EFFECT OF POTTING MEDIUM INGREDIENTS AND SIEVE SIZE ON THE GROWTH OF SEEDLINGS OF SANDALWOOD (*SANTALUM ALBUM* L.) IN ROOT TRAINERS

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Introduction

Santalum album L. commonly known as sandalwood or 'Chandan' is a semi-root parasite tree species of family Santalaceae which is highly valued for its scented wood and oil. Over-exploitation and illicit felling of sandalwood have resulted in decline of population and genetic erosion. On the other hand, natural regeneration of sandalwood is not with the pace of exploitation and the species is considered threatened in its habitats (Meera *et al.*, 2000). In order to meet growing demand and sustainable utilization of bioresources of *S. album,* afforestation and plantations of high quality planting material is essential. Recent liberailsed policies of sandalwood cultivation in Karnataka and Tamil Nadu states have resulted in heavy demand of quality planting stock of *S. album.*

Traditional method of propagation of sandalwood takes 6-8 months period to obtain plantable seedling in polybag of 1500 cc volume with soil, sand and FYM in the ratio of 1 : 2 : 1 with *Cajanus cajan* as a primary host (Rai, 1990). In Western Australia, containers of 1500cc capacity and potting medium combination of sand : peat : perlite 3 : 2 : 2 is used to get plantable seedlings of *S. album* in 5-6 months period using *Alternanthera nana* as a primary host and application of supplementary nutrition (Radomiljac, 1998).

Use of traditional potting media produce seedlings with good shoot growth, but has poor root system (Miller and Jones, 1995). Common problems associated with traditional nursery techniques are bulky and poor nutrient medium, poor water holding capacity, root coiling, less root fibrosity and poor survival in the field. The physical and chemical composition of the potting medium, size and shape of containers mostly affect root development. Fibrous root development is considered one of the key quality parameter, which is often over looked (Miller and Jones, 1995). For production of quality planting stock, ideal potting mixture should have better aeration, good water holding capacity, porosity, low bulk density, low in silt, clay and ash content and promote firm plug formation (Miller and Jones, 1995; Chakrabarthi *et al*., 1998).

Application of root trainer technology and compost as a major potting medium ingredient has proved better than traditional containers and FYM in the potting medium for the production of

quality planting stock in several tree species (Khedkar and Subramanian, 1997, Srivastava *et al.*, 1998, Ginwal *et al.*, 2001, 2002).

There is no report on the effect of potting medium ingredients, their proportion and sieve size of potting medium on seedling growth of *S. album,* particularly in root trainers. The present study was undertaken with an objective to find the effect of potting medium ingredients, their proportion and sieve size of potting medium ingredients on seedling growth for quality seedling production of *S. album* in 270 cc root trainers.

Material and Methods

Analysis of potting medium ingredients : Analysis of potting medium ingredients namely sand, soil, cocopeat and compost were carried out before conducting experiments on potting medium ingredient and sieve size of potting medium. Mechanical analysis of potting medium ingredients was carried by estimating sand, silt and clay per cent by International Pipette Method (Piper, 1966). Physical properties like; bulk density, water holding capacity, porosity and volume expansion were analysed through Keen's cup method (Black, 1965). Chemical analysis was carried out for macro-elements in terms of total percentage of nitrogen by Macrokjeldhal method (Piper, 1966), phosphorus by Vanadomolybdophosphoric method (Piper, 1966), potassium by flame photometry (Piper, 1966), calcium and magnesium by EDTA method (Black, 1965) and sulphur (ppm) by Turbidometry (Chesnin and Yien, 1951). For measuring pH and electrical conductivity (EC) 10 g of soil was taken into beaker and 25 ml of distilled water was added and stirred intermittently. After 30 minutes, pH was recorded using a pH meter (systronics) and after 16 hours conductivity of the supernatant solution was recorded by Conductivity Meter (Century Digital CC 601).

Seed source, pre-treatment and germination : Sandalwood seeds were collected in the month of November 1997 and 1998 from the Clonal Seed Orchard (CSO), Nallal, Bangalore, India. Seeds were depulped, washed thoroughly in water, dried under shade, dressed with fungicide (Bavistin®) and stored in airtight containers. Graded seeds were pretreated with 0.05 per cent gibberellic acid (w/v) over night and sown in sand trays for germination under shade in nursery. Sand was kept moist by watering everyday.

