

Growth Performance and Genetic Divergence of Various Provenances of *Dalbergia Sissoo* ROXB. at Nursery Stage

By H. C. SAGTA and S. NAUTIYAL

Plant Physiology, Botany Division, Forest Research Institute,
Dehradun – 248006, India

(Received 18th August 1998)

Summary

Seeds of *Dalbergia sissoo* ROXB. were collected from 59 provenances in its natural distribution zone (latitudes 24° 42' N to 32° 36' N, longitude 74° 30' E to 94° 36' E, altitude 76 m to 460 m asl) from India and Nepal. Seedlings were raised in polythene bags at four nurseries in India under randomized block design. The data on growth and survival were recorded after one and half year. Significant variation was observed among all the provenance as well as nursery sites for all observed characters at 1% level of significance. Provenance from eastern part of Uttar Pradesh showed average to best results at the four nursery sites. The overall performance of provenances was best at the Lucknow nursery. Average growth in all 4-nurseries exhibited that Shahbad, Pilibhit, Mainpuri, Laxmipur from Uttar Pradesh and Simblewala from Jammu and Kashmir provenance to be the best. Minimum growth observed in Firozabad, Sultanpur and Kunda provenances from Uttar Pradesh and Rohtak provenance from Haryana. Correlation showed that the increasing or decreasing pattern of latitude, longitude, altitude and rainfall did not have any positive or negative effect on the provenance variation.

Key words: *Dalbergia*, provenance, nursery variation.

Introduction

Dalbergia sissoo is one of the important indigenous multi-purpose tree species of northern India. *Dalbergia sissoo* occurs naturally in India in the foothills of Himalayas mostly in tarai and bhabhar areas up to 1404 m above mean sea level from Jammu and Kashmir in the west to Bangal Dwar in the east. Commonly found in bouldery alluvial soils adjoining rivers, often it occurs in association with *Acacia catechu*. It fixes atmospheric nitrogen and is among the villagers most preferred plantation species. Its high quality sawn timber is used for furniture manufacture and building construction. It can be lopped for fodder and small branches can be used as fuel wood. The basic idea of *sissoo* improvement is to improve its growth and form. Normally the tree has an undesirable crooked bole with many bends.

In the tarai area, it has been widely planted, some times in large-scale plantations. It has great potential as a valuable afforestation species, but remarkably, little work has been done on its provenance testing, plus tree selection etc.. These activities were initiated by VAKSHASYA (1988). VAKSHASYA *et al.* (1992), BANGARWA (1993), TEWARI and SHARMA (1994) and SHIV KUMAR *et al.* (1994) in India, REHMAN and Hussain (1986), REHMAN *et al.* (1994) in Pakistan and NEIL (1990), HAWKINS (1986) and WHITE *et al.* (1990, 1994) in Nepal. However, these trials did not have representation of provenance from the entire natural range of distribution of this species nor were those tests carried at multiple sites.

This paper summarises the result of range – wise provenance trial of *D. sissoo* conducted in nurseries at four sites in India.

Material and Method

The seeds of *Dalbergia sissoo* ROXB. were collected during January and February, 1994 from 59 provenances in India and Nepal covering almost the entire range of its natural distribution. Each provenance was represented by the seeds mixed from 25 average trees in natural stands having approximately the same age and mean diameter at breast height. The trees were selected as per the method suggested by F.A.O. (1985), TURNBULL (1975) and MELCHIOR and VENGAS TOVER (1978). Preferably, seeds from the stands in the area of proposed sites were collected and mixed in equal amount as a representative of the general population of that geographical area. The selected trees were located at least 100 m apart from one another. These selected trees were marked before collection of pods. All 59 provenances represented a wide geographical range from 24° 42' N (Lalitpur, Uttar Pradesh) to 32° 36' N (Vijaypur, Jammu) latitude and 74° 30' E (Vijaypur, Jammu) to 94° 36' E (Sibsagar, Assam) longitude (*Table 1* and *Fig. 1*). Altitudinal range of provenance from 76 m (Varanasi, Uttar Pradesh) to 460 m (Chiriyapur, Kotdwar, Uttar Pradesh) above mean sea level. Meteorological data of the seed collection sites exhibited variation in average rainfall from 176 mm/annum (Jind, Haryana) to 2504.30 mm/annum (Sibsagar, Assam) (*Table 1* and *Fig. 1*). The pods were dried in the sun prior to extraction of seed.

Table 2 represents the details of latitude, longitude, temperature variation and average rainfall of various locations of the nurseries where the provenances were tested. Five hundred seeds from each provenance were sown directly on nursery beds at Chichhrauli (Haryana), Hoshiyarpur (Punjab), Jammu (Jammu and Kashmir) and Kukrail (Uttar Pradesh) during April 1994. Around 60% to 70% germination was noticed in all provenances at all nurseries. After 30 days, 200 uniform healthy seedlings of each provenance were uprooted and transferred in polybags (9" length and 5" diameter) containing 2: 1: 1 mixture of soil, sand and farm yard manure. After one-month acclimatization of seedling in polybags, the experiment was set up in randomized block design with four replications and each replication containing 50 seedlings of individual provenance. Same design was followed at all four sites. The data on survival, plant height and collar diameter was recorded during September 1995. 40 plants per provenance (10 plants for each replicate thus 40 plants for four replicates) were measured for plant height and collar diameter, however survival percentage was calculated based on number of seedlings survived out of total 200 seedlings planted in four replicates of each provenance. Analysis of variance was done with SPSS computer software. Critical difference was calculated by the method suggested by SCHEFF, which is based on F statistics.

Result

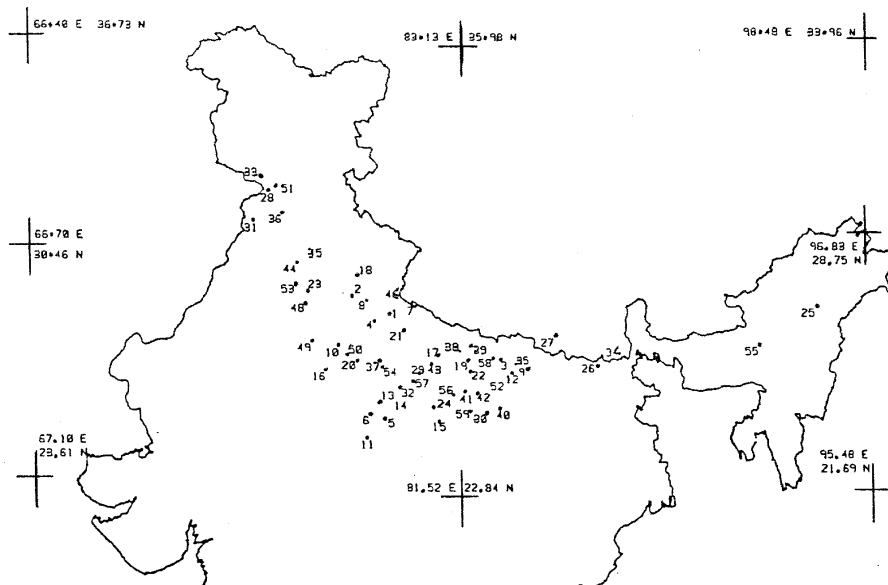
The survival percentage and growth parameters (height and collar diameter) of 59 provenances are shown in *table 3*.

Table 1. – Details of provenance, their location and average rain fall.

