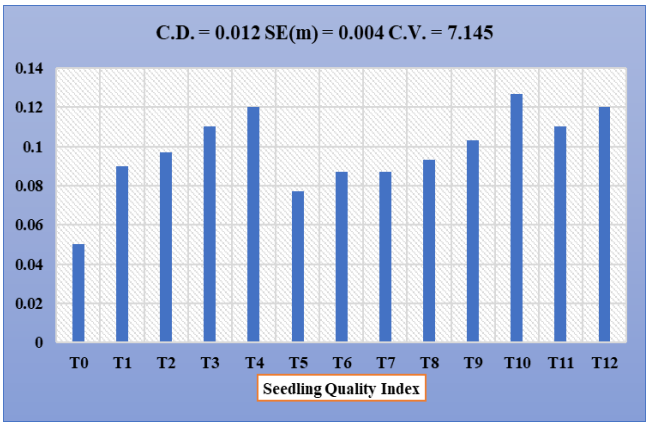

Fig 3: Seedling Quality index as affected by different INM treatments

Table 1: Effect of integrated nutrient management on plant height (cm) of *Santalum album* L. seedling

Treatments	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	Percentage increase over control (90 DAT)	Percentage increase over control (120 DAT)	Percentage increase over control (150 DAT)
T_0	9.97	13.04	15.19	17.12	19.13	-	-	-
T_1	10.74	14.20	17.65	20.03	25.49	16.17	16.98	33.21
T_2	10.77	14.30	17.74	20.40	25.54	16.81	19.16	33.48
T_3	10.34	13.98	16.91	19.66	24.11	11.30	14.84	26.03
T_4	10.35	14.05	16.93	19.83	24.23	11.43	15.85	26.62
T_5	9.99	13.19	15.50	17.97	21.21	2.02	4.95	10.84
T_6	10.00	13.29	15.96	18.62	21.30	5.05	8.76	11.32
T_7	10.27	13.37	16.51	18.99	22.15	8.69	10.94	15.75
T_8	10.28	13.44	16.74	19.50	23.74	10.23	13.90	24.08
T_9	10.29	13.86	16.89	19.65	23.88	11.17	14.76	24.81
T_{10}	10.80	14.55	18.75	21.65	25.85	23.46	26.44	35.12
T_{11}	10.64	14.08	17.14	19.95	24.43	12.84	16.55	27.70
T_{12}	10.73	14.08	17.58	19.99	24.91	15.73	16.74	30.17
SEm ±	0.234	0.408	0.503	0.590	0.687			
CD @ 5%	NS	NS	1.43	1.68	1.96			
CV%	3.90	5.12	5.16	5.25	5.05			

Table 2: Effect of integrated nutrient management on collar diameter (mm) of *Santalum album* L. seedlings

Treatment	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	Percentage increase over control (90 DAT)	Percentage increase over control (120 DAT)	Percentage increase over control (150 DAT)
T_0	1.46	1.82	1.92	2.07	2.28	-	-	-
T_1	1.62	2.07	2.39	2.61	2.93	24.48	26.09	28.51
T_2	1.62	2.08	2.42	2.64	2.96	26.04	27.54	29.82
T_3	1.57	1.96	2.27	2.48	2.76	18.23	19.81	21.05
T_4	1.59	2.03	2.30	2.51	2.77	19.79	21.26	21.49
T_5	1.46	1.92	2.05	2.22	2.52	6.77	7.25	10.53
T_6	1.46	1.93	2.08	2.24	2.55	8.33	8.21	11.84
T_7	1.51	1.93	2.15	2.33	2.63	11.98	12.56	15.35
T_8	1.53	1.94	2.23	2.40	2.70	16.15	15.94	18.42
T_9	1.56	1.96	2.24	2.43	2.71	16.67	17.39	18.86
T_{10}	1.64	2.11	2.50	2.69	3.06	30.21	29.95	34.21
T_{11}	1.59	2.05	2.30	2.55	2.78	19.79	23.19	21.93
T_{12}	1.61	2.06	2.34	2.56	2.90	21.88	23.67	27.19
SEm ±	0.050	0.063	0.052	0.079	0.074			
CD @ 5%	NS	NS	0.15	0.22	0.21			
CV%	5.60	5.53	4.08	5.63	4.71			

Table 3: Effect of integrated nutrient management on number of leaves per plant of Santalum album L. seedling

Treatment	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	Percentage increase over control (90 DAT)	Percentage increase over control (120 DAT)	Percentage increase over control (150 DAT)
T_0	12.33	15.00	16.20	17.33	11.00	-	-	-
T_1	13.15	15.53	18.87	20.33	16.80	16.48	17.31	52.73
T_2	13.17	15.53	19.07	20.43	17.03	17.72	17.89	54.82
T_3	13.03	15.40	17.33	19.33	14.53	6.98	11.54	32.09
T_4	13.13	15.43	17.60	19.67	14.93	8.64	13.50	35.73
T_5	12.57	15.03	16.33	17.40	12.80	0.80	0.40	16.36
T_6	12.67	15.17	16.47	18.20	13.00	1.67	5.02	18.18
T_7	12.70	15.33	16.80	18.33	13.73	3.70	5.77	24.82
T_8	12.73	15.37	16.93	18.80	14.20	4.51	8.48	29.09
T_9	12.93	15.37	17.13	19.00	14.37	5.74	9.64	30.64
T_{10}	13.20	16.07	19.47	20.73	17.93	20.19	19.62	63.00
T_{11}	13.13	15.47	18.07	19.80	15.60	11.54	14.25	41.82
T_{12}	13.13	15.50	18.60	20.13	15.80	14.81	16.16	43.64
SEm ±	0.20	0.26	0.61	0.56	0.39			
CD @ 5%	NS	NS	1.75	1.59	1.13			
CV%	2.76	3.02	6.06	5.07	4.66			