For potting media ingredients, their propotion and sieve size experiments, block type (black colour) root trainers, each block of 12 cells and each cell of 270 cc volume (with 5 ridges) were used. At peak germination stage, seedlings of two-leaf stage were transplanted from germination trays into root trainers. In all the treatments, deoiled neemcake (10 kg/m^3), and single super phosphate (SSP, 4.5 kg/m^3) were added for nutritional enrichment of potting medium and Indophil M-45® and phorate (0.25 kg/m^3, each) as prophylactic measures against soil borne pathogens.

Effect of potting medium : Potting medium ingredients like; sand, soil, cocopeat, compost, burnt rice husk and charcoal were used in eight combinations, now onward called as treatments (Table 2). Potting medium experiment was executed in the month of August 1998 and terminated in February 1999.

Table 1

Physical, mechanical and chemical analysis of potting medium ingredients used for potting medium ingredients and their proportion and sieve size experiments.

Properties	Soil	Sand	Cocopeat	Compost
Physical properties :				
Bulk density (g/cc)	0.90	1.40	0.0750	0.22
Water holding capacity (%)	71.06	26.23	960.660	429.40
Porosity (%)	63.84	36.83	72.990	93.41
Volume expansion (%)	2.31	3.43	0.720	29.24
Mechanical properties :				
Fine Sand content (%)	29.95	0.55	2.200	2.00
Coarse sand content (%)	42.55	96.95	-	-
Silt content (%)	25.00	--	5.000	03.50
Clay content (%)	2.50	2.50	-	-
Chemical properties :				
Nutrients :				
Nitrogen (%)	0.16	0.0010	1.420	2.12
Phosphorus (%)	0.01	0.0002	0.100	0.15
Potassium (%)	0.18	0.0002	0.600	0.84
Calcium and Magnesium (%)	1.00	-	3.000	3.00
Sulphur (ppm)	1040.00	4.0000	932.000	1972
pH	7.5	8.3	5.5	6.2
Electrical conductivity (mmhos/cm)	0.06	0.0300	0.25	0.23

Effect of sieve size of potting medium : In order to find out the best sieve size, five sieve sizes (4 x 4 holes/sq inch to 12 x 12 holes/sq inch) were used for sieving the potting medium ingredients (Table 3). Based on the preliminary results of the first experiment, potting medium (sand, soil and compost in the ratio of 40 :10 :50), which favoured overall growth of *S. album* seedlings, was used for sieve size of potting medium experiment. Sieve size experiment was laid in the month of January 1999 and terminated in June 1999.

Experimental design and growth data : Experiments were laid in a completely randomized design with 4 replicates and 24 seedlings in each replicate. In all the treatments of both the experiments, *Cajanus cajan* was used as a primary host and provided after seven days of transplanting sandalwood seedlings into root trainers. Periodical (monthly) pruning of host plant was carried out. Experiments were conducted at modern R & D nursery (of IWST), Nagaroor, Bangalore.

Table 2

Effect of different potting medium ingredients and their proportion on the seedling growth of S. album in 270 cc block type root trainers at the age of 7 months

