PROGENY TESTING IN *Dalbergia sissoo* Roxb.

By

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IN

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HISAR

1994

DEDICATED

TO

MY PARENTS

CERTIFICATE-I

This is to certify that the thesis entitled "Progeny testing in Dalbergia sissoo Roxb" submitted for the degree of Master of Science in the subject of Agroforestry to the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by Mr.Jitender Singh under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation has been fully acknowledged.

6/10/94

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MAJOR ADVISOR

CERTIFICATE-II

This is to certify that the thesis entitled "Progeny testing in Dalbergia sissoo Roxb" submitted by Mr.Jitender Singh to the Chaudhary Charan Singh Haryana Agricultural University in partial fulfilment of the requirements for the degree of Master of Science, in the subject of Agroforestry, has been approved by the student's Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.

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CONTENTS

INTRODUCTION

Dalbergia sissoo Roxb. (shisham or sissoo) is widely recognised as an important multipurpose tree in India, Pakistan and Nepal. It is a highly valued timber and provides a range of other products such as fodder and fuelwood. A long held, accurate, and precise assessment of Dalbergia sissoo is quoted by William Roxburgh, who named the species early in the nineteenth century : "upon the whole I scarcely know of any other tree that deserves more attention, for when its rapid rate of growth in almost every soil, its beauty, and uses are taken into account, few trees can be compared to it". With its multiple uses and tolerance to a broad range of climatic and soil conditions, this species deserve much greater consideration for agroforestry plantings.

Shisham is a medium to large deciduous tree growing upto 30 m tall and 2.4 m girth in favourable localities. It has a long, thick tap root and long ramifying lateral roots. Shisham is distributed in the entire sub-Himalayan region and the Himalayan valleys; throughout Indo-Gangetic plains and in Rajasthan. It grows well in tropical and sub-tropical areas with semi-arid to humid conditions and annual rainfall of 50-200 cm with 4-6 dry months, temperature being between freezing level and 50°C on altitudes from sea level to 1500 m. It has been found suitable for sand dune afforestation with annual rainfall of even 40 cm. It prefers well drained sandy loam soils with good moisture supply.

Selection of superior trees or provenances from wild populations of Indian tree species for seed collection and usage, on a large scale, is a practical method that can be immediately adapted to achieve genetic gain. In *Dalbergia sissoo* Roxb., straight bole form is most important for production of large quantities of high grade wood. The stem straightness further increases the suitability of the species for agroforestry plantings. Height of main stem is equally important, particularly the length of clear bole that holds and yields the maximum volume of merchantable timber. Besides, emphasis in tree improvement programme is on selecting genotypes capable of rapid growth. Faster growth both vertical and horizontal can result in reduction in harvest age ensuring higher yields of wood quickly. Adaptability and resistance to adverse climate and diseases, respectively are also required to avoid loss of standing timber. Hence, an ideal tree should have complete straightness, higher proportion of main stem and clear bole, fast growth rate, smaller crown size and wider adaptability. Since the selection is based on the external appearance for the different characters, it is necessary to test the progenies of plus trees to confirm that they really possess genotypes for which the selection has been made. Keeping in view the vital importance, progeny testing in *Dalbergia sissoo* Roxb. was conducted with the following objectives:

1. To identify fast growing progenies.
2. To determine genetic variation for different growth characters.

REVIEW OF LITERATURE

Serious attention to selective tree breeding has been paid only in the present century, mainly since 1950 (Burley, 1987). Initially work was concentrated in Europe and north America, then in Australia, Japan and Brazil, lately in Africa and Indian sub-continent. Tree improvement work in India was initiated by Prof. Champion who realized the importance of geographic variation and conducted a seed origin trial of teak during 1930 (Emmanuel *et al.*, 1992). Later on in 1950, Dr.Rao published an article on Genetics and Tree Improvement. In the year 1961 Prof. J.D. Mathews an expert from FAO visited India to give guidelines for the tree improvement work. He initially suggested the work on some priority species viz : *Tectona grandis*, *Bombax ceiba*, *Pinus* spp. and *Dalbergia sissoo* Roxb. However, limited reports are available on progeny testing of *Dalbergia sissoo* Roxb. with the result that references are scanty. Therefore, the most relevant literature on other tree species along with *Dalbergia sissoo* Roxb. has been reviewed under following heads:

2.1 Plus tree selection

2.2 Progeny testing

2.1 Plus tree selection

In collaboration with state forest department approximately 1200 plus trees have been selected (Kedharnath, 1967; 1982a; Rai, 1986; Emmanuel and Bagchi, 1988) for different species, prominent among them were *Tectona grandis*, *Bombax ceiba*, *Dalbergia sissoo*, *Gmelina arborea*, *Pinus roxburghii*, *Santalum album* and *Preocarpus santalinus*.

Khosla (1985) introduced the possibility of genetic improvement of agroforestry trees. Sheikh (1988) raised a large tree form of P.juliflora by collecting seed from plus trees. He further proposed to use the straight tree form for planting in arid and semi-arid areas.

Bangarwa et al. (1990) conducted a survey in the semi-arid and mesic parts of Haryana to select suitable mother trees having narrow crown and a clear straight bole, so that it can be grown in conjuction with the agricultural crops. Majority of trees have crooked stem or wide crown or with both characters. However, a single tree, with a clear bole of 9.0 m and 0.85 m girth and a narrow crown, was found. When compared with neighbouring trees as well as with other trees, it was observed to be an ideal mother tree for agroforestry. The tree was observed to be a self pruning in nature as there was no visible knot up to 5 m height of the trunk.

Gupta et al. (1992) selected plus trees of shisham from natural plantation forests of U.P. based on stem straightness, height and diameter growth.

2.2 Progeny testing

It is necessary to progeny test the plus tree to confirm that they possess a good genotype and are capable of transmitting their good traits to the progeny (Kedharnath, 1982b).

Considerable variability with regard to crooked or straight bole and growth rate exists in Dalbergia sissoo (Vidakovic and Siddiqui, 1968; Vidakovic and Ahsan, 1970). Such variation occurs even in one year old trees so far as the crookedness in stem is concerned, as was evident from a high coefficient of variation for 23, one year old open pollinated progenies. Selection of shisham trees based upon stem form would be profitable as environment has relatively little effect on this trait as compared to growth. Teak seedlings showed no branching upto 3 years (Champion and Seth, 1968). Variability studies and selection for superior tree form can be made on species showing inherent tendencies to form straight bole such as Tectona, Shorea etc. (Dogra, 1981).

A study was made by Vidakovic and Siddiqui (1968) about heritability of height and diameter growth in shisham using parent progeny test. A number of plus trees of shisham with an apparent higher growth rate of diameter and height, were selected in 1963. The seeds from these trees were collected in 1966. The plants were grown in rows so that progeny of every mother tree was represented by one or two rows of plants. About 30 to 35 plants were selected at random from progeny of each mother tree. Measurement of progenies were undertaken at the end of first vegetation period. Calculations of heritability for diameter, height and crookedness were carried out by using regression for parent progeny test. Heritability for height and diameter was very low whereas for crookedness, the heritability was high.

