Growth performance of *Dalbergia sissoo* provenances of Nepal and Pakistan

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With a view to test the growth performance of *Dalbergia sissoo* provenance of Pakistan and Nepal, trials were established by the Forest Research Division in July 1990 at Tarahara and Shankarnagar at the eastern and western Terai of Nepal respectively. Among the eight provenances, three provenances of Nepal were included at Tarahara and one at Shankarnagar. Survival and mean heights were recorded just after planting thereafter and at one year interval upto 5.5 years. Diametre at breast hight (DBH) was measured at the age of 4.5 and 5.5 years. The statistical analysis of data of 5.5 years revealed that the provenances of Pakistan showed poor growth as compared to the other three provenances of Nepal. At Tarahara, Kankai Mai and Godavari provenances out-performed the Kamdi provenance whereas at Shankarnagar, Kamdi revealed the best growth as compared to the Pakistan provenances. Kankai Mai and Godavari provenances can be used as seed sources for planting programmes in lowlands.

Keywords : *Dalbergia sissoo,* Nepal, Pakistan, provenances, growth performance, DBH

Dalbergia sissoo is one of the most important and preferred multipurpose tree species for private plantation in the lowlands of Nepal. It provides highly valued timber and a range of other products such as fodder and fuelwood. It is the most preferred species for afforestation in the Terai, Bhabar and Duns of Nepal (Joshi 1994). Approximately, 90% of the plantations in this region is composed of this single tree species (Gautam 1996). In Nepal, *D. sissoo* occurs from Terai upto 1400 m from msl. It is common on well drained, alluvial soils adjoining rivers and streams where it is associated with *Acacia catechu*. The natural distribution of *D. sissoo* extends in the sub-Himalayan zone of Pakistan, India and Nepal. It grows on a variety of soils but it does not withstand waterlogging.

The seeds used in most of the current sissoo plantation in Nepal is generally chosen without any pre-information on the genetic qualities of trees. Among the various natural populations of *D. sissoo* it is essential to know the best seed source in plantation activities and for tree improvement programmes. In this context, the Forest Research Division of Forest Research and Survey Centre established, in the lowlands of Nepal, the provenance trials of *Dalbergia sissoo* at Tarahara and Shankarnagar in July 1990. The aim was to test the growth performance of provenances from Pakistan and Nepal. The result of the trials would help formulate recommen-dations for planting a particular provenance by obtaining large quantities of seed of known origin.

The sites

Two provenance trials of *D. sissoo* were established on the 15th and 20th of July 1990 at Tarahara and Shankarnagar respectively. Tarahara is situated on the sub-tropical zone and lies in the Terai of Sunsari District in Eastern region contains loamy soils (Annex 2). Its elevation is 155 m above msl and the latitude and longitude are 26°42' N and 87°16' E respectively. The average maximum and minimum temperature were 29.9° C and 18.7° C, the absolute maximum and minimum temperature of 41.8° C and 6° C are recorded. The mean annual rainfall was 1730 mm (Department of Hydrology and Meteorology- 1971 to 1975 and 1981 to 1985). The site was originally sal (*Shorea robusta*) forest mixed with *Terminalia alata, Terminalia bellerica, Syzygium cumuni* and *Lagerstroemia parviflora.*

Shankarnagar (alt. 205 m; latitude and longitude are 27°42' N and 83°28' E respectively.) lies in the

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Terai/Bhabar region of Rupandehi district in the Western region. The average maximum and minimum temperature of this site were 30.21°C and 20.21° C. The annual rainfall was 2452 mm (mean of 15 years records; of Department of Hydrology and Meteorology). The existing had coppice growth of *Shorea robusta* and other species were cleared two months before planting.

Materials and methods

Three provenances of Nepal and five provenances of Pakistan were included at Tarahara whereas only one provenance of Nepal and seven provenances of Pakistan (obtained through the F/FRED bilateral seed exchange programme) were included at Shankarnagar. Three provenances of Pakistan (Chichawatni, Punjab; Jhang Toba and Kanalia) had very poor germination so those could not be included in the trial at Tarahara. Similarly, Kanalia provenance of Pakistan and two provenances (Godavari and Kankai Mai) of Nepal could not be included in the trial at Shankarnagar.