Treatments*	Height (cm)	Collar dia. (mm)	Sturdi-ness Quoti-ent	Shoot dry wt. (g)	Root dry wt. (g)	Total dry wt. (g)	Root: shoot ratio	Fibro-sity	Quality Index
T_1 : (40:10:50:0:0:0)	16.05 c	2.41 bc	6.81 c	0.62 c	0.50 d	1.14 c	0.84 c	0.53	0.14 c
T_2 : (10: 0:50:40:0:0)	13.86 b	2.26 b	6.19 b	0.20 ab	0.19 bc	0.34 ab	0.92 c	0.38	0.06 a
T_3 : (25:0:75:0:0:0)	16.38 c	2.67 c	6.22 b	0.74 c	0.45 cd	1.16 c	0.62 b	0.53	0.14 c
T_4 : (15:10:60:0:7.5:7.5)	13.49 b	2.23 ab	6.11 b	0.15 a	0.05 a	0.19 a	0.38 a	0.48	0.02 a
T_5 : (20:15:50:0:7.5:7.5)	14.60 b	2.36 b	6.24 b	0.25 ab	0.10 ab	0.38 ab	0.40 a	0.54	0.04 a
T_6 : (50:0:50:0:0:0)	14.23 b	2.37 b	6.10 b	0.73 c	0.30 c	1.02 c	0.40 a	0.44	0.12 bc
T_7 : (25:0:60:0:7.5:7.5)	12.30 ab	1.97 a	6.36 b	0.27 ab	0.10 ab	0.39 ab	0.38 a	0.78	0.04 a
T_8 : (50:25:25:0:0:0)	11.97 a	2.44 bc	4.99 a	0.35 b	0.30 c	0.59 b	0.86 c	0.49	0.10 b
SE	0.66	0.13	0.14	0.09	0.06	0.14	0.10	-	0.02
lsd	1.36	0.27	0.28	0.18	0.12 c	0.28	0.21	-	0.04

*Treatments : sand, soil, compost, cocopeat, burnt rice husk and charcoal respectively
SE= standard error; lsd = least significant difference at α =0.05;
Values with the same letter not significantly different at α =0.05

Seedling height and collar diameter were recorded at the end of 7th month in case of potting media experiment, whereas, for experiment on sieve size of potting medium, observations were recorded at the end of 6th month. Sturdiness Quotient (SQ) was calculated by dividing the seedling height (cm) by collar diameter (mm) according to Roller (1977).

For biomass estimation, 3 randomly selected seedlings from each replicate were carefully uprooted without disturbing the root system and washed in running tap water. Excess of water was wiped out by placing them between the folds of blotting paper. The seedling were cut at collar region, dried separately at 80°C temperature in paper bags in hot air oven. Shoot, root and total dry weight was recorded using top pan electronic balance. The root shoot dry weight ratio was worked

Table 3

Effect of different sieve sizes of potting medium ingredients on seedling growth of S. album in 270 cc block type root trainers at the age of 6 months

Treatment-Sieve size (holes/sq.inch)	Height (cm)	Collar dia. (mm)	Sturdi-ness quotient	Total dry wt. (g)	Shoot dry wt. (g)	Root dry wt. (g)	Root : shoot ratio	Quality index
S_1 (12 x 12)	15.97	2.88 a	5.54 b	0.73 a	0.49 a	0.24 a	0.49 a	0.095 a
S_2 (10x 10)	15.94	2.94 a	5.43 b	1.03 a	0.63 a	0.40 ab	0.59 a	0.146 ab
S_3 (8 x 8)	16.45	3.07 ab	5.37 b	1.12 a	0.70 a	0.42 ab	0.61 a	0.158 abc
S_4 (6 x 6)	17.68	3.17 b	5.56 b	1.74 b	1.20 b	0.54 b	0.47 a	0.221 c
S_5 (4 x 4)	16.81	3.08 ab	5.48 b	1.00 a	0.61 a	0.40 ab	0.65 a	0.141 ab
S_6 (10 x 10; sand and 8 x 8 soil and compost)	15.37	3.25 b	4.72 a	1.08 a	0.63 a	0.45 ab	0.75 b	0.177 bc
SE	-	0.11	0.19	0.22	0.14	0.10	0.10	0.032
lsd	--	0.20	0.39	0.46	0.204	0.20	0.20	0.067

SE= standard error; lsd = least significant difference at α =0.05;
Values with the same letter not significantly different at α =0.05

out by dividing the weight of dry root by the weight of dry shoots of each plant, separately. Quality index assessment was made using the formulae developed by Dickson *et al.* (1960) :

$$\text{Quality Index (QI)} = \frac{\text{Seedling dry wt (g)}}{\{\text{Ht (cm)/Dia (mm)}\} + \{\text{Shoot dry wt (g)/ Root dry wt (g)}\}}$$

Results and Discussion

Analysis of potting medium ingredients : Mechanical analysis of the potting medium ingredients revealed that soil consisted maximum fine sand and silt content followed by cocopeat and compost. Physical analysis of potting medium ingredients showed that maximum water holding capacity was recorded in cocopeat (960.66%), followed by compost (429.40%) and minimum in sand (26.23%). Porosity and volume expansion was observed highest (93.44% and 29.24% respectively) in compost. Chemical analysis of potting medium ingredients revealed that compost was rich in macro elements (N, P, K, Ca, Mg and S) followed by cocopeat and soil (Table 1).