It was suggested to raise progenies from a large number of parent trees under the same environmental conditions and subsequently to carry out intensive selection within and between progenies (Sheikh, 1989).

The result of a study on growth and heritability among 6 years old trees of shisham originating from Pakistan have been reported by Rehman and Hussain (1986). The results indicated that generally the trees originating from Chichawatni were significantly different from those originating from Mardan. Similar observations have been endorsed by Hussain and Abbas (1974).

In case of teak, half sib analysis was done by Kedharnath _et al_. (1960). They have calculated broad sense heritability for height, girth and number of internodes as 1.00, 0.88 and 0.91, respectively.

Both half sib and full sib progeny trials were laid out for _Bombax_ (Venkatesh, 1969). Half sib progeny trials were also conducted for _E.tereticornis_, _E.camaldulensis_, _E.grandis_ (Venkatesh and Vakshasya, 1977, Kedharnath, 1982a) and _Santalum album_ (Bagchi and Kulkarni, 1987; Bagchi _et al_., 1987). There were evidences for sufficient genetic variation in mean plant height between families.

Solanki _et al_. (1984) studied variability and heritability for growth parameters in _Prosopis cineraria_. Progenies of different trees showed significant variation and high heritability accompanied by high genetic advance for plant height.

Surendran and Chandrasekharan (1984) studied heritable variation and genetic gain estimates in half sib progenies of _E.tereticornis_. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability estimates and genetic advance as percentage of mean were worked out for eight characters studied in 35 plus trees. The heritability estimates for girth at base, number of branches, leaf breadth and leaf length : breadth ratio were consistent at different stages of growth.

Gupta and Patil (1988) made an investigation of the variation in fodder and fuelwood yield with different plant characteristics in 40 accessions of *L.leucocephala*. The analysis of variance indicated significant differences among the accession for all the characters. Moderate to high estimates of broad sense heritability were observed for most characters.

Dean *et al*. (1988) estimated genetic parameters for height, stem diameter, straightness, internode length and wood density, 5-16 years after planting, in 4 open pollinated progeny tests of hoop pine in Australia. All the traits appeared to be moderately heritable and favourable genetically correlated.

Volker *et al*. (1990) estimated genetic parameters for growth, stem form and branch size from measurements made at around six years in seedling seed orchard of *Eucalyptus globulus*. Individual heritabilities for volume and stem form were moderate.

Jindal *et al*. (1991) studied variability and changes in genetic parameters of height in juvenile progenies of *Tecomella undulata*. Significant difference, among progenies were observed. Heritability and genetic advance showed decreasing trend with increasing age. They also reported that correlation of juvenile height at different stages with mean height of one year old progenies in field was non-significant suggesting that selection for height at juvenile stages in nursery may not be effective.

Bangarwa (1993) reports a significant, large scale trial of 100 progenies. High values of phenotypic coefficient of variation in the 100 progenies at the age of 26 months after establishment and little difference between phenotypic coefficient of variation and genotypic coefficient of variation for: clear bole height, main stem height, straightness, total height and basal diameter suggested the existence of higher proportion of variation as heritable. However, highest variation was found for clear bole height, (63.0) followed by main stem height (47.6), straightness (45.7), basal diameter (39.1) and total height (29.1). The potentiality of the present material for selection of fast growing, straight trees with greater main stem and clear bole was evident. High estimates of broad sense heritability and genetic advantage for all characters under study further confirmed high breeding value of the test material. High estimates of narrow sense heritability (parents offspring regression) for main stem height and straightness proved that these traits have been transmitted from the mother trees to progenies strong positive correlation of height with diameter were also observed in *Populus ciliata* (Khosla *et al*., 1980) *Dalbergia sissoo* Roxb. (Bangarwa, 1993) and *Azadirachta indica* (Singh 1994).

MATERIALS AND METHODS

The present study on _Dalbergia sissoo_ Roxb. (shisham) comprised of progeny testing experiment established in August 1991 after transplanting five months old seedling.

3.1 Experimental material

Open pollinated seed bearing pods collected from 43 plus trees (Trees were selected during Feb-March 1991) from natural population of U.P., Punjab, Haryana, Rajasthan and Bihar on the basis traits suitable for agroforestry, such as, stem straightness, main stem height, clear bole height, low value of crown diameter : stem diameter ratio and low branching habit were used to raise the seedlings for progeny testing. Details of plus trees and their collection regions are given in Table 1, whereas morphological characters of plus trees are presented in Table 2.

3.2 Layout of experiment

Seeds collected from plus trees were extracted from pods manually and were sown in polythene bags (22x10 cm) containing FYM, sand and clay (1:2:1) in third week of March, 1991. Five months old seedlings of each of 43 plus trees were transplanted in research area of Department of Agroforestry, Chaudhary Charan Singh Haryana Agricultural University, Hisar in a randomized block design with four replication. There were five plants of each progenies in each replication.

3.3 Observation recorded

The following observations were recorded during March 1994, at the age of three years .

Table 1. Details of plus trees and their collection region

Region	State	Plus tree no.	Latitude (N)	Longitude (E)	Altitude (m)	Annual Rainfall (cm)
G.Nagar	Rajasthan	36	29°95'	73°95'	190	40
Suratgarh	Rajasthan	33	29°32'	73°92'	188	35
Fazilka	Punjab	34-35	30°44'	74°06'	205	55
Hanumangarh	Rajasthan	32	29°65'	74°36'	185	40
Sardarshahr	Rajasthan	37	28°46'	74°45'	247	40
Dabwali	Haryana	12-16	29°31'	74°96'	195	40
Sirsa	Haryana	10	29°32'	75°02'	195	40
Hisar	Haryana	30-31	29°10'	75°44'	215	40
Ludhiana	Punjab	39-42	30°97'	75°82'	247	68
Narwana	Haryana	09	29°36'	76°07'	232	55
Rohtak	Haryana	7-8	28°54'	76°35'	219	51
Naraingarh	Haryana	11	30°44'	77°50'	230	91
Muzzafarnagar	U.P.	128	29°34'	77°67'	235	94
Dehradun	U.P.	17-18	30°48'	78°05'	597	215
Jhansi	U.P.	1-3	25°48'	78°66'	259	92
Moradabad	U.P.	25	28°88'	78°78'	204	160

Contd.....

Table 1. Contd....

Haldwani	U.P.	26	29°21'	79°37'	376	260
Nainital	U.P.	27	29°48'	79°50'	622	160
Rath	U.P.	4-5	25°65'	79°62'	126	116
Kanpur	U.P.	19-24	26°48'	80°38'	131	89
Banda	U.P.	06	25°54'	80°42'	128	120
Sitapur	U.P.	29	27°59'	80°66'	144	180
Lucknow	U.P.	43	26°88'	81°02'	120	101
Ranchi	Bihar	38	23°34'	83°38'	661	151

Table 2. Morphological characters of Plus tree in *Dalbergia sissoo*.