At Tarahara, *Eupatorium* spp. (Banmara) were cut and burnt in March 1990. Spot weeding including removal of banmara was carried out in August 1990 followed by a complete cultivation in September 1990, and spot weeding in March 1991, September 1991, February 1992 and June 1992. At Shankarnagar, spot weeding was done two times a year, during the months of August and March upto 1.5 years. A dense cover of kush (*Eragrostis* sp.) was observed in this plot. However, they were cut two times a year during the experimental period.

Two months old seedlings (average height, 12 cm) were planted at a spacing of 2 x 2 m. A randomized complete block design of four blocks and eight provenances was implied at Tarahara (see Annex 1 for seed source) whereas three blocks with eight provenances (see Annex 1) was implied at Shankarnagar. A sub-plot of 7 x 7 plants with effective plot size of 5 x 5 plants was used at Tarahara whereas at Shankarnagar sub plot of 5 x 5 plant and the effective plot were of 3 x 3 plants.
Survival rate and height of seedlings were recorded seven months after planting and thereafter at every

Table 1: Means of height (m), DBH (cm) and % survival of eight *D. sissoo* provenances at Tarahara

	Months											
	7		19		30		42			54		
Provenances	Ht	S	Ht	S	Ht	S	Ht	S	DBH (cm)	Ht	S	DBH
Kankai, Jhapa*	0.78	78	3.48	77	5.54	77	6.10	77	6.64	6.5	75	7.88
Kamdi, Banke*	0.65	76	2.01	72	3.05	70	4.19	65	3.82	4.9	62	5.32
Godavari*	0.76	71	2.89	69	4.17	61	5.71	58	5.77	6.1	55	7.73
Kohat	0.70	90	2.00	88	2.75	82	3.17	81	-	3.4	79	3.59
Changamanga	0.68	84	1.93	79	2.57	78	3.04	75	-	3.4	72	3.37
Multan	0.59	86	1.63	84	2.18	76	2.47	72	-	2.8	65	2.98
Daphar	0.74	89	2.20	82	2.81	76	3.19	67	-	3.5	64	3.86
Bannu of Bannu	0.60	74	1.63	70	2.06	69	2.63	64	-	2.8	63	3.37

* Nepali provinance

Table 2: Means of height (m) and DBH cm and % survival of eight *D. sissoo* provenances at Shankarnagar

	Months										
	7		17		31		44		53		
Provenances	Ht	S	Ht	S	Ht	S	Ht	S	Ht	S	DBH
Kamdi, Banke*	0.40	96	1.60	74	2.7	74	4.11	66	5.44	66	5.7
Kohat,	0.38	89	1.10	81	1.6	81	2.10	81	2.93	81	2.3
Changamanga	0.29	96	0.98	85	1.3	78	1.34	74	1.87	70	1.3
Chichawatni	0.37	96	1.10	81	1.7	78	1.72	77	2.57	77	1.9
Multan	0.29	89	0.98	67	1.6	63	2.03	59	2.87	59	3.0
Daphar	0.33	85	1.23	81	2.1	74	2.31	74	3.20	70	3.5
Jhang Toba road	0.36	89	1.17	85	2.0	81	2.35	81	3.10	81	2.6
Bannu of Bannu	0.32	72	1.04	52	1.4	52	1.66	52	2.16	52	2.0

* Nepali provinance

one year for the whole experimental period. DBH was measured at the age of 4.5 and 5.5 years. The 3.5 years dbh data of Pakistan provenances at Tarahara and all dbh data of 3.5 years could not be measured at Shankarnagar due to the small size of plants. The data of 5.5 years were analysed by using ANOVA and Tukey's test.

Results

At Tarahara, on 20 September 1990, few seedlings were damaged by deer, rabbits and monkeys. More than eleven percent seedlings were found dead due to wilting of leaves and top drying which resulted in about ninety percent of mortality.

The mean height, mean dbh and survival percentage at five different periods are shown in Table 1 and 2.

A highly significant difference ($p<0.05$) in height and diameter growth between the provenances tested in the trial was found. At Tarahara, height growth of three Nepal provenances significantly differed ($P<0.05$) with that of the five Pakistani provenances. Similar was the result of Kankai and Godavari provenances with that of the Kamdi provenance of Nepal. However, Kankai and Godavari provenances had shown similar height and diameter growth at 5.5 years. All the five provenances of Pakistan did not differ in height and diameter growth. The diameter growth of Kamdi provenance of Nepal remained similar as that of Daphar provenance of Pakistan (Table 3).