Effect of potting medium : Out of the eight treatments of potting medium ingredients and their proportion (ratio) used, at the age of 7 months, seedlings grown in T_3, consisting of sand and compost (25:75) have shown maximum height (16.38 cm), collar diameter (2.67 mm), shoot dry weight (0.74 g) and total dry weight (1.16g). Maximum root dry weight (0.50 g) was observed in T_1 consisting of sand, soil, compost in the ratio 40:10:50. Among T_1, T_3 and T_6, the

best root-shoot ratio of 0.84 was recorded in treatment T_1 that was significantly superior to the other two treatments (Fig. 1). The best seedling quality index of 0.14 was recorded for T1 and T3 (Table 2).

In case of *S. album* overall seedling growth was found the best in T_1, which provided better aeration and good water holding capacity (Fig. 2). In treatment T_3, shoot dry matter was at par with T_1, but root dry weight was less. This may be due to more retention of water by compost and less aeration due to reduced level of sand, which might have inhibited lateral root development. A good root environment with adequate aeration and low resistance to root penetration favours high root mass (Warkentin, 1984). In the treatment T_6, consisting sand and compost; 50 : 50, total dry weight and shoot dry weight were at par with T_1, but root dry weight was less, which revealed that increased level of sand above 40% and organic matter above 50% is not favorable for overall growth performance of seedlings. In other treatments T_2, T_4 and T_5, the growth was comparatively less due to high organic matter (60-90%) and low sand content, whereas, in treatment T_7 high organic matter along with high level of charcoal and burnt rice husk (each 7.5%) might have resulted in poor growth of seedlings. Incorporation of soil in the potting medium

Figs. 1-2

Effect of different potting media ingredients and their proportion on seedling growth of *S. album* at the age of 7 months in 270 cc block type root trainers.

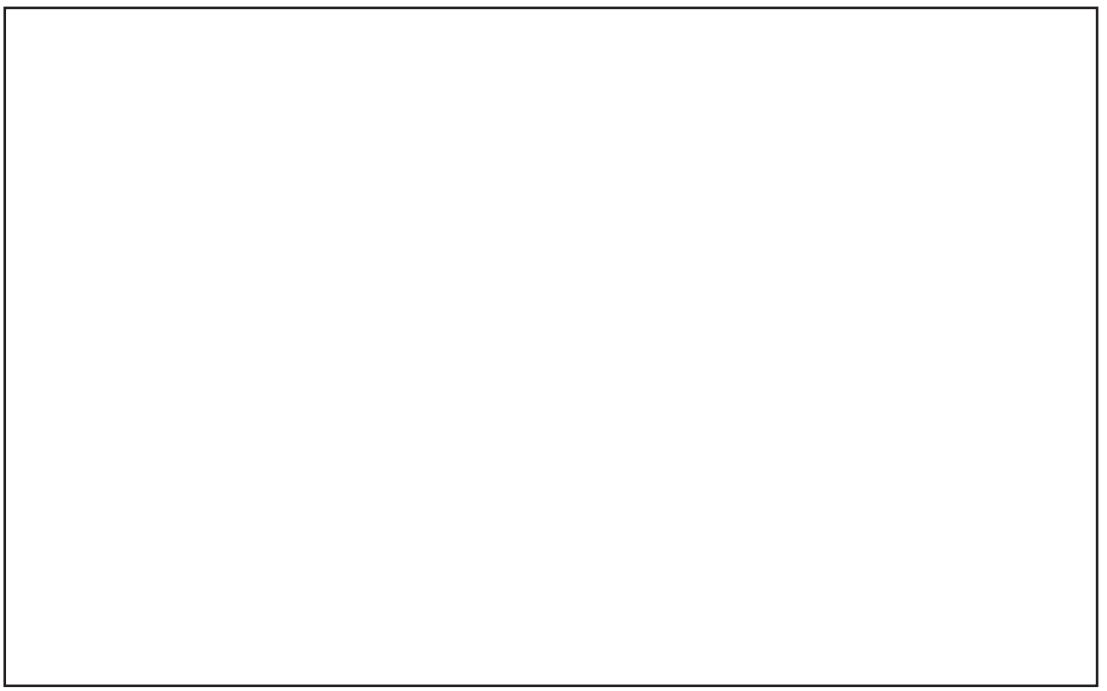
1. Overall growth of seedling in various media (T_7-sand, burnt rice husk + charcoal and compost in 25:15:60; T_3 sand, compost in 25:75; and T_1-sand, soil, compost in 40:10:50 ratio)
2. Over view of seedling with the best potting medium (T_1-sand, soil, compost in 40:10:50 ratio) with plug formation.

