EVALUATION OF OPEN POLLINATED FAMILIES OF *Dalbergia sissoo*

THESIS

by

SUMAN KUMAR JHA

Submitted in partial fulfilment of the requirements for the degree of

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in

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COLLEGE OF FORESTRY
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Affectionately dedicated to my Parents and Brothers

Dr. R.N. Sehgal
Sr. Scientist and Head

Dept. of Tree Improvement & Genetic Resources
College of Forestry
Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) – 173 230

CERTIFICATE-I

This is to certify that the thesis entitled **"Evaluation of open pollinated families of *Dalbergia sissoo*"**, submitted in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE** in **FORESTRY (TREE IMPROVEMENT AND GENETIC RESOURCES)** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan (H.P.) is a bonafide research work carried out by **Mr. Sumankumar Jha (F-99-11-M)** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigations have been fully acknowledged.

Place : Nauni, Solan
Dated : 8th October, 2001

(R.N. Sehgal)
Chairman
Advisory Committee

CERTIFICATE-II

This is to certify that the thesis entitled "entitled "**Evaluation of open pollinated families of *Dalbergia sissoo***", submitted by **Mr. Sumankumar Jha (F-99-11-M)** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan (H.P.), in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE** in **FORESTRY (TREE IMPROVEMENT AND GENETIC RESOURCES)** has been approved by the Student's Advisory Committee after an oral examination of the same in collaboration with the external examiner.

12/11/2001

(R.N. Sehgal)
Chairman
Advisory Committee

External Examiner

12/11/01

Mr. Sanjay Sood
IFS

Sr. Scientist and Head
Department of Tree Improvement and Genetic Resources

22/11/01

Dean
College of Forestry

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Error and omissions are mine.

Nauni, Solan
October 6th, 2001

(Suman Kumar Jha)

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October 4th, 2001

(Suman Kumar Jha)

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INTRODUCTION

Forests are the natures most beautiful and versatile renewable resources providing simultaneously a wide range of economic, social, environmental and cultural benefits and services. Over the years, the worldwide demand for their numerous functions and output is increasing with the expanding population, while the global forest resources are shrinking as a result of over exploitation of these resources, which has resulted in to climatic changes and many such other environmental problems. This has adversely affected the very eco-balance throughout the world.

Under the present scenario there is an urgent need to undertake massive afforestation programme at the rate of 5 million hectares per annum to meet the demand for forest produce and to achieve the stipulated 33 per cent forest cover. Such a large scale plantation programme will demand a large amount of planting material and for this superior planting stock is required so as to make the plantations more productive both quantitative and qualitatively. This necessitates an effective and planned tree breeding programme to capture maximum genetic gain from the natural populations.

Any forest tree improvement/breeding programme starts with the study of existing natural variation in the entire range of species distribution and delineation of provenances capable of providing the best adapted and productive trees (Suri, 1984). Provenance studies are carried out to screen the naturally available genetic variation to select the best planting material for higher productivity and further breeding work (Shiv Kumar and Banarjee, 1986). Most successful Tree Improvement Programmes are those in which proper provenances are used (Zobel and Talbert, 1984).

Dalbergia sissoo Roxb. (Shisham), family Papilionaceae, is a large deciduous tree with a light crown and somewhat crooked bole (Troup, 1983). It is an Important multipurpose timber tree species. The heartwood of the tree is brown, very hard, strong and durable. On account of its strength, elasticity, grain and attractive surface, the wood is highly valued for furniture, constructional and other purposes. Shisham occurs naturally throughout the Sub-Himalayan tract from Indus to Assam, and in Himalayan valleys usually up to 900 m., but sometimes ascending to about 1500 m. The species however, is found throughout the country.

Dalbergia sissoo is regarded as the most important species for afforestation along the banks of rivers, as a shade tree and also for rehabilitation of degraded woodlands . It is amongst the principal tree species commonly recommended for afforestation programmes in dry region for soil and water conservation, as well as for production of timber and fuel wood (Tewari,, 1994).

The occurrence of this species over a wide geographic range encompassing a great diversity of edaphoclimatic conditions of its habitat is expected to be reflected in the genetic constitution of its diverse populations. The species, therefore, offers an opportunity for studying variation and also to select the superior provenances for adaptability and growth. Due to longer rotation period of the tree, there is very less information available on its genetic improvement.