Plus tree no.	Source	Straight-ness	Total height (m)	Diameter at breast height (cm)	Main stem height (m)	Clear bole height (m)
1	Jhansi	4.0	10.6	24.0	7.2	4.65
2	Jhansi	4.5	10.0	18.0	6.2	2.60
3	Jhansi	4.0	8.5	18.0	6.0	2.50
4	Rath	4.0	14.1	27.0	10.8	5.20
5	Rath	4.0	17.3	31.0	10.9	6.15
6	Banda	4.0	16.4	29.0	12.9	6.50
7	Rohtak	4.5	16.2	30.0	8.9	4.80
8	Rohtak	3.5	26.6	46.0	14.4	4.50
9	Narwana	5.0	19.2	30.0	14.5	10.10
10	Sirsa	4.5	19.5	36.0	15.8	9.90
11	Naraingarh	5.0	20.5	71.0	15.9	10.20
12	Dabwali	4.0	17.4	41.0	13.5	9.00
13	Dabwali	4.5	22.8	70.0	18.4	9.60
14	Dabwali	5.0	22.8	67.0	16.9	11.40
15	Dabwali	4.0	23.7	86.0	16.6	5.40
16	Dabwali	5.0	23.8	65.0	18.6	4.20

Contd.....

Table 2. Contd.....

17	Dehradun	4.0	24.4	47.0	16.2	7.30
18	Dehradun	5.0	28.6	54.0	20.5	5.48
19	Kanpur	5.0	17.0	48.0	14.5	12.00
20	Kanpur	4.0	21.0	57.0	16.9	13.00
21	Kanpur	4.0	22.0	58.0	17.4	15.00
22	Kanpur	4.5	16.0	44.0	12.1	9.50
23	Kanpur	4.5	20.0	54.0	16.0	14.00
24	Kanpur	5.0	14.0	38.0	11.9	9.10
25	Moradabad	4.5	38.6	82.0	14.9	8.50
26	Haldwani	5.0	32.5	64.0	16.8	7.50
27	Nainital	5.0	34.0	79.0	17.0	10.00
28	Muzzafarnagar	5.0	15.5	42.0	12.5	7.50
29	Sitapur	4.0	21.0	52.0	14.5	8.20
30	Hisar	5.0	18.9	49.0	10.2	4.80
31	Hisar	4.0	18.1	48.0	10.8	7.80
32	Hanumangarh	3.5	10.5	49.0	5.8	4.20
33	Suratgarh	4.0	8.4	33.0	6.5	4.20

Contd.....

Table 2. Contd....

34	Fazilka	4.5	10.5	40.0	7.2	3.30
35	Fazilka	5.0	25.5	64.0	19.6	13.50
36	G.nagar	4.0	11.4	43.0	7.9	4.60
37	Sardarshahr	3.5	9.6	44.0	6.5	3.60
38	Ranchi	3.0	6.8	21.0	3.9	2.40
39	Ludhiana	4.0	9.3	55.0	13.2	7.90
40	Ludhiana	4.5	16.3	41.0	11.6	7.60
41	Ludhiana	4.0	16.9	49.0	12.2	9.10
42	Ludhiana	4.0	18.1	51.0	14.5	10.30
43	Lucknow	4.5	20.2	62.0	14.6	12.00

3.3.1 Total height (m)

Height was recorded from the ground level to the apical bud of the leading shoot. It was measured with the help of metre rod and marked pole.

3.3.2 Main stem height (m)

Height of stem from the ground level up to the unforked point was measured with the help of metre rod and marked pole.

3.3.3 Basal diameter (cm)

Dial calliper was used to measure the basal diameter of the tree at ground level.

3.3.4 Stem straightness

Trees were ranked from 0 (crooked) to 5 (complete straight).

3.3.5 Initiation of seed production

Presence or absence of pods were observed in December 1993 and May 1994.

3.4 Meteorological data

Meteorological data were collected from the Department of Meteorology, CCS Haryana Agricultural University, Hisar, for duration of experiment and are shown in Fig.1.

3.5 Statistical analysis

3.5.1 Analysis of variance

The replicated data for all characters recorded for progenies were analysed statistically (Panse and Sukhatme, 1978). The ANOVA is presented in Table 3.

