

EFFECT OF SEED SOURCE AND SIZE ON SEED GERMINATION AND SEEDLING VIGOUR OF SANDAL (*SANTALUM ALBUM*)

V. Manonmani

Department of Seed Science and Technology, Agricultural Research Station, Aliyar Nagar - 642 101, Tamil Nadu, India

&

K. Vanangamudi*

Department of Seed Science and Technology, Forest College and Research Institute, Mettupalayam - 641 301, Tamil Nadu, India

Sandal (*Santalum album*) is valued in India for its oil which contain santalol extracted from its heartwood. Sandal is nominated as one of the priority species in the establishment of industrial plantation forests. The execution of this programme faces many problems, such as limited seed source and seed handling techniques. Seed is now available only from scattered natural stands. Seed weight of sandal varied significantly among various localities (Bagchi & Sharma 1989). Seedling vigour parameters differed significantly among different seed sources (Veerandra & Sarma 1990). Sandal exhibits polymorphism in characters like seed shape, size and weight. Difference in weight of seeds play an important role in the germination of seeds and survival of seedlings. In addition, it also reflects the adoptive variability of the species. A study was formulated with an objective of screening the best of the available sources for good seed quality and to delineate the effect of seed size on the seed germinability and seedling vigour.

Mature sandal seeds collected from Harur, Siruvani, Coimbatore and Mettupalayam areas of Tamil Nadu were cleaned and dried to safe moisture content of 12%. Seeds were observed for (1) 100 fruit weight (g), (2) seed length (cm), (3) seed breadth (cm) and (4) 100 seed weight (g). Seeds were then subjected to germination test in sand medium by sowing four replications of 25 seeds each (Anonymous 1993). Twenty-eight days after sowing counts were made and germination was expressed as the percentage of seeds which produced normal seedlings. Ten random seedlings were measured for root and shoot length. The vigour index (VI) was derived from the formula by Abdul-Baki & Anderson (1973).

$$VI = \text{Percentage germination} \times \text{seedling length (cm)}$$

where seedling length is the sum of root and shoot length.

Fifty seeds selected at random were pre-washed thrice with water and soaked in 50 ml of deionised water for 12 hours at room temperature and decanted. Electrical conductivity of the seed leachate was read in an Elico type CM 82 conductivity bridge with cell constant of one, in duplicate, and expressed as dS m^{-1} (Presley 1958). The oil extraction process was

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**Author for correspondence. Present address: Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore - 641 003, India. E-mail: kvanangamudi@rediffmail.com.*

carried out in Soxhlet apparatus as per the AOAC (1960) procedure. Oil content was calculated as below:

$$\text{oil content (\%)} = \frac{\text{weight of oil (g)}}{\text{weight of seed (g)}} \times 100$$

Mature sandal seeds collected from four different seed sources listed above were graded according to size using 72 mm (18/64") and 68 mm (17/64") sieves to obtain three seed size grades, namely, 72 R, 68 R and 68 P. Each grade was observed for seed recovery percentage on weight basis, seed length (cm), seed breadth (cm), 100 seed weight, germination percentage, root length (cm), shoot length (cm), dry matter production (mg), vigour index and oil content.

The experiments were set up in a completely randomised design. The results were subjected to analysis of variance and tested for significant differences ($p = 0.05$) as per Panse & Sukhatme (1967).

The effect of source was tangible in all physical and physiological parameters related to the seeds. Among the four sources included in the study, namely, Harur, Siruvani, Coimbatore and Mettupalayam, the 100 fruit weight, seed length, seed breadth and 100 seed weight ranged from 60.6 to 76.3 g, 7.1 to 7.7 cm, 6.2 to 6.7 mm and 16.5 to 18.5 g respectively (Table 1). Coimbatore recorded the highest values while Mettupalayam recorded the lowest. The same trend was reflected for germination percentage, root length, shoot length, dry matter production, vigour index and oil content (Table 2). The percentage increase for the above parameters recorded by Coimbatore over Mettupalayam was 13.0, 12.5, 16.6, 19.0, 25.9 and 9.5 respectively.