upto 10% (v/v) proved helpful in the overall growth of seedlings and better plug formation. Details of the results obtained for the effect of various treatments on seedling growth parameters are given in Table 2.

Improvement in the growth of seedlings with addition of organic mix like cocopeat in *Pterocarpus macorcarpus* (Kijkar, 1991) and *Swietenia macrophylla* (Woods *et al.*, 1998), compost in *Eucalyptus tereticornis* (Srivastava *et al.*, 1998), *Acacia nilotica* and *Dalbergia sissoo* (Ginwal *et al.*, 2001, 2002) and mushroom waste in *Casuarina equisitefolia* (Savio *et al.,* 1999) have been reported. The requirement of organic matter in potting medium varies with species, in *S. album* 50 per cent compost was optimum for obtaining the best overall seedling growth. However, in *Acacia nilotica* and *Dalbergia sissoo* 80 per cent compost resulted in the best growth and *Eucalyptus tereticornis* required only 40 per cent compost (Srivastava *et al*., 1998). Woods *et al.* (1998) observed better growth of *Swietenia macrophylla* seedlings at nursery stage as well as in the field by using organic potting mixture

Effect of sieve size of potting medium : This study reveled that sieve size of the potting medium ingredients has significant effect on the seedling growth. It is evident from the results that at the age of six months, treatment S_4 (6 x 6 holes/sq.inch) showed maximum seedling height (17.68cm), collar

Fig. 3



Effect of different sieve size of potting medium ingredients on overall seedling growth of *S. album* at the age of 6 months in 270 cc block type root trainers.

diameter (3.17 mm), shoot dry weight (1.20g), root dry weight (0.54g), total dry matter (1.72 g) and quality index (0.22). Increase of sieve size from 12x12 to 6x6 holes/ sq inch, resulted in increase in seedling growth (Fig. 3). This can be attributed to long gestation period (6 months) and its parasitic nature, which need particularly coarse textured material to accommodate roots (Scagal and Davis, 1988). The other reason could be that by increasing the particle size there is increase in aeration and porosity, thereby better growth of seedling. Further increase of sieve size to 4 x 4 holes/sq inch exhibited poor seedling growth. This may be due to large particle size of the potting medium ingredients particularly sand, which has poor water holding capacity in the potting medium. Details of the results of sieve size of potting medium on seedling growth are given in Table 3.

Conclusion

It is concluded from the present study that the potting medium ingredients, their proportion and sieve size have significant effect on the growth of sandalwood seedlings. Plantable quality seedlings of sandalwood can be recovered within six month period using potting medium with compost, sand and soil in the ratio of 50:40:10 and sieved by sieve size of 6 x 6 holes/sq inch in 270 cc block type root trainers with *Cajanus cajan* as a primary host. Analysis of potting medium ingredients provides scope for further nutritional enrichment of medium to boost seedling growth.