S. No.	Place of provenance	State	Month of Seed Collection	Latitude	Longitude	Altitude (m)	Average Rainfall (mm/annum)
1	Anwala, Ram Nagar Bareilly	Uttar Pradesh	February 94	28° 24" N	79° 30" E	173	1068.30
2	Sohanpur, Nazibabad	Uttar Pradesh	January 94	29° 36" N	78° 18" E	214	1465.00
3	Basti	Uttar Pradesh	February 94	26° 29" N	82° 28" E	225	1054.00
4	Bilari, Moradabad	Uttar Pradesh	February 94	28° 48" N	78° 48" E	088	0628.00
5	Mahavranipur, Jhansi	Uttar Pradesh	February 94	25° 18" N	79° 12" E	250	0250.00
6	Jhansi	Uttar Pradesh	February 94	25° 24" N	78° 36" E	251	1000.00
7	Gauri Bazar, Dewaria	Uttar Pradesh	February 94	28° 42" N	80° 30" E	162	0991.00
8	Binawar, Malgan, Badaun	Uttar Pradesh	February 94	28° 12" N	78° 58" E	224	1267.00
9	Shahbad, Rampur	Uttar Pradesh	January 94	26° 36" N	83° 48" E	078	0634.00
10	Mathura	Uttar Pradesh	January 94	27° 30" N	77° 42" E	127	0750.00
11	Lalitpur	Uttar Pradesh	January 94	24° 42" N	78° 30" E	211	0854.00
12	Rudrapur, Deoria	Uttar Pradesh	February 94	26° 24" N	83° 36" E	148	0982.00
13	Garautha, Jhansi	Uttar Pradesh	February 94	25° 48" N	79° 00" E	260	0950.00
14	Rajpura, Simora, Pilibhit	Uttar Pradesh	January 94	25° 30" N	79° 24" E	112	0896.00
15	Manikpur, Banda	Uttar Pradesh	January 94	25° 06" N	81° 06" E	157	0761.00
16	Mau, Ranipur, Jhansi	Uttar Pradesh	January 94	26° 48" N	77° 06" E	128	0835.00
17	Shajanwa, Basti	Uttar Pradesh	January 94	27° 00" N	81° 06" E	235	1013.00
18	Chiriyapur, Kotdwar	Uttar Pradesh	January 94	29° 36" N	78° 30" E	460	1166.00
19	Firozabad	Uttar Pradesh	January 94	26° 48" N	82° 06" E	088	0834.00
20	Bahraich	Uttar Pradesh	January 94	27° 05" N	81° 14" E	124	1177.00
21	Raikheeda, Shahjahanpur	Uttar Pradesh	February 94	27° 54" N	79° 54" E	221	0714.00
22	Sultanpur	Uttar Pradesh	January 94	26° 30" N	82° 10" E	085	0754.00
23	Sweeti, Hisar	Haryana	January 94	29° 12" N	75° 42" E	221	0446.00
24	Allahabad	Uttar Pradesh	January 94	25° 30" N	80° 54" E	098	1027.00
25	Sibsagar	Assam	January 94	27° 00" N	94° 36" E	097	2504.30
26	Koshi Tappu, Sunsari	Nepal	January 94	26° 23" N	86° 35" E	085	1992.10
27	Rapti River, Hitaunda	Nepal	January 94	27° 18" N	85° 12" E	166	2288.00
28	Simblewala, Jammu	Jammu & Kashmir	January 94	32° 18" N	74° 48" E	324	0978.00
29	Kanpur, Zoo	Uttar Pradesh	February 94	26° 30" N	80° 24" E	126	0879.00
30	Mirzapur	Uttar Pradesh	February 94	25° 12" N	82° 36" E	141	0683.00
31	G.T. Road, Amritsar	Punjab	February 94	31° 18" N	74° 54" E	234	0649.00
32	Kalpi, Jalaun	Uttar Pradesh	February 94	26° 06" N	79° 42" E	128	1096.00
33	Vijaypur, Jammu	Jammu & Kashmir	January 94	32° 36" N	74° 30" E	366	1148.00
34	Kankai, Gaire Domukha, Jhapa	Nepal	February 94	26° 25" N	87° 31" E	121	2491.00
35	Farinda, Gorakhpur	Uttar Pradesh	February 94	26° 42" N	83° 14" E	197	0942.00
36	Johan Khelan, Hoshiyarpur	Punjab	February 94	31° 30" N	75° 54" E	230	0710.00
37	Mainpuri	Uttar Pradesh	February 94	27° 00" N	79° 02" E	157	0671.90
38	Tulsipur, Gonda	Uttar Pradesh	January 94	27° 06" N	81° 54" E	110	1294.00
39	Laxmipur, Gonda	Uttar Pradesh	January 94	27° 15" N	82° 18" E	178	0821.00
40	Varanasi	Uttar Pradesh	January 94	25° 18" N	83° 00" E	076	1113.40
41	Pratapgarh	Uttar Pradesh	January 94	25° 54" N	81° 54" E	144	1234.00
42	Halia, Mirzapur	Uttar Pradesh	January 94	25° 48" N	82° 18" E	140	0655.00
43	Kukrail, Lucknow	Uttar Pradesh	January 94	26° 48" N	80° 54" E	111	0992.40
44	Sonti, Kurukshetra	Haryana	January 94	30° 00" N	76° 24" E	210	0475.00
45	Rajpur, Tikkipur, Ambala	Haryana	January 94	30° 24" N	76° 54" E	272	0958.80
46	Tanakpur, Nainital	Uttar Pradesh	February 94	29° 06" N	80° 00" E	118	1235.00
47	Faizabad	Uttar Pradesh	February 94	26° 48" N	82° 06" E	088	0834.00
48	Tilya Mini Zoo, Rohtak	Haryana	February 94	28° 54" N	76° 36" E	178	0567.00
49	Kashganj, Etah	Uttar Pradesh	February 94	27° 42" N	76° 18" E	160	0895.34
50	Agra	Uttar Pradesh	February 94	27° 12" N	78° 00" E	169	0765.40
51	Pathankot	Punjab	January 94	32° 18" N	75° 42" E	312	1486.40
52	Jaunpur	Uttar Pradesh	February 94	25° 48" N	82° 42" E	168	1110.00
53	Jind, Ukhilana	Haryana	February 94	29° 24" N	76° 18" E	302	0176.00
54	Etawah	Uttar Pradesh	February 94	26° 48" N	79° 06" E	130	0850.43
55	Udali, Nowgong	Assam	February 94	26° 13" N	92° 27" E	104	2485.00
56	Kunda, Pratapgarh	Uttar Pradesh	February 94	25° 47" N	81° 30" E	140	1249.00
57	Kanpur	Uttar Pradesh	February 94	26° 16" N	80° 14" E	120	0890.00
58	Khalilabad	Uttar Pradesh	February 94	26° 45" N	83° 00" E	220	1040.00
59	Phulpur, Allahabad	Uttar Pradesh	January 94	25° 19" N	82° 04" E	108	1073.00

Height, collar diameter and survival percent were significant influenced by provenance and nursery sites. Interaction of provenances with nursery sites was also significant at 1% level of significance. The maximum survival (86.67% and 83.50%) was recorded at four nursery sites for Mainpuri and Pratapgarh provenance from Uttar Pradesh. Minimum survival (11.50%) was observed for the provenance of Firozabad. Overall, the provenances showed that best survival (84.64%) at Lucknow nursery followed by the Jammu, Chichhrauli and

Hoshiyarpur nursery sites in respective order. Survivals at four nursery sites were significantly different from each other at 1% probability level. Further provenance with site, interaction maximum (100%) survival was observed for 15 provenances from different part of India at Jammu nursery sites. Minimum survival (2.5%) was observed for Rudrapur (Uttar Pradesh) provenance at Hoshiyarpur nursery followed by 4.5% for Hitaunda (Nepal) at Chichhrauli nursery and 8.00% for Firozabad at Jammu nursery.