Table 1 Effect of seed source on initial seed quality parameters of sandal wood

Seed source	100 fruit weight (g)	Seed length (cm)	Seed breadth (mm)	100 seed weight (g)
Harur	75.65	7.67	6.61	18.15
Siruvani	62.63	7.37	6.49	16.77
Coimbatore	76.32	7.69	6.66	18.48
Mettupalayam	60.60	7.06	6.20	16.46
SED	0.08	0.01	0.02	0.05
CD ($p = 0.05$)	0.17	0.02	0.05	0.10

Table 2 Effect of seed source on germination, seedling attributes and biochemical parameters in sandal

Seed source	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (g seedling ⁻¹)	Vigour index	Electrical conductivity (dS m ⁻¹)	Oil content (%)
Harur	72.3 (58.3)	7.05	9.95	0.021	1230	0.117	57.00
Siruvani	67.5 (55.2)	6.73	8.68	0.018	1041	0.119	55.00
Coimbatore	74.5 (59.7)	7.19	10.23	0.021	1298	0.115	57.67
Mettupalayam	64.8 (53.6)	6.29	8.53	0.017	961	0.124	52.17
SED	0.22	0.04	0.06	0.00007	8	-	0.42
CD ($p = 0.05$)	0.46	0.09	0.12	0.00014	16	ns	0.88

The seeds collected from the above source recorded three different grades of size, 72 R, 68 R and 68 P, in varying frequencies. The ratio of 72 R, 68 R and 68 P recorded from Harur, Siruyani, Coimbatore and Mettupalayam seed sources were 1.37:1.35:1, 1.35: 1.29:1, 1.40:1.32:1 and 1.36:1.26:1 respectively. Within the same size grade the seed dimensions, namely, seed length, seed breadth and 100 seed weight were the highest for Coimbatore and the lowest for Mettupalayam (Table 3).

The size grades, 72 R, 68 R and 68 P, of Coimbatore location recorded a percentage increase of 16.1, 16.2 and 16.0 over the respective size grades of the next best location, which was Harur. Seedling growth, dry matter production and vigour index also followed the same line. The oil content of seeds from Coimbatore was the highest (55.2 %) followed by Harur (53.8%). It was also observed that the seed size and oil content were directly proportional. The seeds of 72 R recorded 3.0 and 10.0 % increases over 68 R and 68 P grades respectively (Tables 4 and 5). Hedge *et al.* (1991) reported that seedling establishment was positively associated with seed size.

Srimathi *et al.* (1977), Srimathi & Kulkarni (1982) and Manonmani *et al.* (1996) established that medium and heavier seeds performed better than lighter seeds. Growth of seedlings from large and heavy seeds can be assigned not only to the large reserve of nutritional matter in them but also to their chemical composition. Translocation of reserves from endosperm to embryo proceed differently in large and small seeds. Better-filled, large seeds of *Pinus thunbergii* transform more nitrogen from the endosperm to the embryo after sowing compared with small seeds (Katsuka 1964). Seed germination characters were under genetic control and the pattern of behaviour in cultivated or wild species may have resulted from selection for seed size, vigour and seedling growth (Wittington 1973). Small seeds gave maximum percentage of germination in comparison with big and medium seeds (Nagveni & Ananthapadmanabha 1986). However, bigger seeds recorded better survival and establishment than smaller- and medium-sized seeds.

Results of this experiment showed that it is important to collect sandal seeds from proven source (Coimbatore) and select only big-sized seeds in order to obtain maximum germination percentage and increased seedling vigour.