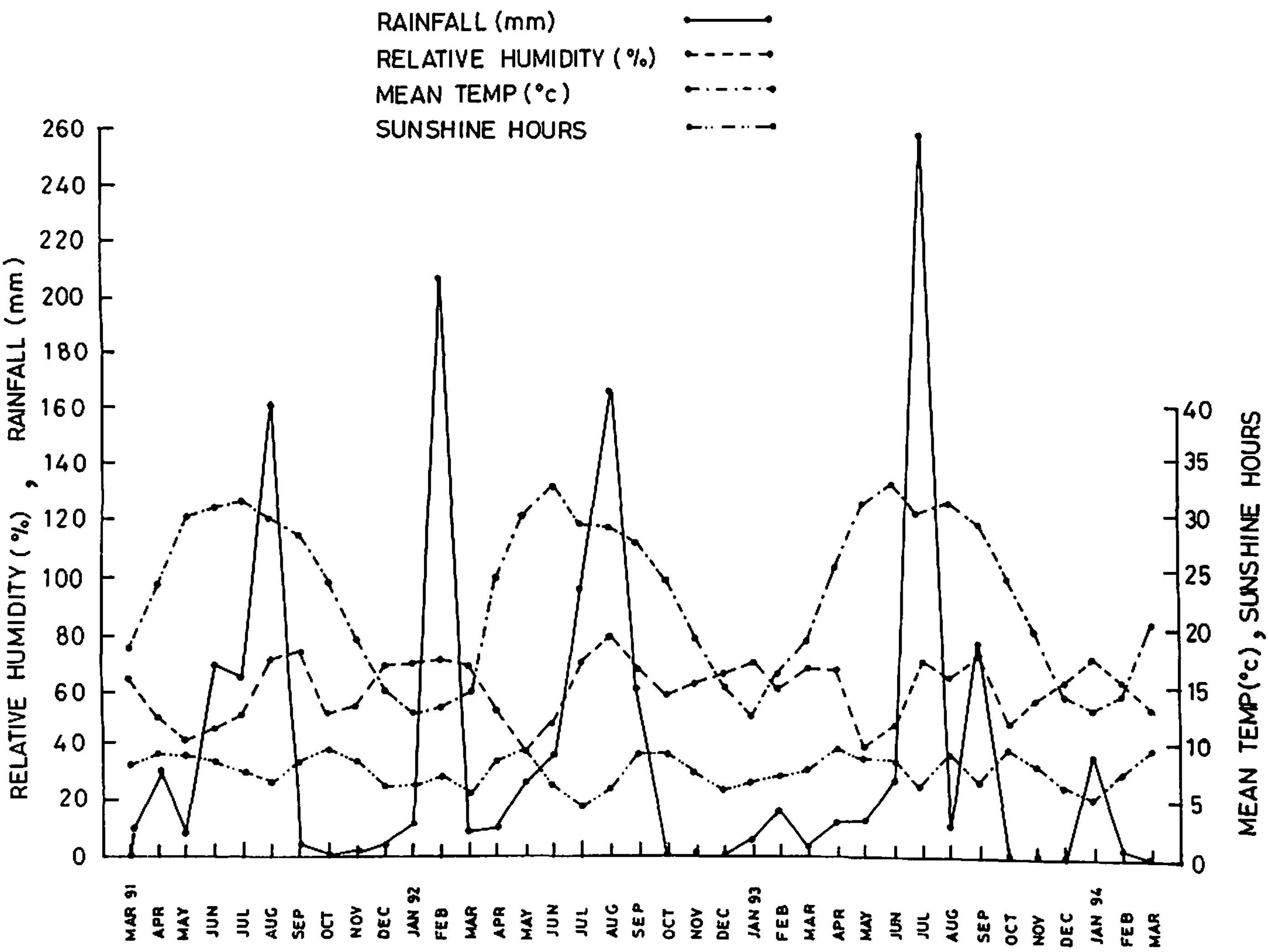

FIG.1 METEOROLOGICAL PARAMETERS DURING THE PERIOD OF EXPERIMENT

Table 3. **ANOVA for progeny testing**

Source of variation	d.f.	Expectations of mean squares	
Blocks	(r-1)	$\sigma^2 e + g\ \sigma^2 r$	σ
Progenies	(g-1)	$\sigma^2 e + r\ \sigma^2 g$	MS_2
Error	(r-1) (g-1)	$\sigma^2 e$	MS_1

Where as,

r = number of blocks

g = number of progenies

Significance of variance ratio was tested at P 0.05 and P 0.01 using 'F' tables by Fisher and Yates (1963).

Using mean square values, the components of variance for progeny testing were calculated as :

Error variance $(\sigma^2 e) = MS_1$

Genotypic variance $(\sigma^2 g) = (MS_2 - MS_1)/r$

Phenotypic variance $(\sigma^2 P) = \sigma^2 g + \sigma^2 e$

3.5.2 **Mean**

The mean value of each character was worked out by dividing the totals by corresponding number of observations:

$$\bar{X} = \frac{\sum X_{ij}}{N}$$

Where X_{ij} = Any observation in i^{th} genotype and j^{th} replication

N = Total number of observations

3.5.3 Range

The lowest and the highest values for each character were recorded.

3.5.4 Standard error

Standard error for difference of two means were calculated with the help of error mean square from the analysis of variance table like:

$$\text{Standard Error (S.Ed)} = \sqrt{\frac{2\ \text{EMS}}{r}}$$

Where,

EMS = Error mean squares

r = Number of replications

3.5.5 Critical difference

Critical difference for all the characters were calculated to compare the treatment means. Critical difference were calculated with the help of standard error for the difference of two means and tabulated value of 't' at 5 per cent level of significance for error degree of freedom like:

$$\text{CD} = \text{S.Ed} \times t \text{ at } 5\% \text{ error d.f.}$$

3.5.6 Coefficient of variation

Genotypic and phenotypic coefficient of variation were estimated by the formula suggested by Burton (1952) for each character as:

Genotypic coefficient of variance

$$\text{G.C.V} = \frac{\sigma_g}{\bar{X}} \times 100$$

Phenotypic coefficient of variance

$$P.C.V. = \frac{\sigma_p}{\bar{X}} \times 100$$

Where $\bar{X}$ mean of that particular character.

3.5.7 Heritability (in broad sense)

Heritability in broad sense was calculated according to the formula suggested by Johnson et al. (1955) for each character.

Heritability (broad sense) in per cent

$$h^2 = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

where,

σ^2_g = genotypic variance

σ^2_p = phenotypic variance

3.5.8 Genetic advance expressed in percentage of mean

Estimates of appropriate variance components were substituted for the parameters to predict expected genetic gain as suggested by Lush (1949). The expected genetic advance was calculated at 5 per cent selection intensity for each character as:

Genetic advance (% of mean)

$$\frac{K.\sigma_p.h^2}{\bar{X}}$$

where,

K	=	Selection differential (2.06)
σ_p	=	Phenotypic standard deviation
h^2	=	Heritability in broad sense
$\bar{X}$	=	Mean value for that character overall the genotypes

3.5.9 Metroglyph and index score analysis (Anderson, 1957)

Metroglyph and index score analysis was carried out using data of progenies at the age of 3 years. Basal diameter and total height were used in plotting the glyphs. Remaining characters had been represented by rays at different positions on the glyph and range by length of ray.

3.5.10 Correlation coefficient

The correlation among different character combination was calculated using the following formula :

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}}$$

Where,

X_i	=	Individual value of one character
Y_i	=	Individual value of another character

EXPERIMENTAL RESULTS

Three years old progenies were evaluated and the results so obtained have been presented under different heads:

4.1 Analysis of variance

The analysis of variance for total height, main stem height, basal diameter and straightness of three years old progeny testing has been presented in Table 4. The mean squares due to progenies were highly significant for all the characters viz : total height, main stem height, basal diameter and straightness indicating the presence of sufficient amount of variation in three years old progenies of Dalbergia sissoo Roxb. This suggested the scope of selection for further improvement.

4.2 Variability, heritability and genetic advance

The data on phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), mean, range, heritability estimates and genetic advance as percentage of mean for different characters have been presented in Table 5.

The highest phenotypic coefficient of variation (37.24 per cent) was recorded for main stem height followed by basal diameter (30.94 per cent) and total height (27.44 per cent). The phenotypic coefficient of variation for straightness was just 11.26 per cent. It was expected because straightness was main criteria for the selection of plus trees of present investigation. Like phenotypic coefficient of variation, the

Table 4. Analysis of variance for different characters of 3 years old progenies in *Dalbergia sissoo*

Source of variation	d.f.	Mean sum of squares			
		Total height	Main stem height	Basal diameter	Straightness
Blocks	3	0.142	0.114	0.765	0.032
Progenies	42	3.725*	3.383*	14.496*	0.715*
Error	126	0.264	0.142	0.884	0.033

* Significant at 5 per cent level of significance

Table 5. Variability, heritability and genetic advance of three years old progenies in _Dalbergia sissoo_

Characters	Phenotypic coefficient of variation	Genotypic coefficient of variation	h^2 (broad sense)	Genetic advance as per cent of mean	Mean	Range
Total height (m)	27.44	24.01	76.59	37.89	3.87	2.44-6.54
Main stem height (m)	37.24	34.35	85.08	60.20	2.62	0.63-4.52
Basal diameter (cm)	30.94	27.57	79.37	45.08	6.69	3.58-10.50
Straightness	11.26	10.30	83.74	17.78	4.00	2.8-4.8

highest genotypic coefficient of variation was observed for main stem height (34.35 per cent) followed by basal diameter and total height. Little differences were observed between phenotypic coefficient of variation and genotypic coefficient of variation.