S. No.	Name of provenance	S. No.	Name of provenance	S. No.	Name of provenance
1	Barcilly	21	Shahjahanpur	41	Pratapgarh
2	Nazibabad	22	Sultanpur	42	Halia
3	Khalilabad	23	Hisar	43	Kukrail
4	Moradabad	24	Allahabad	44	Kurukshetra
5	Mahavranipur	25	Sibsagar	45	Ambala
6	Jhansi	26	Koshi Tappu	46	Nainital
7	Gauri Bazar	27	Hitaunda	47	Faizabad
8	Badaun	28	Simblewala	48	Rohatak
9	Shahbad	29	Kanpur, Zoo	49	Etah
10	Mathura	30	Mirazapur	50	Agara
11	Lalitpur	31	Amritsar	51	Pathankot
12	Deoria	32	Kalpi	52	Jaunpur
13	Garautha	33	Vijaypur	53	Jind
14	Pilibhit	34	Jhapa	54	Etawah
15	Manikpur	35	Farinda	55	Nowgong
16	Mau	36	Hoshiyarpur	56	Kunda
17	Shajanwa	37	Mainpuri	57	Kanpur
18	Chiriyapur	38	Tulsipur	58	Khalilabad
19	Firozabad	39	Laxmipur	59	Phulpur
20	Bahariach	40	Varanasi		

Fig. 1. – Distribution of seed sources for *Dalbergia sissoo* over North Indian plains.

Table 2. – Location and meteorological data of nursery sites.

S. N.	Nursery Sites	State	Latitude	Longitude	Altitude (m)	Mean annual temperature (C)		Average Rainfall mm/annum
						Max.	Min.	
1.	Chichhraulí, Ambala	Haryana	30° 21'N	77° 30'E	272	45.80 °	2.00 °	0958.80
2.	Hoshiyarpur	Punjab	31° 19'N	75° 34'E	230	46.00 °	4.00 °	0710.00
3.	Jammu	Jammu & Kashmir	32° 26'N	74° 32'E	366	45.20 °	4.40 °	1148.30
4.	Kukrail, Lucknow	Uttar Pradesh	26° 33'N	80° 35'E	111	45.50 °	4.30 °	0992.40

Comparison average height at four nursery sites for all provenances showed that Pilibhit (92.47 cm), Mainpuri (92.03 cm) and Shahabad (89.90 cm) provenances from Uttar Pradesh were best among all. They also had shown the non-significant difference between each other but both significantly different from all other provenances at 1% level of significance. However, minimum height 53.35 cm was observed for Firozabad provenance from Uttar Pradesh. The average provenance performance with respect to height was best at Lucknow nursery followed by the Hoshiyarpur, Jammu and Chichhraulí nurs-

eries. Except Chichhraulí and Jammu nurseries, seedling height all other nurseries were significantly different from each other at 1% level of significance. For provenances with site interaction, Pilibhit and Kalpi from U.P. gained maximum height (134.30 cm and 136.95 cm) at Lucknow nursery and minimum observed for Mathura (36.4 cm) and Allahabad (36.00 cm) provenances at Hoshiyarpur nursery.

For collar diameter of seedling at all 4 nurseries Shahbad (6.81 mm) and Mahavranipur (6.70 mm) performed the best and Firozabad provenance from Uttar Pradesh (4.76 mm) prov-

Table 3. – Survival percentage, height and collar diameter of all the provenances at 4 sites.

S. No.	Name of Provenances	State	Survival Percentage (%)					Height (cm)					Collar Diameter (mm)				
			C	H	J	L	Mean	C	H	J	L	Mean	C	H	J	L	Mean
1	Bareilly	Uttar Pradesh	41.00 (39.67)	15.00 (22.15)	100.00 (90.05)	80.00 (63.84)	59.00 (53.92)	59.70 ±7.69	82.9 ±4.75	64.6 ±6.92	82.2 ±2.17	72.35 ±7.11	5.26 ±0.46	4.79 ±0.36	4.10 ±0.50	5.90 ±0.34	5.01 ±0.38
2	Nazibabad	Uttar Pradesh	22.50 (28.15)	20.00 (26.20)	100.00 (90.05)	87.50 (69.86)	57.50 (53.57)	65.60 ±3.69	91.6 ±8.02	69.8 ±5.15	93.9 ±3.56	80.23 ±7.30	6.21 ±0.42	6.41 ±0.75	4.86 ±0.31	6.04 ±0.34	5.88 ±0.35
3	Basti	Uttar Pradesh	52.00 (46.19)	75.00 (60.67)	95.00 (80.82)	85.00 (67.39)	76.75 (63.77)	60.50 ±4.70	57.3 ±5.15	62.5 ±4.43	97.4 ±3.43	64.43 ±9.39	6.02 ±0.16	5.03 ±0.28	4.30 ±0.40	6.71 ±0.38	5.52 ±0.53
4	Moradabad	Uttar Pradesh	17.50 (24.46)	12.50 (20.67)	78.00 (62.44)	90.00 (74.18)	49.50 (45.43)	55.7 ±4.57	77.8 ±4.69	69.2 ±5.04	94.2 ±4.05	74.23 ±8.06	4.64 ±0.45	6.45 ±0.45	5.36 ±0.46	6.57 ±0.20	5.76 ±0.46
5	Mahavranipur	Uttar Pradesh	18.00 (26.16)	—	27.00 (31.22)	90.00 (71.60)	45.00 (42.99)	65.1 ±5.07	—	68.3 ±5.05	105.3 ±6.04	79.57 ±12.92	5.76 ±0.43	—	5.01 ±0.20	9.32 ±0.31	6.70 ±1.33
6	Jhansi	Uttar Pradesh	—	74.00 (59.41)	65.00 (53.78)	87.50 (69.86)	75.33 (61.02)	—	75.2 ±7.13	62.6 ±6.19	78.4 ±4.90	72.07 ±4.83	—	6.87 ±0.63	4.54 ±0.44	5.96 ±0.30	5.79 ±0.68
7	Gauri Bazar	Uttar Pradesh	19.00 (25.53)	11.50 (19.81)	60.00 (50.87)	85.00 (70.48)	43.88 (41.67)	62.8 ±5.48	78.1 ±4.86	66.8 ±5.47	111.75 ±7.19	79.86 ±11.11	5.30 ±0.38	6.44 ±0.48	5.37 ±0.47	8.36 ±0.28	6.37 ±0.71
8	Badaun	Uttar Pradesh	57.50 (49.36)	42.50 (40.63)	100.00 (90.05)	80.00 (66.94)	69.88 (61.75)	71.88 ±3.9	68.2 ±8.40	59.3 ±3.86	122.1 ±7.62	80.37 ±14.16	6.36 ±0.36	6.17 ±0.70	4.25 ±0.38	8.01 ±0.35	6.20 ±0.77
9	Shahbad	Uttar Pradesh	26.50	—	60.00	85.00	57.17	62.2	—	74.30	133.2	89.90	5.64	—	5.11	9.67	6.81

ed the poorest. In nursery sites, Lucknow nursery showed the maximum collar diameter followed by the Chichhrauli, Hoshiyarpur and Jammu nurseries. For collar diameter, Chichhrauli nursery was not significantly different from Hoshiyarpur nursery but with other nurseries were showing the significant differences at 1% level of significance. For provenances and nursery sites interaction, many provenances at Lucknow nursery were best in comparison to other three nurseries. Mostly the provenances at Hoshiyarpur nursery showed the minimum collar diameter.