The results of Shankarnagar after 5.5 years indicated that the height and diameter growth of the Nepali provenance were significantly different than that of the four provenances of Pakistan, namely Kohat, Changamanga, Chichawatni and Bannu of Bannu. However, the Kamdi provenance of Nepal remained similar in height and diameter growth as that of the Daphar and Jhang Toba provenances of Pakistan ($p<0.05$). All Pakistani provenances were more or less similar in height and diameter growth (Table 4).

At Tarahara, Bannu of Bannu provenance of Pakistan had the greatest variation in height growth (57.8%) at 5.5 years followed by other four provenances of Pakistan and one Nepal provenance (Kamdi, Banke). In contrast, height of trees of Kankai Mai and Godavari provenances were varied by only about 30 %, but the variation in diameter growth was about 38 percent (See Table 3). All Pakistan provenances and one Kamdi provenance of Nepal varied greatly in diameter growth (coefficient of variation being not less than 45 % - see Table 3). Moreover, variation in diameter growth was found higher than variation in height growth in all the eight provenances.

At Shankarnagar, although, the Kohat provinance of Pakistan had the highest survival, the Kamdi of Nepal attained the highest height growth (Table 4).

Discussion

Higher growth of Kamdi provenance at Shankarnagar than at Tarahara may be due to nearness of the seed source. Similar result of the Kankai provenance at Tarahara could also be due to the same reason. All the Pakistani provenances tested at the both sites, showed poor growth the reasons of which are not clear.

Table 3: Height, DBH, standard error of mean and coefficient of variation of eight provenances used at Tarahara at 5.5 years

Provenances	S (%)	Mean Ht (m)	SE	CV (%)	Mean DBH (cm)	SE	CV (%)
Kankai, Jhapa, Nepal	72.0	8.7 a	0.29	28.4	9.2	0.37	34.6
Kamdi, Banke, Nepal	58.0	6.6 b	0.37	42.5	6.8	0.48	52.2
Godavari, Kailali, Nepal	52.0	8.6 a	0.34	29.0	8.9	0.46	37.6
Kohat, Pakistan	69.0	4.5 c	0.21	39.5	4.6	0.26	45.4
Changamanga, Pakistan	64.0	4.2 c	0.23	43.4	4.3	0.29	50.2
Multan, Pakistan	58.0	3.5 c	0.22	47.3	3.8	0.32	59.6
Daphar, Pakistan	57.0	4.4 c	0.26	44.6	5.0	0.40	61.2
Bannu of Bannu, Pakistan	59.0	3.4 c	0.27	57.8	4.4	0.39	63.3

Means followed by the same letters do not differ significantly by Tukey's test.
Tukey's value for height = 1.946 Tukey' value for DBH = 1.920

In contrast, Godavari provenance of Nepal, which is located at about 700 Km west from Tarahara, had shown better performance in height and diameter growth. The Godavari seed source grew quickly than the Pakistan provenances in Pakistan also (Rehman, *et al.* 1993). It may be due to the genetic superiority of the trees used for seed collection, which is a matter of further research. Allozyme analysis of three provenances of Nepal could be one of the suitable and quick methods for the genetic comparison.

Wildlife damage and rust disease at Tarahara, might have decrease the survival percent within seven months of planting and reduced the growth subsequently in subsequent years (Table 1 and 3). In the early stage, the mortality of Nepali provenances was more than the mortality rate of Pakistan provenances. However, survival of six provenances aged 5.5 years at Tarahara differed slightly with one another except Kankai Mai (local provenance) and Kohat, Pakistan provenance (Table 3). It clearly reveals the higher mortality rate of the six Pakistani provenances in later years revealing unsuitability of these provenances.

The previous provenance trials established by the then Nepal-UK Silviculture Research Project at Adabhar in the Bhabar Terai in 1983 on *D. sissoo* had shown that the Pakistani provenances were not suitable for planting in Nepal (Neil 1989). Similar result was found in this study too.

A field trial established at Sagarnath, Sarlahi District by the Sagarnath Forest Development Project in September 1985 using six provinances of Nepal indicated that Kailali, Seti river was an outstanding sub-provenance for volume production, and was recommended for widespread planting (White *et al.* 1990).