The highest heritability (85.08 per cent) was observed for main stem height. The heritability estimate (83.74 per cent) for straightness was also quite high. The heritability estimates were more than 75 per cent for all the characters under study which reflected the predominance of heritable variation for all the characters.

The genetic advance as percentage of mean was recorded highest for main stem height (60.20) followed by basal diameter (45.08) and total height (37.89). The genetic advance as percentage of mean was recorded 17.78 for straightness. The range values indicated the highest variability for main stem height (0.63-4.52). The range for basal diameter (3.58-10.50) and total height (2.44-6.54) were quite high. The range for straightness was from 2.8 to 4.8.

Simultaneous consideration of all the parameters of variability (Table 5) indicated that the characters like main stem height, basal diameter and total height had sufficient variation and that too as heritable in the collection of Dalbergia sissoo.

4.3 Mean performance of progenies

The mean performance of forty three progenies for different characters alongwith critical difference and general mean at the age of three years are presented in Table 6. The detailed results are being described characterwise.

Table 6. Mean performance of 3 years old progenies in *Dalbergia sissoo*

Progeny	Origin	Total height (m)	Main stem height (m)	Basal diameter (cm)	Straightness
P 1	Jhansi	3.75	2.72	5.79	4.2
P 2	Jhansi	2.65	1.64	4.03	4.4
P 3	Jhansi	4.38	3.05	9.47	3.3
P 4	Rath	3.39	2.34	5.39	3.7
P 5	Rath	3.66	2.55	5.95	3.9
P 6	Banda	3.98	2.63	6.85	3.7
P 7	Rohtak	3.14	2.18	4.81	3.8
P 8	Rohtak	2.44	1.85	3.58	2.9
P 9	Narwana	4.30	3.40	7.33	4.4
P 10	Sirsa	3.92	2.45	7.10	4.2
P 11	Naraingarh	2.99	2.49	4.13	4.3
P 12	Dabwali	4.58	3.46	8.52	3.9
P 13	Dabwali	4.87	4.40	8.52	4.2
P 14	Dabwali	3.98	2.82	6.12	4.6
P 15	Dabwali	3.08	2.23	5.95	4.0
P 16	Dabwali	5.23	4.52	9.19	4.6

Contd.....

Table 6. Contd.....

P 17	Dehradun	2.90	2.14	4.29	3.9
P 18	Dehradun	3.81	2.77	6.74	4.5
P 19	Kanpur	4.37	3.56	7.73	4.4
P 20	Kanpur	3.56	2.35	5.79	4.1
P 21	Kanpur	3.46	2.33	6.57	3.9
P 22	Kanpur	3.46	2.01	5.51	4.2
P 23	Kanpur	5.64	4.40	10.50	4.3
P 24	Kanpur	4.42	3.20	8.43	4.0
P 25	Moradabad	3.75	0.77	5.03	4.3
P 26	Haldwani	6.54	4.42	9.12	4.3
P 27	Nainital	6.31	4.03	9.89	4.4
P 28	Muzzafarnagar	5.05	3.73	9.92	4.7
P 29	Sitapur	4.01	2.28	6.85	3.9
P 30	Hisar	3.77	1.56	7.29	4.2
P 31	Hisar	3.48	2.35	6.68	3.9
P 32	Hanumangarh	2.61	0.63	3.61	3.3
P 33	Suratgarh	2.46	1.79	4.53	3.9
P 34	Fazilka	4.71	3.27	9.09	4.2

Contd.....

Table 6. Contd....

P 35	Fazilka	4.84	3.02	8.97	4.8
P 36	Sriganganagar	3.56	2.46	7.56	3.9
P 37	Sardarshahr	2.65	1.65	4.30	3.6
P 38	Ranchi	2.81	1.35	4.67	2.8
P 39	Ludhiana	3.56	2.06	7.28	3.8
P 40	Ludhiana	3.78	2.50	6.54	3.9
P 41	Ludhiana	3.75	2.52	6.15	3.8
P 42	Ludhiana	2.59	1.87	4.23	3.8
P 43	Lucknow	4.22	2.93	7.91	4.1
	General Mean	3.87	2.62	6.69	4.0
	C.D. at 5 per cent	0.712	0.522	1.303	0.251

4.3.1 Total height (m)

The total height of three years old progenies varied from 2.44 to 6.54 m. The progeny P 26 from Haldwani showed the highest total height (6.54 m) whereas, the progeny P 27 from Nainital ranked second for total height (6.31 m). In total nine progenies viz., P 12, P 13 and P 16 from Dabwali, P 23 from Kanpur, P 26 from Haldwani, P 27 from Nainital, P 28 from Muzzafarnagar, P 34 and P 35 from Fazilka were observed to have total height significantly higher than general mean. Significant differences were recorded for total height between the progenies of different origin as well as among the progenies of same origin. P 8 from Rohtak showed the lowest value (2.44 m) of total height.

4.3.2 Main stem height (m)

The main stem height varied from 0.63 m to 4.52 m. P 16 from Dabwali showed the highest main stem height (4.52 m) whereas, P 26 from Haldwani ranked second for main stem height with mean value of 4.42 m. P 9 from Narwana, P 12 and P 13 from Dabwali, P 19, P 23 and P 24 from Kanpur, P 27 from Nainital, P 28 from Muzzafarnagar, and P 34 from Fazilka were also observed to have main stem height significantly higher than general mean. Significant differences were observed for main stem height between progenies of different origin as well as among progenies of same origin.

4.3.3 Basal diameter (cm)

The basal diameter of three years old progenies varied from 3.58 cm to 10.50 cm. P 23 from kanpur showed the highest basal diameter (10.50 cm). P 28 from Muzzafarnagar ranked second for basal diameter with a mean value of 9.92 cm. P 3 from Jhansi, P 12, P 13 and P 16 from Dabwali, P 24 from Kanpur, P 26 from Haldwani, P 27 from Nainital, P 28 from Muzzafarnagar, P 34 and P 35 from Fazilka were also found to have basal diameter significantly higher than general mean. Significant differences were found between progenies of different origin as well as among progenies of same origin for basal diameter. The basal diameter of P 23 from Kanpur was found nearly three times of P 8 from Rohtak.

4.3.4 Straightness

Straightness varied from 2.8 of P 38 from Ranchi to 4.8 of P 35 from Fazilka. Significant differences were observed among progenies of same origin for straightness. The progenies viz., P 2 from Jhansi, P 9 from Narwana, P 11 from Naraingarh, P 14 and P 16 from Dabwali, P 18 from Dehradun, P 19 and P 23 from Kanpur, P 25 from Moradabad, P 26 from Haldwani, P 27 from Nainital, P 28 from Muzzafarnagar and P 35 from Fazilka showed significantly better straightness than general mean.