The performances of different provenances at different nurseries are as follows.

(i) Chichhrauli (Haryana)

As shown in table 3 in the Chichhrauli nursery of the 200 seedlings, best survival percentage was observed in the provenance of Simblewala (80%) and Jaunpur (75%). Provenances from Nepal, mainly Hitaunda and Jhapa showed that minimum survival (4.5% and 9.5%).

Provenances had significant differences in growth and survival at nursery stage. The maximum height (76.9 cm) was measured in Farinda and Pilibhit provenances of Uttar Pradesh. However, minimum height 44.5 cm was recorded in Hitaunda (Nepal) followed by 46.5 cm by Jaunpur (Uttar Pradesh). A similar result was also obtained for the collar diameter. The maximum collar diameter (6.95 mm) was measured for Shahjahanpur (Uttar Pradesh) and 6.87 mm for Jhapa (Nepal). Minimum collar diameter (4.08 mm) was measured for Hoshiyarpur (Punjab).

(ii) Hoshiyarpur (Punjab)

Major difference in survival percentage was recorded at the Hoshiyarpur nursery (Punjab). There were seven provenances in which seeds failed to germinate or seedlings died at the time of pricking out. Only two out of 59 seed lots in Hoshiyarpur nurseries reported more than 75% survival and provenance of Farinda (Uttar Pradesh) and Pratapgarh (Uttar Pradesh) were best with 80.5% survival. Least survival percentage was observed in the provenance of Rudrapur (2.50%) and Mathura (6.00%) (Table 3).

The Hoshiyarpur nursery showed that maximum height (104.4 cm and 99.8 cm) for Shahjahanpur and Shahjanwa and minimum height for Mathura (36.4 cm) and Allahabad (36.00 cm) provenances. Maximum collar diameter measured 8.37 mm and 7.54 mm for the provenance of Hitaunda (Nepal) and Kanpur (Uttar Pradesh) and minimum collar diameter

3.62 mm and 3.25 mm was measured for seed lot of Allahabad and Mathura provenance of Uttar Pradesh.

(iii) Jammu (Jammu and Kashmir)

Nursery at Jammu had remarkable survival percentage. Maximum number of seedlings survived in all seed lots with an average growth rate. There were maximum 15 seed lots with the highest 100% survival in comparison to other nurseries and minimum (8%) survival was observed for Firozabad (Uttar Pradesh) provenances only.

Maximum height recorded for Shahbad (74.3 cm) and Shaharanpur (72.00 cm) provenances of Uttar Pradesh. However, minimum height was recorded at 56.80 cm for Firozabad (Uttar Pradesh) and 57.00 cm in Hissar (Haryana). There was also a slight difference in collar diameter a maximum of 6.18 mm for Hoshiyarpur (Punjab) and 5.58 mm for Tulsipur (Uttar Pradesh) and a minimum of 4.10 mm for Bareilly (Uttar Pradesh) provenance was observed.

(iv) Kukrail, Lucknow (Uttar Pradesh)

Kukrail (Lucknow) nursery had the highest survival percentage in all the 59 provenances at germination stage. After one year in nursery trial 97.5% and 93.5% survival was recorded for Amritsar (Punjab) and Farinda (Uttar Pradesh). However, two provenances from Uttar Pradesh i.e. Sultanpur and Shahjahanpur showed that less than 65% survival.

The maximum height was measured at 134.3 cm and 136.95 cm for the Pilibhit and Kalpi provenances of Uttar Pradesh and minimum in case of Sultanpur (Uttar Pradesh) and Agra (Uttar Pradesh) (73.7 cm and 74.67 cm) respectively. Maximum collar diameter was observed to be 9.67 mm in Shahbad, 9.45 mm for Kalpi (Uttar Pradesh) and Laxmipur (Uttar Pradesh) and minimum 4.66 mm and 5.55 mm for Lalitpur and Agra provenance of Uttar Pradesh.

Correlation matrix

No significant differences, either positive or negative, were observed in between the parameter of geographical location and plant growth characters at 5% level of significance.

Discussion

Provenance covering the entire geographical range of *D. sissoo* distribution exhibited highly significant effect of provenance, nursery sites and provenance in to nursery site interaction. Similar study with 6 year old *Dalbergia sissoo* ROXB. plant from different provenances was done by the REHMAN and