Conclusion

Root length shoot length ratio was recorded maximum (0.837) in T_6 (Azospirillum @ 10 g/seedling) whereas shoot root ratio on dry weight bases (3.013) was found maximum in treatment T_1 (1.0 g of NPK / Seedling). Highest seedling quality index was recorded under T_{10} (1 g NPK + Vermicompost @ 25 g/ seedling). The plant height, collar diameter and number of leaves per plant as well as percentage increase over control was recorded maximum in T_{10} (1 g NPK + Vermicompost @ 25 g/ seedling). So, it is concluded that an application of 1 g NPK + Vermicompost @ 25 g/ seedling can be used for quality seedling production of Sandalwood.

References

1. Barrett DR, Fox JED. A protocol suitable for raising seedlings of *Santalum album* in Timor. In: Sandalwood Seed Nursery and Plantation Technology, FAO, Suva, Fiji. RAS/92/361. Field Document, Edited by Gjerum, L., Fox, J.E.D. and Ehrhart, L. 1995;8:163-164.
2. Binotto AF, Lucio ADC, Lopes SJ. Correlations between growth variables and the Dickson quality index in forest seedlings. Cerne. 2010;16(4):457-464.
3. Dickson A, Leaf AL, Hosner JF. Seedling quality—Soil fertility relationships of white spruce, and red and white pine in nurseries. The Forestry Chronicle. 1960;36(3):237-241.
4. Dutt S, Verma KS. Effect of collection of time, pre-sowing treatments and sowing time on the germinability of sandal (*Santalum album* L.) seeds under nursery conditions. J Non-timber For. Products. 2005;12:205-208.
5. Gairola S, Aggarwal PS, Ravikumar GS. Status of production and marketing of sandalwood (*Santalum album* L.). In: Proceedings of the National Seminar on Conservation, Improvement, Cultivation and Management of Sandal. 12–13 December 2007, Edited by Gairola *et al*., Bangalore, 2008, 1–8.
6. Govind Prajapati VM, Tandel MB. Effect of integrated nutrient management on seedling growth and biomass of sandalwood (*Santalum album* L.). Indian Journal of Ecology. 2021;48(4):1047-1050.
7. Husen A, Pal M. Effect of N, P and K application to stock-plants on nutrient status of coppiced shoots of teak (*Tectona grandis* Linn. f.) stock plants. Annals of Forest Science. 2004;12:22-28.
8. Jain SH, Angadi VG, Ravikumar G, Theagarajan KS, Shankaranarayana KH. Studies on cultivation and chemical utilisation of Sandal (*Santalum album* L.). Fafai Journal, 1999, 49-53.
9. Jaisankar I, Revathi R, Parthiban KT, Backiyavathy MR,

Jude R, Sudhagar, *et al*. Response of *Dalbergia sissoo* Roxb. clones to integrated nutrient management practices. Indian Journal of Hill Farming. 2013;26(2):42-48.
10. Jeeva V, Saravanan S, Devaraj P, Lakshmidevi R. Malady and remedy of sandal cultivation in farmlands and private lands: An overview. In Sandal and its Products. Edited by A.M. Radomiljac, H.S. Ananthapadmanabha, R.M. Welbourn, and K. Satyanarayana Rao. ACIAR Proceedings. No.84. ACIAR, Canberra, Australia, 1998, 16-18.
11. Korwar GR, Pratibha G, Ravi V, Palanikumar D. Influence of organics and inorganics on growth, yield of aonla (*Emblica officinalis*) and soil quality in semi-arid tropics. Indian Journal of Agricultural Sciences. 2005;76(8): 457-461.
12. Kumar BM, George SJ, Chinnamani S. Diversity, structure and standing stock of wood in the home gardens of Kerala in Peninsular India. Agroforestry System. 1994;25:243-262.
13. Nagaveni HC, Vijayalakshmi G, Annapnrna D, Ananthapadmanabha HS. Association of sandal with vesicular arbuscular mycorrhiza (VAM) Fungi. Sandal and its products. 1997;18:155.
14. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers, 4th edn., K. L. Chadha and G Kallo (eds.). Published by ICAR, New Delhi, 1987, 349.
15. Rashmiprava M, Manmohan JD, Behera LK, Madhuri S. Enhancement of seedling vigour through biofertilizers application in gamhar (*Gmelina arborea* Roxb.). International Journal of Chemical Studies. 2018;6(5):54-60.
16. Roy RN. FAO, fertilizer programme with special reference to integrated plant nutrition system. Fertilizer in agricultural development. Krishak Bharati Cooperative Limited, New Delhi, India, 1986, 149-169.
17. Singh R, Singh D, Siddiqui S, Godra RK. Effect of NPK on chlorophyll content, fruit set, fruit drop and mineral composition of fruit and leaf of sapota. Haryana Journal Horticultural Science. 2003;32:185-186.
18. Surendran C, Parthiban KL, Bhuvaneshwaram C, Murugesh M. Silvicultural strategies for augmentation of sandal regeneration. In: ACIAR Proceedings of the Conference on Sandal. 18–19 December 1997, Bangalore, 1998, 69-73.