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SUMMARY

Eight combinations of potting medium ingredients and five sieve sizes of potting medium were used to find their effect on seedling growth of *Santalum album* L. in 270 cc block type root trainers using *Cajanus cajan* as a primary host. Analysis of potting medium ingredients was also carried out to find their mechanical, physical and chemical properties to understand its impact on seedling growth. The best seedling growth in terms of height, collar diameter, total dry weight, shoot dry weight, root dry weight and root shoot ratio was observed in potting medium consisting sand: soil: compost in the ratio of 40:10:50. High level of compost and low level of sand (75:25) favoured shoot growth and collar diameter, but further increase in organic matter (compost + cocopeat) inhibited overall growth of seedlings. Potting media consisting rice husk and charcoal (7.5% each) exhibited poor growth. Low level of soil (10%) in the potting medium favoured less compaction, better plug formation and seedling growth. Sieve size had significant effect on seedling growth. Potting medium sieved through 6 x 6 holes/sq inch proved the best for overall growth of seedlings, followed by 8 x 8 holes/sq inch. Increase (4 x 4 holes/sq inch) or decrease (12 x 12 and 10 x 10 holes/sq inch) in sieve size of the potting medium resulted in poor growth of the seedlings. By integrating the results of potting medium and sieve size, quality seedlings of sandalwood can be obtained within six months in 270 cc root trainers.

जड़े प्रसाधकों में *सैण्टेलम एल्बम* लि० (चन्दन) के पौधों की बढ़वार पर उगाने के माध्यम के घटकों और चालनियों के आकार से पड़ता प्रभाव

डी० अन्नपूर्णा, टी०एस० राठौड़ व जी० जोशी

सारांश

कैजानस कैजान को प्रधान पोषी के रूप में लेकर 270 घनसेरी के खण्ड प्रकार के जड़ प्रसाधकों में *सैण्टेलम एल्बम* लि० के पौधों की बढ़वार पर पड़ते प्रभावों का पता लगाने के लिए पौधों को उगाने के माध्यम घटकों के आठ संयोग और उनकी छनाई करने के पांच चालनी आकारों को उपयोग कर देखा गया। पौधों की बढ़वार पर पड़ते प्रभाव समझने के लिए उगाने के माध्यम के घटकों की संघारी, भौतिक एवं रासायनिक विशेषताएं जानने के लिए उनका विश्लेषण भी किया गया। पौधों की बढ़वार को उनकी ऊंचाई, मूलसंधि पर व्यास, कुल शुष्कभार, प्ररोहों का शुष्क भार, जडों का शुष्कभार एवं जड़ प्ररोह अनुपात की दृष्टि से पोधे उगाने के माध्यम में देखा गया तो सर्वोत्तम बढ़वार उस माध्यम में देखी गई जिसमें रेतः मृदाः कंपोस्ट को 40:10:50 समनुपात में मिलाया गया था। अधिक मात्रा में कंपोस्ट और अल्पमात्रा में रेत (75:25) मिश्रण प्ररोह वृद्धि और मूलसंधि पर व्यास के अनुकूल रहा किन्तु माध्यम में जैव पदार्थ (कंपोस्ट + नारियल की जीर्णमृदा) बढ़ाने से पौधों की समग्र बढ़वार बाधित हुई। गमला माध्यम जिसमें धान की भूसी और लकड़ी–कोयला (प्रत्येक 7.5%) मिलाए गए थे, से पौधों की बढ़वार घटिया रही। गमला माध्यम में मृदा कम रखने (10%) से गमला माध्यम मिट्टी की निविड़ता कम बनी, प्लग निर्माण और पौधा वृद्धि ज्यादा अच्छी रही। चालनी आकार का पौधा, की बढ़वार पर सार्थक प्रभाव पड़ा। गमला मिट्टी (या माध्यम) जिसे 6 x 6 छेद/इंच^2 चालनी में छाना गया पौधों की समग्र बढ़वार के लिए सर्वोत्तम सिद्ध हुआ, उसके बाद 8 x 8 छेद/इंच^2 चालनी से छना माध्यम रहा। छेद आकार में वृद्धि (4 x 4 छेद/इंच^2) या कमी (12 x 12 छेद और 10 ग 10 छेद/इंच^2) माध्यम को छानने की चालनी के आकार में करने से पौधों की बढ़वार घटिया हो गई। गमला माध्यम और चालनी आकार में परिणामों को मिलाने पर चन्दन के गुणवत्ता वाले पौधे 270 धनसेमी वाले जड़ प्रसाधकों में छह महीनों के अन्दर प्राप्त किए जा सकते हैं।

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