		Pradesh	(30.91)	(50.86)	(70.48)	(50.75)	+3.00		+0.35	+6.36	+21.96	+0.45		+0.27	+0.59	+2.04	
10	Mathura	Uttar Pradesh	15.50 (23.19)	6.00 (11.79)	90.50 (74.68)	85.00 (70.48)	49.25 (45.04)	48.1 ± 2.02	36.4 ± 5.14	57.2 ± 8.19	113.95 ± 4.78	63.91 ± 17.21	4.25 ± 0.16	3.25 ± 0.29	4.21 ± 0.63	9.38 ± 0.67	5.27 ± 1.39
11	Lalitpur	Uttar Pradesh	27.00 (31.23)	10.00 (18.15)	100.00 (90.05)	80.00 (70.42)	54.25 (52.46)	69.9 ± 4.05	66.3 ± 5.13	59.3 ± 3.71	82.05 ± 2.53	69.39 ± 4.76	5.88 ± 0.38	5.21 ± 0.45	5.15 ± 0.29	4.66 ± 0.25	5.23 ± 0.25
12	Rudrapur	Uttar Pradesh	30.00 (32.2)	2.50 (4.61)	25.00 (29.96)	90.00 (74.47)	36.88 (35.34)	66.5 ± 7.99	46.00 ± 11.0	63.4 ± 2.72	120.7 ± 3.38	74.15 ± 16.16	6.48 ± 4.01	4.07 ± 0.76	4.66 ± 0.34	8.59 ± 0.28	5.95 ± 1.02
13	Garautha	Uttar Pradesh	32.50 (34.77)	22.50 (28.16)	63.50 (52.87)	90.00 (76.76)	32.13 (48.14)	62.4 ± 4.95	72.00 ± 7.26	62.8 ± 5.78	116.2 ± 3.17	78.35 ± 12.81	5.90 ± 0.56	5.74 ± 0.63	5.19 ± 0.48	8.12 ± 0.31	6.24 ± 0.65
14	Pilibhit	Uttar Pradesh	31.00 (33.67)	—	57.50 (49.57)	87.50 (69.86)	68.67 (50.96)	76.9 ± 6.19	—	66.2 ± 5.37	134.3 ± 5.13	92.47 ± 21.17	6.26 ± 0.57	—	5.20 ± 0.67	8.61 ± 0.51	6.69 ± 1.01
15	Banda	Uttar Pradesh	35.50 (36.53)	16.00 (22.67)	100.00 (90.05)	92.50 (76.50)	61.00 (56.43)	59.8 ± 5.62	83.33 ± 11.85	65.6 ± 4.33	124.7 ± 2.56	83.36 ± 14.66	5.28 ± 0.43	7.04 ± 1.08	4.78 ± 0.36	8.91 ± 0.45	6.50 ± 0.44
16	Mau	Uttar Pradesh	40.00 (39.17)	6.50 (10.05)	37.50 (37.73)	67.50 (55.35)	37.88 (35.58)	67.30 ± 6.30	47.5 ± 4.29	59.00 ± 3.83	86.7 ± 5.85	65.13 ± 8.26	5.82 ± 0.43	3.70 ± 0.30	5.15 ± 0.34	7.47 ± 0.30	5.54 ± 0.78
17	Shajanwa	Uttar Pradesh	47.00 (43.30)	18.50 (25.29)	32.50 (34.77)	87.50 (69.85)	46.38 (43.30)	66.10 ± 5.04	99.8 ± 8.97	70.3 ± 3.29	94.1 ± 4.49	82.58 ± 8.42	5.67 ± 0.65	7.26 ± 0.68	5.33 ± 0.34	7.08 ± 0.31	6.34 ± 0.49
18	Chiriyapur	Uttar Pradesh	16.50 (23.77)	16.00 (23.40)	90.00 (77.12)	90.00 (74.47)	53.13 (49.69)	68.1 ± 3.96	90.56 ± 6.72	65.50 ± 2.24	100.8 ± 2.84	81.24 ± 8.61	5.51 ± 0.32	6.40 ± 0.50	4.73 ± 0.15	6.94 ± 0.42	5.90 ± 0.49
19	Firozabad	Uttar Pradesh	—	15.00 (23.65)	8.00 (16.38)	—	11.50 (20.02)	—	49.9 ± 4.16	56.8 ± 4.59	—	53.35 ± 0.71	—	4.55 ± 0.37	4.97 ± 0.42	—	4.76 ± 0.21
20	Bahraich	Uttar Pradesh	32.00 (35.97)	8.50 (16.43)	62.50 (52.32)	91.00 (75.24)	48.38 (44.99)	49.33 ± 4.41	56.4 ± 5.30	58.3 ± 4.59	100.40 ± 4.48	66.11 ± 11.59	5.61 ± 0.54	4.28 ± 0.33	4.87 ± 0.46	7.81 ± 0.42	5.64 ± 0.77
21	Shahjahanpur	Uttar Pradesh	14.50 (22.27)	20.00 (26.21)	50.00 (45.02)	65.00 (54.03)	37.38 (36.86)	65.70 ± 3.72	104.4 ± 9.39	72.00 ± 2.98	83.5 ± 6.69	81.40 ± 8.51	6.95 ± 0.26	6.80 ± 0.85	5.05 ± 0.39	6.38 ± 0.30	6.30 ± 0.43
22	Sultanpur	Uttar Pradesh	37.00 (37.43)	27.50 (31.53)	90.00 (76.76)	63.00 (52.57)	54.38 (49.57)	57.6 ± 6.92	53.3 ± 7.54	63.6 ± 3.52	73.7 ± 4.58	62.05 ± 4.42	5.98 ± 0.31	4.41 ± 0.35	4.64 ± 0.22	5.92 ± 0.36	5.24 ± 0.41
23	Sweeti, Hisar	Haryana	30.00 (33.03)	27.50 (31.53)	100.00 (90.05)	85.00 (67.39)	60.53 (55.50)	66.5 ± 3.42	89.4 ± 7.11	57.00 ± 5.99	98.5 ± 3.69	77.85 ± 9.68	5.39 ± 0.62	7.40 ± 0.77	5.05 ± 0.64	7.66 ± 0.59	6.38 ± 0.67
24	Allahabad	Uttar Pradesh	47.50 (43.58)	48.50 (44.15)	100.00 (90.05)	77.50 (61.89)	68.38 (59.92)	59.1 ± 4.05	36.00 ± 0.87	58.6 ± 3.84	105.63 ± 3.77	64.83 ± 14.63	5.42 ± 0.29	3.62 ± 0.19	5.02 ± 0.26	7.71 ± 0.39	5.44 ± 0.85
25	Sibsagar	Assam	60.50 (51.15)	35.00 (36.16)	25.00 (29.72)	75.00 (60.03)	48.88 (44.27)	58.7 ± 6.25	64.00 ± 2.83	67.3 ± 4.60	92.65 ± 3.32	70.66 ± 7.54	5.15 ± 0.35	4.76 ± 0.32	5.24 ± 0.54	7.39 ± 0.21	5.64 ± 0.59
26	Koshi Tappu	Nepal	20.50 (26.56)	25.50 (30.29)	19.00 (25.57)	85.00 (67.39)	37.50 (37.45)	59.9 ± 2.17	69.70 ± 4.98	59.7 ± 5.24	108.54 ± 3.38	74.46 ± 11.60	6.06 ± 0.18	5.77 ± 0.47	5.27 ± 0.58	8.81 ± 0.25	6.48 ± 0.79
27	Hitaunda	Nepal	4.50 (11.74)	11.00 (18.41)	100.00 (90.05)	87.50 (69.86)	50.75 (47.51)	44.5 ± 6.18	93.2 ± 6.36	61.1 ± 7.03	109.3 ± 3.72	77.03 ± 14.76	4.46 ± 0.52	8.37 ± 0.71	4.68 ± 0.64	7.13 ± 0.43	6.16 ± 0.95