Keeping in view, the above factors and in order to study the extent and pattern of variation in morphological traits, biochemical traits and genetic variation the present investigation entitled, "Evaluation of open-pollinated families of *Dalbergia sissco*" were undertaken selecting 59 open pollinated families distributed in different parts of Himachal Pradesh and Jammu & Kashmir with the following objectives:

i) Evaluation of open pollinated families of *Dalbergia sissoo.*

ii) Biochemical evaluation of leaves of different open pollinated families.

iii) Correlation of biochemical and some macro-nutrient content with growth characters.

REVIEW OF LITERATURE

Chapter-2

REVIEW OF LITERATURE

Variation is the rule of nature. It does exist among species, races and individuals within species due to their genetic make up, environment in which they grow and interaction between genetic and environmental factors. Study of natural variation is important for any breeding or improvement programmes as it helps in detection of relative performance of various traits of economic value. Among the total variation genetic variation is important from the breeders point of view. Determination of that portion of variation which is genetically controlled in economically important traits is useful in tree improvement programmes. The estimate of heritability can further help in formulations effective and efficient selection and breeding strategies. The relevant literature on variation studies is being reviewed under the following heads:

2.1 Genetic variability and heritability

2.2 Variation nutrient (NPK) and biochemical composition of leaves

2.3 Correlation and association analysis

2.4 Genetic divergence

2.1 GENETIC VARIABILITY AND HERITABILITY

In natural populations of a species the presence of land masses, water bodies and mountains cause variation. High genetic variation within and among populations has been demonstrated and this distribution of variation and evolutionary histories can lead to the recommendations of future breeding programmes (Namkoong, 1984).

Hanover and Barnes (1969) from a study of heritability of height growth in western pine seedlings demonstrated that choice of individual parent or parental population could greatly influence heritability estimated from progeny analysis.

Brewbaker *et al.* (1972) observed the varietal variation in 104 strains of *Leucaena* sp. and showed that genetic variation was quantitative and prominent for leaf character, pod length, seed number, size and mimosine content.

The morphological and physiological traits exhibit significant amount of genetic variation both within and between plant populations (Stebbins, 1950, Stern and Roche, 1974).

Significant variation in various phenotypic characters such as needles and seed dimension of *Pinus densiflora* was recorded with respect to altitude and similar variations were observed for *Pinus thunbergii* (Bab, 1976; Hayashi and Mural, 1978).

Kedarnath and Vakashasya (1977) have reported decreasing heritability of *Eucalyptus tereticornis* seedling height from $h^2 = 0.42$ to 0.25 at 4 year age.

Surendran and Chandrasekharan (1984) recorded height, number of leaves, number of branches, collar diameter, leaf length, breadth, length/breadth ratio and internodal length of seedlings grown from seeds of thirty five *Eucalyptus tereticornis* plus trees selected from different parts of Tamil Nadu. Heritability and genetic advance were found to be high for number of branches. They, therefore, recommended that this could be useful in selection programme for high biomass production.

Rehfeldt (1985) reported genotypic covariances between different characters under study for *Pinus contorta*. Maximum was found between branches and whorls, whereas minimum was found between whorls and branch lengths. The degree of treatment responses depend on the genetic variance, covariances and correlations.

Cannell et al (1985) reported significant effect of total height of the progeny within each plantation family and also between sites and family interactions in open-pollinated families of *Pinus ponderosa*. Narrow sense heritability estimates within and between plantations indicated substantial genetic variation and that selection practices can achieve good response.

Boyle and Morgestern (1987) in a study on black spruce (*Picea mariana*) estimated variation within population amounting to 99 per cent of total variation.

Jhonsen *et al.* (1988) observed significant difference for root growth potential among different provenances of white pine. Heritability estimates have little genetic control over root growth potential in seedlings.

Kiss and Yeh (1988) estimated the narrow sense heritability after third, sixth and tenth growing season as 0.5, 0.36 and 0.20, respectively for height growth of *Picea glauca*. The corresponding family heritability was 0.81, 0.73 and 0.67 per cent, respectively.

Samarawira (1988) observed appreciable amount of variation in germination (57.6-95.2%) in date palm. Heritability estimates for seed weight, length, leaf emergence and sprouting were low which varied between 58 per cent (seed weight) and 20 per cent (sprouting) in case of *Phoenix dactylifera* Linn.