4.4 Top ten progenies

Top ten progenies for total height and basal diameter are presented in Table 7. P 26 from Haldwani was observed to have maximum total height of 6.54 m. This progeny ranked second for main stem height (4.42 m). For basal diameter this progeny ranked sixth with a value of 9.12 cm. The progeny also showed reasonably good straightness with a average score of 4.3.

P 27 from Nainital ranked second for total height with a average total height of 6.31 m whereas, this progeny ranked third for basal diameter with an average basal diameter of 9.89 cm. The main stem height (4.03 m) was about 65 per cent of its total height (6.31). The straightness score (4.4) of this progeny was also high.

Table 7. **Top ten progenies at the age of 3 years in _Dalbergia sissoo_**

Progenies	Origin	Total height (m)	Main stem height (m)	Basal diameter (cm)	Straightness
P 12	Dabwali	4.58	3.46	8.52	3.9
P 13	Dabwali	4.87	4.40	8.52	4.2
P 16	Dabwali	5.23	4.52	9.19	4.6
P 23	Kanpur	5.64	4.40	10.50	4.3
P 24	Kanpur	4.42	3.20	8.43	4.0
P 26	Haldwani	6.54	4.42	9.12	4.3
P 27	Nainital	6.31	4.03	9.89	4.4
P 28	Muzzafarnagar	5.05	3.73	9.92	4.7
P 34	Fazilka	4.71	3.27	9.09	4.2
P 35	Fazilka	4.84	3.02	8.97	4.8
	General mean	3.87	2.62	6.69	4.0
	C.D. at 5 per cent	0.71	0.52	1.30	0.25

P 23 from Kanpur ranked third for total height with average total height of 5.64 m whereas, this progeny was at top for basal diameter with a average basal diameter of 10.50 cm. Main stem height of this progeny was about 80 per cent of total height. The progeny also showed reasonably good straightness.

P 16 from Dabwali ranked fourth for total height (5.23 m) and fifth for basal diameter (9.19 cm). This progeny showed the highest value of 4.52 m for main stem height. The straightness rank (4.6) was very high for this progeny. All these four progenies were found significantly superior than general mean for all the four characters viz., total height, main stem height, basal diameter and straightness.

P 28 from Muzzafarnagar ranked fifth for total height (5.05 m) and second for basal diameter (9.92 cm). Main stem height of this progeny was above 75 per cent of total height. Straightness score for this progeny was very high (4.7). This progeny was also found significantly superior than general mean for all the four characters under study.

4.5 Metroglyph and index score analysis

Metroglyph and index score analysis was carried out in fourty threeee progenies of Dalbergia sissoo using data for total height, main stem height, basal diameter and straightness at the age of 3 years. The class intervals and index score for various characters are shown in Fig.2. Total height and basal diameter are most important characters from breeding point of view and therefore, they were used in plotting the glyphs (Fig.2). Main stem height and straightness has been represented by rays at different positions on the glyphs and the range by the length of rays. The index scores were obtained by alloting numerical values (1,2

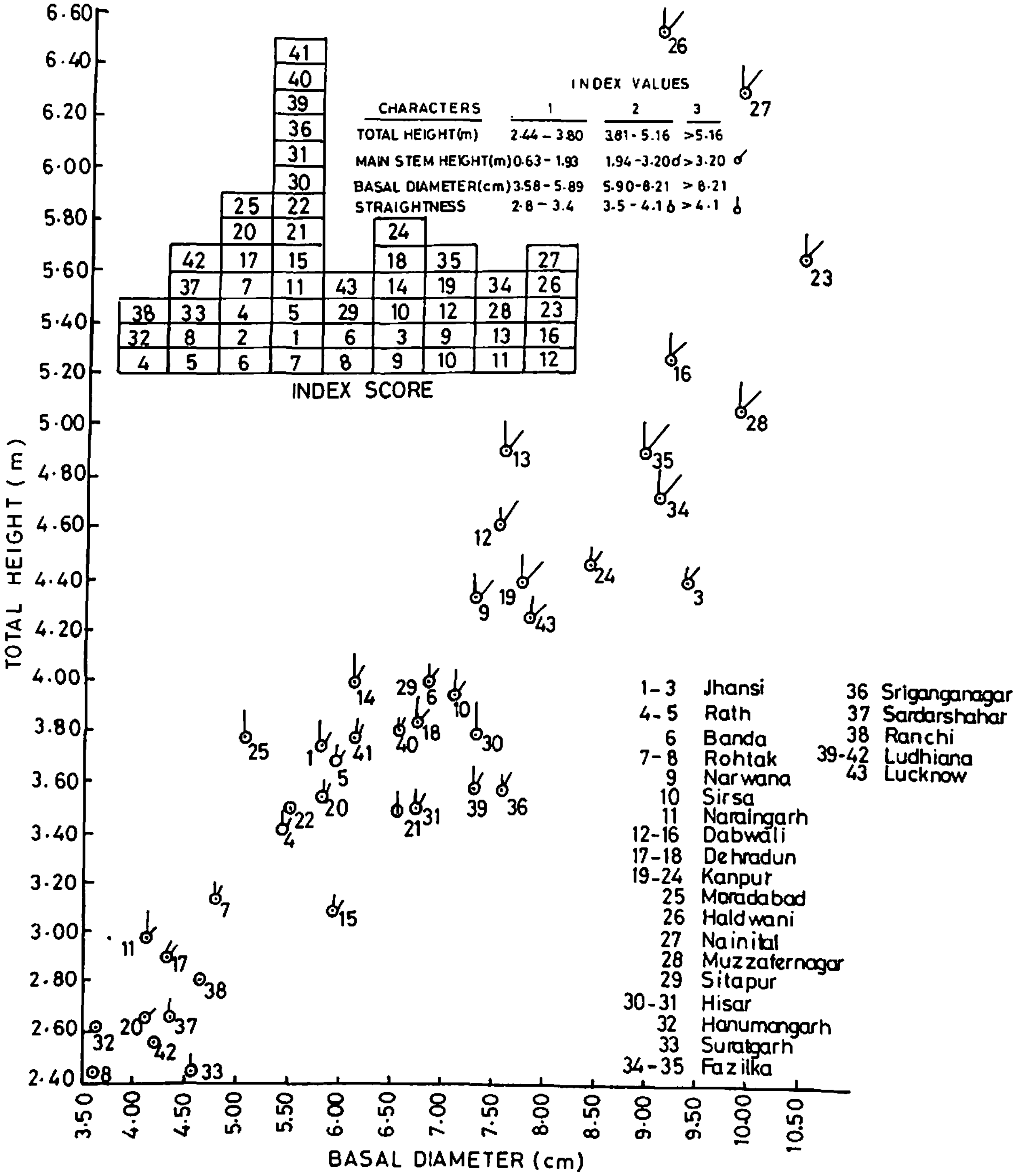

FIG.2 METROGLYPH ANALYSIS IN 3 YEARS' OLD PROGENIES OF <u>D. SISSOO</u>

or 3) to the three grades of expression recognised in respect of each character and finally summing up the scores obtained by each progeny for all the four characters. The maximum possible score can thus, be 12.