28	Simblewala	Jammu & Kashmir	80.00 (67.31)	11.00 (19.33)	100.00 (90.05)	84.50 (66.85)	68.88 (60.89)	73.4 ± 5.03	92.3 ± 6.83	66.6 ± 0.32	112.37 ± 4.09	86.17 ± 10.29	6.62 ± 0.51	6.86 ± 0.51	4.87 ± 0.60	7.81 ± 0.22	6.54 ± 0.61
29	Kanpur, Zoo	Uttar Pradesh	31.50 (34.0)	35.00 (36.27)	55.00 (47.97)	90.00 (74.18)	52.88 (48.13)	61.9 ± 3.67	76.9 ± 4.88	64.7 ± 2.31	120.5 ± 3.86	81.00 ± 13.56	5.05 ± 0.25	6.11 ± 0.40	5.06 ± 0.26	8.34 ± 0.14	6.14 ± 0.77
30	Mirzapur	Uttar Pradesh	23.50 (28.47)	25.50 (30.29)	100.00 (90.05)	88.00 (70.45)	59.25 (54.81)	66.2 ± 3.34	70.3 ± 4.81	61.1 ± 4.70	87.96 ± 0.99	71.39 ± 5.84	5.70 ± 0.25	5.40 ± 0.35	4.68 ± 0.65	5.78 ± 0.29	5.39 ± 0.25
31	Amritsar	Punjab	24.00 (29.31)	15.00 (22.66)	100.00 (90.06)	97.50 (85.43)	59.13 (56.86)	58.7 ± 3.59	55.9 ± 6.52	58.5 ± 5.42	106.96 ± 1.57	70.02 ± 12.33	5.70 ± 0.29	4.10 ± 0.53	5.27 ± 0.44	7.34 ± 0.35	5.60 ± 0.67
32	Kalpi	Uttar Pradesh	36.50 (37.30)	27.50 (31.53)	68.50 (56.00)	90.00 (74.18)	55.63 (49.75)	60.6 ± 4.82	50.4 ± 3.40	66.4 ± 5.54	136.95 ± 3.56	78.59 ± 19.73	4.68 ± 0.29	4.20 ± 0.17	4.55 ± 0.47	9.45 ± 0.27	5.72 ± 1.25
33	Vijaypur	Jammu & Kashmir	60.50 (51.15)	16.50 (22.95)	58.00 (49.66)	91.00 (72.67)	56.50 (49.11)	60.6 ± 4.02	53.3 ± 5.99	67.3 ± 1.67	120.9 ± 4.37	75.53 ± 15.39	6.81 ± 0.47	4.13 ± 0.37	4.97 ± 0.33	8.44 ± 0.44	6.09 ± 0.96
34	Jhapa	Nepal	9.50 (17.65)	61.00 (41.45)	55.00 (47.31)	89.50 (73.50)	53.75 (47.63)	59.3 ± 3.03	54.8 ± 4.17	58.6 ± 4.83	120.5 ± 3.94	73.30 ± 15.76	6.87 ± 0.51	4.59 ± 0.18	4.65 ± 0.52	8.54 ± 0.28	6.18 ± 0.96
35	Farinda	Uttar Pradesh	54.00 (48.54)	80.50 (67.95)	33.00 (35.07)	93.50 (77.28)	65.25 (57.21)	76.9 ± 3.57	69.5 ± 4.96	57.5 ± 4.87	93.39 ± 5.39	74.32 ± 7.51	6.53 ± 0.41	5.75 ± 0.43	5.09 ± 0.56	7.20 ± 0.32	6.14 ± 0.46
36	Hoshiyarpur	Punjab	46.50 (43.01)	66.50 (54.71)	59.00 (50.30)	85.00 (67.40)	64.25 (53.85)	51.2 ± 3.14	99.00 ± 4.16	67.00 ± 3.04	102.5 ± 3.51	79.93 ± 12.47	4.08 ± 0.53	7.52 ± 0.74	6.18 ± 0.31	7.29 ± 0.35	6.27 ± 0.91
37	Mainpuri	Uttar Pradesh	—	70.00 (56.97)	100.00 (90.05)	90.00 (76.76)	86.67 (74.59)	—	82.5 ± 3.81	63.1 ± 5.89	130.5 ± 5.33	92.03 ± 20.06	—	6.78 ± 0.34	4.49 ± 0.51	8.22 ± 0.44	6.50 ± 1.09
38	Tulsiapur	Uttar Pradesh	13.50 (21.27)	20.50 (26.56)	78.50 (62.63)	91.00 (72.77)	50.88 (45.81)	64.9 ± 4.36	57.4 ± 5.20	69.0 ± 2.93	109.4 ± 9.51	75.18 ± 11.66	5.72 ± 0.29	4.85 ± 0.33	5.38 ± 0.37	8.62 ± 0.38	6.19 ± 0.83
39	Laxmipur	Uttar Pradesh	28.50 (32.10)	—	95.00 (78.07)	88.50 (71.10)	70.67 (60.72)	76.9 ± 4.76	—	64.1 ± 3.23	117.35 ± 3.23	86.12 ± 16.07	6.35 ± 0.27	—	5.10 ± 0.43	9.45 ± 0.21	6.47 ± 1.29
40	Varanasi	Uttar Pradesh	50.50 (45.31)	—	69.00 (56.31)	88.50 (71.10)	69.33 (57.57)	64.5 ± 3.91	—	63.6 ± 5.97	120.05 ± 4.53	82.72 ± 18.69	5.57 ± 0.49	—	5.22 ± 0.67	8.38 ± 0.35	6.39 ± 1.00
41	Pratapgarh	Uttar Pradesh	71.00 (57.61)	80.50 (67.90)	97.50 (85.44)	85.00 (67.39)	83.50 (69.59)	73.8 ± 5.90	61.3 ± 5.81	61.4 ± 3.00	125.2 ± 2.76	80.43 ± 15.21	6.85 ± 0.48	5.53 ± 0.28	4.75 ± 0.30	8.27 ± 0.27	6.35 ± 0.77
42	Halifa, Mirzapur	Uttar Pradesh	22.00 (27.84)	20.00 (25.22)	67.50 (55.35)	90.00 (76.76)	49.88 (46.29)	51.9 ± 3.17	56.00 ± 5.35	64.8 ± 4.53	129.65 ± 6.25	75.59 ± 18.22	5.53 ± 0.40	3.92 ± 0.37	4.90 ± 0.42	6.97 ± 0.69	5.33 ± 0.64
43	Kukrail	Uttar Pradesh	31.50 (34.14)	30.50 (35.50)	33.50 (35.37)	85.00 (68.05)	45.13 (42.74)	64.7 ± 6.48	42.5 ± 4.38	63.7 ± 7.28	120.35 ± 4.67	72.81 ± 16.65	6.35 ± 0.50	3.81 ± 0.25	5.01 ± 0.66	7.94 ± 0.21	5.78 ± 0.89
44	Kurukshetra	Haryana	42.00 (40.32)	79.00 (63.15)	31.50 (34.10)	85.00 (67.39)	59.38 (51.24)	68.9 ± 4.14	64.7 ± 4.58	63.9 ± 5.64	99.05 ± 5.33	74.14 ± 8.38	5.57 ± 0.35	4.69 ± 0.21	4.78 ± 0.36	8.66 ± 0.20	5.93 ± 0.93
45	Tikkipur	Haryana	26.50 (30.53)	65.00 (53.78)	100.00 (90.05)	87.50 (69.86)	69.75 (61.05)	51.00 ± 3.58	66.00 ± 2.45	61.5 ± 2.16	100.25 ± 5.88	69.69 ± 10.66	5.28 ± 0.41	5.4 ± 0.19	4.97 ± 0.27	7.89 ± 0.43	5.89 ± 0.67
46	Nainital	Uttar Pradesh	41.50 (40.11)	60.00 (50.86)	90.00 (74.18)	75.00 (60.09)	66.63 (56.31)	56.6 ± 3.66	80.4 ± 6.62	62.7 ± 3.73	99.1 ± 5.52	74.70 ± 9.57	4.48 ± 0.23	6.49 ± 0.60	4.32 ± 0.34	7.83 ± 0.43	5.78 ± 0.84