Salazar (1989) reported considerable variation among provenances of *Acacia mangium* for seed dimension, plant growth and leaf dimension at nursery level. Further he reported that more than 93 per cent of variation in character was due to provenances.

Alvarez and Montalvo (1990) evaluated half-sib progeny trial with 26 families of *Pinus cubensis* at age of 10 years. The broad and narrow-sense estimates of heritability range from 0.842-0.964 and 0.551-0.85, respectively for total height, diameter at breast height and total volume.

Jaswal (1992) revealed that all the growth parameters in *Grewia optiva* viz., seedling height, collar diameter, leaf area, length and weight (dry) of root and shoot and their respective ratio showed significant variation among the seed sources.

Chauhan and Verma (1993) evaluated the progeny performance of eight different provenances of *Acacia catechu* collected from different agro-climatic zones of Himachal Pradesh. The study revealed high heritability coupled with high genetic advance four seedlings height, collar diameter, number of leaves and branches per plant, thereby, indicating the importance of additive gene effects. Further, they suggested to give greater importance to the above characters while carrying out selection.

Dhillon (1995) calculated variability, heritability and expected genetic gain for seven growth characters studied in 30 superior phenotypes of Shisham collected from different agro-climatic zones of Haryana. Variability was recorded for all the growth characters. High heritability, coupled with high genetic advance (% of mean) was observed for number of branches, number of leaves and weight of leaves/seedling, suggesting them to be controlled by additive genetic effects.

Srivastava (1995) reported that high genetic coefficient of variability for *Bauhinia variegata* was accompanied by high heritability and genetic gain in seed weight, germination percentage, germination value, germination energy index shoot dry weight and root dry weight thereby, depicting the scope for improvement of this character by direct selection.

Singh *et al.* (1995) derived information on genetic variability, heritability and genetic advance from data on total height, main stem height, basal diameter and straightens in the 3 years old progeny of 43 plus trees of *Dalbergia sissoo* from natural populations of Uttar Pradesh, Punjab, Haryana, Rajasthan and Bihar. High heritability estimates were recorded, ranging from 0.78 for total height to 0.85 for main stem height.

Hosalli (1997) concluded moderate to high heritability and genetic gain for seedling height, collar diameter, internodal length, shoot and root fresh and dry weight among 49 species/varieties of *Leucaena leucocephala*.

Gupta and Sehgal (2000) estimated the variability for phenotypic character of *Toona ciliata* among the altitudinal provenances and zones in Himachal Pradesh. Heritability was found maximum (81.54%) under altitudinal provenances and relatively lower for zones (51.57%) with respect to leaf length among all other phenotypic parameters with genetic gain of 43.36 per cent and genetic advance of 14.08 per cent. Wide range of genetic variabilities were observed for almost all the characters.

2.2 VARIATION IN NUTRIENT (NPK) AND BIOCHEMICAL COMPOSITION OF LEAVES

Several workers have reported that there exists considerable variation in chemical composition of leaves in woody plants growing under different environmental conditions. Studies on chemical composition, nutritive value and palatability of some fodder tree species in India have been carried out by Keher *et al.* (1962). Nutritional aspect of some of the fodder tree species in Himachal Pradesh was carried out by Negi *et al.* (1980). The work of some of them is reviewed as under:

Kaushal *et al.* (1986) reported significant variation in foliar composition of *Robinia pseudoacacia* growing in three different localities. They concluded that phosphorus varied significantly with localities and further assigned these variations to climatic, geographic and edaphic factors.

Parrota (1987) determined nutrient content in leaves of 2 year old *Albizia lebbek* which contained 3.72 per cent N 0.18 per cent P and 10.1 per cent K.

Sniezko and Stewart (1989) found significant differences in some of the nutrient contents in shoot among provenances of *Acacia albida*. They assigned the variation to provenances and microbial association with the seedlings.

Jaswal (1992) studied leaf fodder value of 24 seed sources of *Grewia optiva* in terms of dry matter content, proximate principles and mineral nutrients which varied significantly among seed sources and indicated high heritability, high genetic gain, thereby higher genetic control of these characters.

Bhola (1995) investigated the foliar nutrient content of some NFT's and recorded 2.56 per cent N, 0.15 per cent P and 0.85 per cent K in *Dalbergia sissoo.*

Sehgal and Jaswal (1996) observed that early to late winter variation in leaf fodder value in *Grewia optiva* was significant within the seed sources. Leaf fodder nutrition value and leaf biomass per plant were highly heritable and predicted genetic gains were high.