The range of index score was 4 to 12. P 16 from Dabwali, P 23 from Kanpur, P 26 from Haldwani and P 27 from Nainital showed the highest index score of 12 which indicated the overall superiority for these progenies. P 13 from Dabwali, P 28 from Muzzafarnagar and P 34 from Fazilka ranked second with index score value of 11 which indicated the superiority of these progenies for three of the four characters. An examination of the scatter diagram revealed the presence of substantial variability among progenies. No clear cut grouping could be established. P 23 from Kanpur, P 26 from Haldwani, P 27 from Nainital can be grouped for fast growth, Whereas P 8 from Rohtak, P 32 from Hanumangarh and P 33 from Suratgarh were grouped together for slow growth. Progenies of same origin are widely scattered. The distribution of different progenies also reflected the positive association between total height and basal diameter.

4.6 Correlation coefficient among growth characters

The correlation coefficients among different growth character were estimated and the same have been presented in Table 8. Strong positive correlation coefficients were observed among total height, main stem height and basal diameter. The correlation coefficients of straightness with each of total height, main stem height and basal diameter were also found significantly positive. This has suggested the effectiveness of selection for all desirable characters simultaneously.

Table 8. **Correlation coefficients among growth characters in *Dalbergia sissoo***

Characters	Main stem height	Basal diameter	Straightness
Total height	0.883**	0.905**	0.642**
Main stem height		0.818**	0.653**
Basal diameter			0.691**
Straightness			

** Significant at 1 per cent level

4.7 Seed pod production age

The presence or absence of seed pods were observed during third year and fourth year and are presented in Table 9.

Twenty four progenies out of forty three progenies showed seed pod production during third year. All the progenies showed seed pod production during fourth year of growth. Seed production behaviour of different progenies of a particular origin was similar which indicated the influence of seed source on seed production behaviour. All the progenies from Jhansi, Rohtak, Narwana, Sirsa, Dabwali, Muzzafarnagar, Hisar, Hanumangarh, Suratgarh, Fazilka, Sriganganagar, Sardarshahr and Ludhiana showed seed pod production during third year of growth. Progenies from all other seed sources viz., Rath, Banda, Naraingarh, Dehradun, Kanpur, Moradabad, Haldwani, Nainital, Sitapur, Ranchi and Lucknow also started seed pod production during fourth year.

Table 9. Seed production age in *Dalbergia sissoo*

Progeny	Origin	Total height (m)	Basal diameter (cm)	Seed pod production	
				Third year	Fourth year
P 1	Jhansi	3.75	5.79	+	+
P 2	Jhansi	2.65	4.03	+	+
P 3	Jhansi	4.38	9.47	+	+
P 4	Rath	3.39	5.39	-	+
P 5	Rath	3.66	5.95	-	+
P 6	Banda	3.98	6.85	-	+
P 7	Rohtak	3.14	4.81	+	+
P 8	Rohtak	2.44	3.58	+	+
P 9	Narwana	4.30	7.33	+	+
P 10	Sirsa	3.92	7.10	+	+
P 11	Naraingarh	2.99	4.13	-	+
P 12	Dabwali	4.58	8.52	+	+
P 13	Dabwali	4.87	8.52	+	+
P 14	Dabwali	3.98	6.12	+	+
P 15	Dabwali	3.08	5.95	+	+
P 16	Dabwali	5.23	9.19	+	+

Contd.....

Table 9. Contd.....

P 17	Dehradun	2.90	4.29	-	+
P 18	Dehradun	3.81	6.74	-	+
P 19	Kanpur	4.37	7.73	-	+
P 20	Kanpur	3.56	5.79	-	+
P 21	Kanpur	3.46	6.57	-	+
P 22	Kanpur	3.46	5.51	-	+
P 23	Kanpur	5.64	10.50	-	+
P 24	Kanpur	4.42	8.43	-	+
P 25	Moradabad	3.75	5.03	-	+
P 26	Haldwani	6.54	9.12	-	+
P 27	Nainital	6.31	9.89	-	+
P 28	Muzzafarnagar	5.05	9.92	+	+
P 29	Sitapur	4.01	6.85	-	+
P 30	Hisar	3.77	7.29	+	+
P 31	Hisar	3.48	6.68	+	+
P 32	Hanumangarh	2.61	3.61	+	+
P 33	Suratgarh	2.46	4.53	+	+
P 34	Fazilka	4.71	9.09	+	+
P 35	Fazilka	4.84	8.97	+	+

Contd.....

Table 9. *Contd.....*

P 36	Sriganganagar	3.56	7.56	+	+
P 37	Sardarshahr	2.65	4.30	+	+
P 38	Ranchi	2.81	4.67	-	+
P 39	Ludhiana	3.56	7.28	+	+
P 40	Ludhiana	3.78	6.54	+	+
P 41	Ludhiana	3.75	6.15	+	+
P 42	Ludhiana	2.59	4.23	+	+
P 43	Lucknow	4.22	7.91	-	+
	General mean	3.87	6.69		
	C.D. at 5 per cent	0.712	1.303		

+ Presence of seed pod production

- Absence of seed pod production

Simultaneous consideration of seed pod production and growth parameters of different seed sources suggested the association of seed production age with geographic region.

DISCUSSION

Dalbergia sissoo Roxb. is an important broad leaved tree, growing naturally in Indian sub-continent. With its multiple uses and tolerance to a broad range of climate and soil conditions, this species deserves much greater consideration for agroforestry. Poor stem form with generally crooked and forked pole results in poor wood quality and constitute a major draw back to shisham production (Vidakovic and Ahsan, 1970; Gupta et al., 1992). A great variability, however, exists in the growth and stem form of shisham (Dogra, 1981). Stem form ranged from crooked and forked to completely straight (Bangarwa and Singh, 1994). A very high frequency of Dalbergia sissoo Roxb. in natural populations are with crooked and forked stem with very little proportion of straight trees (Bangarwa et al., 1990).

The principles and practices of plant breeding for tree are well established (Wright 1976, Zobel and Talbert, 1984) and they apply equally to industrial plantations and to small agroforestry holdings and fodder tree plantations. Plus trees are selected from the best populations. Basically, this selection exploits the natural variability available with in a population of the choosen tree species. Since the selection is based on the external appearance, it is necessary to progeny test such plus trees to confirm that they are superior genetically as well i.e. identification of elite trees. Superior genotypes are then planted in special seed production areas or seed orchards where open or controlled pollination provides seed for further plantations and if needed for further selection, testing and breeding (Burley, 1980).