HUSSAIN (1986) and found significant variation for growth characters. Variation in growth characteristics of different tree species has also been reported by SHIV KUMAR and BANERJEE (1986), DHILLON *et al.* (1995) and GINWAL *et al.* (1995). Data collected from the provenances at four nurseries indicated the

provenance from the eastern part of Uttar Pradesh, which is considered the home of *Dalbergia sissoo*, showed above average growth in all the locations. However, in survival percentage, the local provenances for a particular nursery site were observed to be the best. For instance, Hoshiyarpur provenance per-

47	Faizabad	Uttar Pradesh	28.50 (32.12)	—	26.00 (30.60)	86.00 (68.31)	46.83 (43.67)	60.9 ± 3.47	—	64.00 ± 5.64	101.3 ± 4.75	75.40 ± 13.00	5.72 ± 0.28	—	5.36 ± 0.52	8.25 ± 0.31	6.44 ± 0.91
48	Rohtak	Haryana	22.00 (27.84)	27.50 (31.54)	90.00 (74.18)	80.00 (63.84)	54.88 (49.35)	61.5 ± 4.17	51.1 ± 5.84	58.6 ± 2.91	84.3 ± 5.42	63.88 ± 7.15	5.74 ± 0.37	4.37 ± 0.30	4.72 ± 0.33	5.83 ± 0.46	5.17 ± 0.37
49	Kashgarj	Uttar Pradesh	39.00 (38.60)	70.00 (56.98)	35.50 (36.56)	82.50 (65.36)	56.75 (49.37)	59.1 ± 5.59	42.4 ± 2.98	58.6 ± 5.38	102.65 ± 2.62	65.68 ± 12.92	5.18 ± 0.36	4.16 ± 0.22	4.83 ± 0.52	7.61 ± 0.45	5.45 ± 0.75
50	Agra	Uttar Pradesh	42.00 (40.39)	7.50 (13.54)	64.00 (53.16)	70.00 (56.97)	45.88 (41.02)	62.4 ± 6.88	67.00 ± 2.56	58.9 ± 5.28	74.67 ± 5.22	65.74 ± 3.41	6.10 ± 0.71	5.48 ± 0.38	5.37 ± 0.62	5.55 ± 0.41	5.63 ± 0.16
51	Pathankot	Punjab	39.50 (38.94)	68.00 (55.67)	100.00 (90.05)	85.00 (67.39)	73.13 (63.01)	54.9 ± 9.27	73.4 ± 7.21	62.7 ± 2.56	74.75 ± 9.58	66.44 ± 5.47	5.95 ± 0.71	4.80 ± 0.41	6.73 ± 0.31	5.74 ± 0.45	5.74 ± 0.41
52	Jaunpur	Uttar Pradesh	75.00 (60.09)	55.50 (48.19)	82.50 (65.59)	75.00 (60.09)	72.00 (58.49)	46.5 ± 5.83	65.2 ± 7.12	66.6 ± 4.21	98.78 ± 2.35	69.27 ± 10.85	4.69 ± 0.41	6.47 ± 0.80	5.10 ± 0.46	6.85 ± 0.41	5.78 ± 0.52
53	Jind	Haryana	41.50 (40.11)	62.50 (52.28)	100.00 (90.05)	—	68.00 (60.81)	62.4 ± 5.84	72.7 ± 4.17	66.9 ± 7.54	—	67.33 ± 2.98	5.38 ± 0.47	5.84 ± 0.28	4.49 ± 0.63	—	5.24 ± 0.40
54	Etawah	Uttar Pradesh	46.50 (43.01)	20.00 (26.01)	36.50 (37.15)	85.00 (67.39)	47.00 (43.44)	55.1 ± 5.02	68.5 ± 8.32	62.5 ± 5.35	80.5 ± 6.50	66.65 ± 5.37	5.45 ± 0.49	5.83 ± 0.65	5.01 ± 0.58	6.52 ± 0.45	5.70 ± 0.88
55	Udali	Assam	—	33.00 (35.07)	55.00 (47.90)	80.00 (63.92)	56.00 (48.96)	—	67.2 ± 5.67	60.4 ± 4.95	105.75 ± 4.19	77.78 ± 14.12	—	5.64 ± 0.51	4.37 ± 0.36	9.44 ± 0.35	6.48 ± 1.52
56	Kunda, Pratapgarh	Uttar Pradesh	70.00 (56.86)	—	45.00 (42.14)	—	57.50 (49.50)	60.8 ± 5.9	—	63.2 ± 3.07	—	62.00 ± 1.20	6.50 ± 0.62	—	5.24 ± 0.32	—	5.87 ± 0.63
57	Kanpur	Uttar Pradesh	35.50 (37.15)	75.50 (60.15)	60.00 (51.08)	85.00 (68.05)	64.00 (54.31)	70.3 ± 3.85	91.4 ± 3.28	63.1 ± 4.85	89.8 ± 3.83	78.65 ± 8.87	6.79 ± 0.47	7.54 ± 0.54	5.19 ± 0.41	6.94 ± 0.30	6.62 ± 0.50
58	Khalilabad	Uttar Pradesh	53.50 (47.03)	16.00 (23.40)	59.00 (50.23)	85.00 (67.39)	53.38 (47.01)	59.8 ± 4.47	98.00 ± 8.58	69.1 ± 1.26	97.4 ± 3.43	81.08 ± 9.79	5.15 ± 0.52	6.85 ± 0.68	5.35 ± 0.28	6.71 ± 0.38	6.02 ± 0.44
59	Phulpur, Allahabad	Uttar Pradesh	66.50 (54.70)	33.50 (35.27)	33.00 (35.07)	83.00 (65.73)	54.00 (47.69)	75.9 ± 3.38	84.5 ± 4.27	65.1 ± 3.74	104.8 ± 3.64	82.58 ± 9.70	6.45 ± 0.31	6.30 ± 0.45	4.66 ± 0.24	7.51 ± 0.36	6.23 ± 0.59
Mean			36.88 (36.96)	34.62 (34.73)	68.03 (60.61)	84.64 (68.73)	56.71 (50.74)	62.42	69.25	63.50	104.14	74.77	5.7	5.56	4.94	7.6	5.02
Standard error of mean			± 2.39	± 3.29	± 3.67	± 1.27	± 3.92	± 2.13	± 3.24	± 1.92	± 2.83	± 9.73	± 0.19	± 0.25	± 0.18	± 0.62	± 0.39
Range	Minimum	4.50 (11.74)	2.50 (4.61)	8.00 (16.38)	63.00 (52.57)	11.50 (20.02)	44.50	36.40	56.80	74.67	53.35	4.08	3.25	4.10	4.66	4.76	
	Maximum	80.00 (67.31)	80.50 (67.90)	100 (90.05)	93.50 (77.28)	86.67 (74.59)	76.90	104.40	74.30	136.95	92.47	6.95	8.37	6.18	9.67	6.81	
CRITICAL DIFFERENCES																	
			Survival percentage				Height				Collar diameter						
Probability	Provenances	Site	Provenances * Site		Provenances	Site	Provenances * Site		Provenances	Site	Provenances * Site						
5%	14.61	1.20	45.39		22.59	1.86	70.73		3.57	0.29	11.18						
1%	15.55	1.45	47.08		23.97	2.24	73.91		3.79	0.35	11.68						

• Arc sine values of survival percentage and standard error of height and collar diameter are given in parentheses.

• C = Chichhrauli H = Hoshiyarpur J = Jammu L = Lucknow

formed better with 66.50% at Hoshiyarpur nursery, while its average survival at all the other sites was 64.25%. Better adaptability was observed in the provenances from eastern part of Uttar Pradesh. SINGH (1998) has made similar observations at nursery conditions for six provenances of *Dalbergia sissoo* from all natural sites in India and Nepal. The overall performance of the provenances was best at the Lucknow nursery. It may be because of the site being situated in the area, which is most favourable for *sissoo* growing. At Lucknow nursery, germination of seed was more than 90% and survival after transplantation was good. Maximum height and collar diameter was also observed in one-year-old seedlings at this nursery, which is an indicator of favorable environmental conditions for all provenances. Hoshiyarpur and Jammu nurseries showed that least overall survival for provenances. It may be due to the location of these sites in more northerly and low rainfall regions.

The best average growth at all four nursery sites was observed in Shahbad, Pilibhit, Mainpuri, and Laxmipur provenance from Uttar Pradesh and Simblewala provenance from Jammu and Kashmir. Among these Pilibhit, Mainpuri and Shahbad from Uttar Pradesh were outstanding and significantly different from all the other provenances. Minimum growth occurred in the provenances of Firozabad, Sultanpur, Kunda, from Uttar Pradesh and Rohtak from Haryana. In a study by SHIV KUMAR and BANERJEE (1986) it was observed that growth characters like height and collar diameter of *Dalbergia sissoo* exhibited significant variation due to provenance effect.

Table 4. - Correlation matrix between geographical location and recorded parameter.

Geographical location	Parameters		
	Survival	Height	Collar diameter
Latitude	0.145	-0.018	-0.051
Longitude	-0.176	0.056	0.158
Altitude	0.211	0.107	0.022
Average rainfall	-0.045	-0.028	0.106

Correlation matrix (Table 4) showed that non-significant correlation between parameter of geographical location and plant growth characters. It showed that increasing pattern of latitude, longitude, altitude and rainfall does not have any positive or negative effect on seedling growth. However, it shows the seed lots from the central part of India, natural range, mainly eastern parts of Uttar Pradesh, were best performs in all the four-nursery sites. The limited provenance trials of *Dalbergia sissoo* conducted until now have yielded conflicting results on variation between the provenance (NEIL, 1989; WHITE *et al.*, 1990). The provenance trial of *sissoo* was transferred in the field at all four sites during August 1996. The data is being collected annually and will be presented in paper form after analysis of data. That will give the field performance of various provenances at different locations.