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Table 3 Effect of seed source and size grades on seed parameters in sandal

Seed source	Seed recovery (%)				Seed length (mm)				Seed breadth (mm)				100 seed weight (g)			
	72 R	68 R	68 P	Mean	72 R	68 R	68 P	Mean	72 R	68 R	68 P	Mean	72 R	68 R	68 P	Mean
Harur	37.03	36.08	26.89	33.33	7.81	6.92	5.99	6.91	6.86	6.36	6.06	6.43	17.98	16.12	14.21	16.10
Siruvani	37.17	35.43	27.39	33.33	7.57	6.51	6.00	6.69	6.71	6.31	5.96	6.33	16.96	15.63	13.79	15.47
Coimbatore	37.66	35.55	26.79	33.33	7.99	7.15	6.12	7.09	6.96	6.41	6.14	6.50	18.77	16.86	14.24	16.63
Mettupalayam	37.58	34.86	27.56	33.33	7.36	6.42	5.87	6.55	6.62	6.28	5.88	6.26	16.47	14.82	13.08	14.79
Mean	37.36	35.48	27.16		7.68	6.75	5.99		6.79	6.34	6.01		17.55	15.86	13.83	
	S	G	SG		S	G	SG		S	G	SG		S	G	SG	
SED	-	0.07	0.14		0.02	0.02	0.03		0.006	0.005	0.011		0.05	0.04	0.09	
CD (p = 0.05)	NS	0.14	0.27		0.04	0.03	0.07		0.013	0.010	0.022		0.10	0.09	0.18	

S = seed source; G = seed size grades

Table 4 Effect of seed source and size grades on germination as well as root and shoot length in sandal seeds

Seed source	Germination (%)				Root length (cm)				Shoot length (cm)			
	72 R	68 R	68 P	Mean	72 R	68 R	68 P	Mean	72 R	68 R	68 P	Mean
Harur	72.2 (59.7)	70.0 (57.8)	65.6 (55.6)	69.3 (56.4)	7.10	6.86	6.22	6.73	10.10	9.42	9.06	9.53
Siruvani	68.4 (58.2)	64.0 (56.8)	60.8 (54.1)	64.4 (53.4)	6.82	6.72	6.04	6.53	8.80	8.46	7.60	8.29
Coimbatore	74.6 (53.3)	71.6 (51.7)	68.0 (49.9)	71.4 (57.7)	7.28	6.98	6.40	6.89	10.32	9.94	9.58	9.95
Mettupalayam	64.2 (55.8)	61.6 (53.1)	58.6 (51.2)	61.5 (51.6)	6.30	6.06	5.86	6.07	8.54	8.22	7.46	8.07
Mean	69.9 (56.7)	66.8 (54.9)	63.3 (52.7)		6.88	6.66	6.13		9.44	9.01	8.43	
	S	G	SG		S	G	SG		S	G	SG	
SED	0.16	0.14	0.28		0.04	0.03	0.06		0.05	0.04	0.07	
CD (p = 0.05)	0.32	0.28	0.56		0.07	0.06	0.13		0.09	0.08	0.16	

S = seed source; G = seed size grades

Figures in parentheses indicate arcsin transformed values.

Table 5 Effect of seed source and size grades on dry matter production, vigour index and oil content in sandal seeds

Seed source	Dry matter production (g seedling ⁻¹)				Vigour index				Oil content (%)			
	72 R	68 R	68 P	Mean	72 R	68 R	68 P	Mean	72 R	68 R	68 P	Mean
Harur	0.022	0.025	0.023	0.023	1242	1140	1002	1128	58.9	54.2	50.2	53.8
Siruvani	0.018	0.017	0.017	0.018	1069	972	829	957	54.2	53.4	50.6	52.7
Coimbatore	0.029	0.027	0.024	0.027	1313	1212	1081	1202	57.9	56.0	51.6	55.2
Mettupalayam	0.016	0.016	0.014	0.016	953	880	780	871	51.8	50.6	48.2	50.2
Mean	0.022	0.022	0.019		1144	1051	923		55.2	53.6	50.2	
	S	G	SG		S	G	SG		S	G	SG	
SED	0.0004	0.0003	0.0006		6	5	10		0.4	0.4	0.7	
CD (p = 0.05)	0.0007	0.0006	0.0013		11	10	20		0.8	0.7	0.4	

S = seed source; G = seed size grades

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