In the present studies of progeny testing in Dalbergia sissoo Roxb. at the age of 3 years, variations due to progenies were highly significant for total height, main stem height, basal diameter and straightness. This has suggested the scope of further improvement through selection of superior progenies. Phenotypic coefficient of variation ranged from 11.26 per cent for straightness to 37.24 per cent for main stem height. This means that inspite of selection of mother trees on the basis of desirable traits such as straightness and main stem height, ample variability exists among progenies of selected plus trees. This has suggested the potentiality of the test material for further selection of fast growing progenies suitable for agroforestry plantation. Such advantages of plus tree selection and progeny testing have been indicated by Gupta et al. (1992). Little difference between genotypic coefficient of variation and phenotypic coefficient of variation and high estimates of heritability for all the characters under study revealed the heritable nature of variability present. High estimates of heritability (above 75 per cent) have also envisaged that environment has little influence for the expression of total height, main stem height, basal diameter and straightness. High estimates of genetic advance as percentage of mean ranging from 17.78 for straightness to 60.20 for main stem height further suggested the potentiality of test material for improvement through selection specially for main stem height, total height and basal diameter. Straightness was already high in three years old progenies. However, it can be improved further upto some extent. It is for the tree breeders to exploit such variability for stem form and growth through appropriate breeding and selection in order to improve the species genetically. Solanki et al. (1984) studied variability and heritability for growth parameters in Prosopis cineraria. Progenies of different trees showed significant variation and high genetic advance for plant height. Jindal et al. (1991) studied variability in juvenile progenies of Tecomella undulata and significant differences among progenies and high heritability with high genetic advance were observed.

In the present study, significant differences were observed between progenies of different origin as well as among progenies of same origin for total height, main stem height, basal diameter and straightness. This has suggested that for the improvement of total height, main stem height, basal diameter and straightness, individual plus tree selection from every region is of prime importance. The individual tree selection for the improvement of staightness and height of clear bole in pine were found important (Zobel et al., 1960; Zobel and Talbert, 1984). Bangarwa and Singh (1994) has also suggested the plus trees selection from different geographic region for genetic improvement in Dalbergia sissoo Roxb.

The progeny performance of P 26 from Haldwani was found extra ordinarily good with higher values for total height, main stem height, basal diameter and straightness. All these traits are important from economic view point in tree breeding. Progeny performance of P 16 from Dabwali, P 23 from Kanpur, P 27 from Nainital, P 28 from Muzzafarnagar and P 35 from Fazilka were also found promising for total height, main stem height, basal diameter and straightness. Index score analysis clearly indicated the overall superiority of P 16 from Dabwali, P 23 from Kanpur, P 26 from Haldwani and P 27 from Nainital. The results have further suggested the selection of plus trees from Dabwali, Kanpur, Haldwani and Nainital. Identification of superior progenies in progeny trials have been carried out for teak (Kedharnath et al., 1960), Bombax (Venkatesh and Vakshasya, 1977), Santalum album (Bagchi and Kulkarni, 1987; Bagchi et al., 1987) and Dalbergia sissoo Roxb. (Bangarwa, 1993). It was suggested to raise progenies from a large number of parent trees under the same environmental conditions and subsequently to carry out intensive selection between progenies (Sheikh, 1989).

An examination of the scatter diagram revealed the presence of substantial variability among progenies. P 23 from Kanpur, P 26 from Haldwani and P 27 from Nainital could establish a group for fast growth. The distribution of different progenies reflected the positive association between total height and basal diameter. Strong positive correlation coefficients were observed among total height, main stem height and basal diameter. The correlation coefficients of straightness with each of total height, main stem height and basal diameter were also found significantly positive. This has suggested the effectiveness of selection for all the desirable characters simultaneously. Strong positive correlation of height with diameter were also observed in Populus ciliata (Khosla et al., 1980) Dalbergia sissoo Roxb. (Bangarwa, 1993) and Azadirachta indica (Singh 1994).

An adequate supply of high quality seed is necessary for afforestation work. The reproductive capability of good genotypes is, therefore, very important for production of large quantities of good quality seed. The efficiency of reproductive system depends on our understanding of factors affecting reproductive biology. In the present study, seed pod production behaviour of different progenies of a perticular origin was similar, which indicated the influence of seed source on seed production behaviour. All the progenies from Jhansi, Rohtak, Narwana, Sirsa, Dabwali, Muzzafarnagar, Hisar, Hanumangarh, Suratgarh, Fazilka, Sriganganagar, Sardarshahr and Ludhiana showed seed pod production during third year of growth. Progenies from all other seed sources viz., Rath, Banda, Naraingarh, Dehradun, Kanpur, Moradabad, Haldwani, Nainital, Sitapur, Ranchi and Lucknow also started seed pod production during fourth year. It is very important to note that seed production in some seed sources of shisham can occur during 3rd year whereas seed production starts during fourth year in all the seed sources of Dalbergia sissoo. Leucaena leucocephala was reported to flower even in 102 days after sowing (Gupta and Patil, 1985). Flowering in E. tereticornis occured after 18 months of sowing under Dehradun conditions (Arya & Haque, 1982).

SUMMARY

The present investigation on shisham (Dalbergia sissoo Roxb.) comprised of evaluation of progenies established during August 1991 after transplanting, the five months old seedlings of 43 progenies (Seed pods were collected from 43 plus trees selected on the basis of straightness, main stem height, clear bole height and low value of crown diameter to stem diameter ratio), in the research area of Department of Agroforestry, Chaudhary Charan Singh Haryana Agricultural University, Hisar following randomized block design with four replications. The data were recorded during March 1994. The results so obtained are summarised as under:

6.1 Analysis of variance showed the presence of sufficient amount of variation for total height, main stem height, basal diameter and straightness in three years old progenies of Dalbergia sissoo Roxb.

6.2 Little difference between genotypic coefficient of variation and phenotypic coefficient of variation and high estimates of heritability for all the characters understudy revealed the heritable nature of variability present.

6.3 High estimates of genetic advance as percentage of mean suggested the potentiality of test material for improvement through selection specially for main stem height, basal diameter and total height.

6.4 Significant differences were observed between progenies of different origin as well as among progenies of same origin for total height, main stem height, basal diameter and straightness.

6.5 Progenies viz., P 16 from Dabwali, P 23 from Kanpur, P 26 from Haldwani, P 27 from Nainital, P 28 from Muzzafarnagar and P 35 from Fazilka were found promising for total height, main stem height, basal diameter and straightness.

6.6 Positive correlation coefficients were observed among total height, main stem height, basal diameter and straightness.

6.7 Progenies from Jhansi, Rohtak, Narwana, Sirsa, Dabwali, Muzzafar-nagar, Hisar, Hanumangarh, Suratgarh, Fazilka, Sriganganagar, Sardarshahr and Ludhiana showed seed pod production during third year, whereas progenies from Rath, Banda, Naraingarh, Dehradun, Kanpur, Moradabad, Haldwani, Nainital, Sitapur, Ranchi and Lucknow also started seed pod production during fourth year.

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