References

BANGARWA, K. S.: Studies on provenance variation, progeny testing and reproduction in *Dalbergia sissoo* ROXB. Ph. D. thesis CCS Haryana

Agricultural University Hissar, India, Pp. 181 (1993). — DHILLON, R. S., BISLA, DHANDA, S. K. and SINGH, V. P.: Genetic variation and heritability of some growth traits in shisham (*Dalbergia sissoo* ROXB.). *Annals of Biol.* **11**(1): 107–110 (1995). — F.A.O.: A guide to forest seed handling: with special reference to tropics. FAO forestry paper No. 20/2, FAO, Rome, p. 379. (1985). — GINWAL, H. S., RAWAT, P. S., GERA, M., GERA, N. and SRIVASTAVA, R. L.: Study on the pattern of seed germination of various sub species cum provenance of *Acacia nilotica* WILLD. ex DEL. under nursery conditions. *Ind. For.*, pp. **29** (1995). — HAWKINS, T.: *Dalbergia sissoo* provenance trial. Forest Research Project Adabhar Trial Site Research Result 1980 to 1986. Forest Research and Survey Office, Deptt. of Forests, Kathmandu, Nepal (1986). — MELCHIOR, G. H. and VENEGAS TOVER, L.: Propuesta para Asegurar el Suministro de similar de *E. globus* en calidad comercialmente. Mezorados Psojeed Investigaciones de Desarrollo Industrial Forestales Col/74/005 PIF No. 14, Bogota, Colombia (1978). — NEIL, P. E.: Preliminary provenance testing of *Dalbergia sissoo*. *Banko Janakari* **2**(2): 113–114 (1989). — NEIL, P. E.: *Dalbergia sissoo* provenance testing in Nepal. Nitrogen fixing tree research report **8**: 130–132 (1990). — REHMAN, S. A., GUNASENAL, J. P. M. and JOSHI, R. B.: Comparative growth of *Dalbergia sissoo* ROXB. provenance. In: Proceeding of an International Workshop. SIDNEY B. WESTLEY and JAMES M. ROSHETTKO (eds.). Morrilton (AR) USA: NFTA. pp. 187–189 (1994). — REHMAN, S. A. and Hussain, A.: Growth and heritability estimates among six year old geographical source of Shisham (*Dalbergia sissoo*). *Pakistan. J. Forestry* **36**: 67–72 (1986). — SHIV KUMAR, P. and BANERJEE, A. C.: Provenance trials of *Acacia*

nilotica. *J. Tree Sci.* **5**(1): 53–56 (1986). — SHIV KUMAR, P., RAI, A. M., DWIVEDI, A. K. and BANERJEE, A. C.: Genetic improvement of *Dalbergia sissoo*. In: Proceeding of an International Workshop. SIDNEY B. WESTLEY and JAMES M. ROSHETHO (eds.). Morrilton (AR) USA: NFTA. pp. 183–186 (1994). — SINGH, N.: Physiological and biochemical parameters vis-à-vis genetic improvement in *Dalbergia sissoo*. ROXB. Thesis submitted to Deemed University, Forest Research Institute, Dehradun, India (1998). — TEWARI, D. N. and SHARMA, K. K.: Production of *Dalbergia sissoo* in India. In: Proceeding of an International Workshop. SIDNEY, B. WESTLEY and JAMES M. ROSHETTKO (eds.). Morrilton (AR) USA: NFTA. pp. 190–199 (1994). — TURNBULL, J.: Seed collection – sampling consideration and collection tech. In: Report of FAO/DANIDA training course of forest seed collection on handling held in Chiang Mai, Thailand, Feb./March. FAO/IF/RAS – 11 (DEN), FAO, Rome (1975). — VAKSHASYA, R. K.: Growth and foliar variation among provenances of *Eucalyptus camaldulensis* Dehradun. growth in Dehradun. *Proc. Indian Acad. (Plant Sci.)* **98**(6): 507–513 (1988). — VAKSHASYA, R. K., RAJORA, O. P. and RAWAT, M. S.: Seed and seedling traits of *Dalbergia sissoo* ROXB. provenance variation studies among ten source in India. *Forest Ecology and Management* **48**: 265–275 (1992). — WHITE, K. J., GAUTAM, I. and DAHL, M.: A study of six Nepal provenance of *Dalbergia sissoo* ROXB. at Sagarnath Forest Project, Central Nepal. *Banko Janakari* **2**: 363–381 (1990). — WHITE, K. J., GAUTAM, I. and DAHL, M.: *Dalbergia sissoo* ROXB. provenance trial at Sagarnath in Nepal. In: Proceeding of an International Workshop. SIDNEY B. WESTLEY and JAMES M. ROSHETHO (eds.). Morrilton (AR) USA: NFTA. pp. 200 (1994).

Genetic Divergence in *Bombax ceiba* L. Germplasm

By O. P. CHATURVEDI and N. PANDEY

Department of Forestry, Rajendra Agricultural University, Pusa (Samastipur)-848 125, Bihar, India

(Received 18th November 1999)

Abstract

Thirty germplasm lines of *Bombax ceiba* were evaluated for ten traits to study the pattern of genetic divergence using MAHALANOBIS' D^2 statistics. The genotypes were grouped in ten clusters. Cluster II, III and IV showed greater divergence. Cluster II was the most distant from others. Clusters mean indicated that cluster III was the best for plant height, stem girth (diameter), primary and secondary branches, root length and stem biomass, while cluster II and IV was the best for root width, leaf biomass and root biomass, respectively. Based on mean performance, genetic distance and clustering pattern hybridization involving germplasm lines, belonging to cluster II, III and IV, respectively; as parents for intra-population improvement may pave way for enhancing variability so as to select progenies with greater plant height, stem diameter and improved timber quality.

Key words: Genetic divergence, germplasm, *Bombax ceiba*.

Introduction

Bombax ceiba (semal) is an important tree species in India as economic value lies mainly in rapid growth and volume production. The wood is soft, light and whitish in colour. It is in great demand as match wood and very suitable for light plywood. The semal occurs in region showing a wide variability in temperature and rainfall, but thrives best in a comparatively moist tropical climate. It is often found scattered in mixed deciduous forests and in sal (*Shorea robusta*) forests and it is a characteristic tree on grassy savannah lands, where it often

becomes gregarious. Its wide distribution is due to the fact that the cotton covered seeds are carried by the wind to very considerable distance.

The species possesses enormous wealth of variability and great potential for economic yield which attract the breeders in utilizing the species in hybridization. A logical way to start any breeding programme is to survey the variations present in the germplasm. A clear understanding of the degree of divergence for important traits in the species will be an added adequate advantage in this regards, as inter-mating of divergent groups would increase variability and range of frequency distribution (ALICCHIO and PALENZONA, 1974). Precise information on the nature and degree of genetic divergence helps the plant breeder in choosing the diverse parents for purposeful hybridization (ARUNACHALAM, 1981). In a breeding programme progenies derived from diverse crosses are expected to show a broad spectrum of genetic variability, providing a greater scope for isolating transgressive segregants in the advance generations (BEALE, 1969). In fact, the work of genetic improvement of *B. ceiba* was initiated by establishing seed orchard raised in Assam during 1917 from the seed collected from all over India. At the same time F.R.I., Dehra Dun has also establish a biconal seed orchard of the species for frost resistance. The work on organized breeding of semal was started during 1960 at F.R.I., Dehra Dun (KEDHARNATH, 1983). However, no published information on genetic divergence of this species is available from Bihar. This study is aimed at estimating the degree of genetic divergence in *B. ceiba* germplasm lines and identifying