In low quality site at Sagarnath, the height and diameter growth of sissoo at 5 years was 7.6 m and 7.4 cm respectively (Jackson 1994). The present study revealed that the growth of Nepal provenances (Kankai and Godavari) was slightly higher than the growth of sissoo in low quality site at Sagarnath. The profuse growth of weeds in the winter along with witling and rust at the trial site might have considerably decreased the growth of provinance.

The results from a particular provenance trial are, strictly speaking, only applicable for larger planting programmes if conditions on trial planting sites match well (Kjaer *et al.* , 1995). Considering the above fact, results obtained from Tarahara and Shankarnagar can be used safely in those sites similar to experimental sites. Restricted to 5.5 years growth of three provenances of Nepal, two provenances (Kankai and Godavari) can be used as seed sources for afforestation programme. Eventhough, it is most important to keep in mind that seed must be collected only from the morphologically sound as well as disease free trees.

Morphological study on trees of three Nepal provenances at Tarahara may help identify and compare the tree forms of the three provenances.

Table 4: Height, DBH, standard error of mean and coefficient of variation (%) of the eight provenances at Shankarnagar after 5.5 years.

Provenances	S (%)	Mean Ht (m)	SE of Mean (m)	CV (%)	Mean DBH (cm)	SE of Mean (cm)	CV (%)
Kamdi, Banke, Nepal	66.0	7.4 a	0.83	47.3	8.0 a	0.96	47.0
Kohat, Pakistan	81.0	3.5 b	0.30	40.3	3.9 b	0.54	56.2
Changamanga, Pakistan	67.0	2.5 b	0.23	38.5	2.4 b	0.38	47.8
Chichawatni, Pakistan	77.0	3.0 b	0.26	38.5	3.2 b	0.42	45.2
Multan, Pakistan	59.0	4.1 b	0.38	37.4	5.0 ab	0.79	60.0
Daphar, Pakistan	63.0	4.7 a b	0.33	29.1	4.8 ab	0.50	37.9
Jhang Toba road, Pakistan	78.0	4.2 a b	0.33	33.2	4.3 ab	0.40	39.3
Bannu of Bannu, Pakistan	52.0	2.8 b	0.34	43.1	3.0 b	0.81	63.1

Means followed by the same letters do not differ significantly by Tukey's test.
Tukey's value for height is 3.766, and 4.096 for DBH

Conclusion

Based on the 5.5 years results from Tarahara and Shankarnagar, *Dalbergia sissoo* provenances of Pakistan are not suitable for planting in Nepal. Two provenances of Nepal, namely Kankai and Godavari seed sources can be used for afforestation

programmes in the lowlands, however, priority could also be given to Godavari for seed collection.

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Annex 1 : Information on seed sources

Seedlot Number	Provenance	Latitude	Longitude	Altitude (m)
1619	Kankai, Jhapa, Nepal	26°40'	87°50'	411
1629	Kamdi, Banke, Nepal	28°05'	81°45'	210
1652	Godavari, Kailali, Nepal	28°52'	80°38'	350
1674	Kohat, Pakistan	33°34'	71°27'	492
1675	Changamanga, Pakistan	31°05'	73°58'	190
1676	Chichawatni, Punjab, Pakistan	30°32'	72°41'	160
1677	Multan, Pakistan	30°12'	71°31'	130
1678	Daphar, Pakistan	32°34'	74°04'	230
1679	Jhang Toba Road, Pakistan	31°34'	72°30	170
1681	D. I. Khan, Bannu of Bannu, Pakistan	31°54'	70°54'	172

Annex 2:Report on soil of Tarahara

Sample No.	Depth (cm)	pH	N%	K%	ppm P	Organic carbon %	E. C.	C:N	Na
1	0-25	6.00	0.20	0.5	82	3.2	0.16	16	0.1
2	25-50	6.43	0.06	0.2	40	0.6	0.05	10	0.1
3	50-75	6.51	0.05	0.2	43	0.4	0.05	8	0.1
4	75-100	6.50	0.03	0.2	49	0.2	0.05	7	0.1

Note: Seedlot No 1619, 1629, 1652, 1674, 1675, 1677, 1678 and 1681 were used at Tarahara trial site. Seedlot No 1629, 1674, 1675, 1676, 1677, 1678, 1679 and 1681 were used at Shankarnagar trial site.