Hosalli (1997) reported significant differences in foliar nutrient composition among 49 species/varieties of *Leucaena leucocephala*.

Meshram (1999) analyzed the leaves of nine seed source of *Dalbergia sissoo* attacked by *Plecoptera reflexa* and reported 0.18-0.27 per cent phosphorus and 0.76-0.96 per cent potassium in leaf samples.

Lunderstadt (1980) analysed phenols and proteins in needles of *Picea abies* and found that phenol concentration differed more as a result of genotypic than environmental effect.

Singh and Puri (1987) collected seed from eight seed stands of chir pine (*Pinus roxburghii*) from four zones of Himachal Pradesh state, covering an altitudinal gradient of 450-2400 m and examined quantitatively for starch content, sugars (both reducing and non-reducing) and protein. The starch content of seed increased with increase in altitude while sugar content remained high in seed from all stands.

Hiremath (1993) studied changes in biochemical constituents of *D. sissoo* leaves infected by blight and powdery mildew. The total sugar, reducing sugar and phenol contents were significantly decreased in infected leaves.

Teotia (1997) studied the change in leaf biochemical constituent infected by *Pseudocercospora mori* and found that water content, protein, sugar, RNA and amino acid contents were decreased and phenol content was increased in the infected leaves.

2.3 CORRELATION AND ASSOCIATION ANALYSIS

Rathinam *et al.* (1982) applied path coefficient analysis technique to find out the interrelationship of wood yield components in *Eucalyptus tereticornis* and concluded that girth at breast height was most closely related to stem wood weight and suggested its use as a selection index for biomass production.

Khosla *et al.* (1985) evaluated the correlation between shoot dry weight and other seedling characters in *Pinus roxburghii* and found that the root and shoot length, shoot and root fresh weight contributed directly to the shoot dry weight and were important for increase in the ultimate dry weight.

Gupta and Patil (1988) investigated variation in *Leucaena* species for fodder yield fuelwood yield, yield per plant, plant height, collar diameter length of leaf and seed traits and found significant positive association of five characters with fodder as well as fuelwood both at genotypic and phenotypic levels. Correlation coefficient at genotypic level of fodder yield, seedling weight, collar diameter and leaves per plant in all positive combinations were positive and highly significant. Further, forage yield indicated a high and direct effect in the above characters.

Srivastava *et al.* (1993) conducted correlation and path coefficient studies on six attributes of *Terminalia arjuna* using data from an eight year old plantation. The study revealed that plant height and number of leaves per branch had a direct effect on leaf yield and they suggested that these two attributes should be given greater importance while formulating selection indices.

Hooda and Raj Bahadur (1993) reported significant differences among genotypes of *Leucaena leucocephala* for some seed traits. Hundred seed weight had high genotypic correlation of variance, phenotypic correlation of variance, heritability and genetic advance, positive correlation was also noticed between seed length, breadth, thickness and weight.

Reddy and Subramaniam (1998) found higher genotypic correlation than phenotypic correlation in *Santalum album*. They reported strong genotypic association of plant height, basal diameter, leaf length and leaf breadth with volume and phenotypic association of first two characters with volume.

Tyagi *et al.* (1999) reported positive correlation of germination (0.873-0.964) with all the seed characters studied viz. seed length, seed width, seed thickness, seed volume and 100 seed weight among the provenances of *Grewia optiva*.

Gera *et al.* (1999) observed higher direct and indirect effects of characters viz. polyphenol, number of branches, pod length and germination per cent on field height in *Dalbergia sissoo*. Further they emphasized on the use of these parameters as selection criteria for improving field height.

2.4 GENETIC DIVERGENCE

Assessment of genetic divergence between populations is vital to success of plant genetic improvement planned to exploit the genetic diversity within and among populations and heterosis is often obtained by wide crossing. Multivariate assessments are often made by using phenotypic population means. If these are based on sufficiently large sample sizes and the traits measured show significant differences between populations, they can provide a reasonable representation of over-all genetic performance.

Multivariate procedures have helped to evaluate germplasm collections used for evaluation, selection and breeding in a number of grass species (Humphreys *et al.*, 1980, Charmet *et al.*, 1988).

Multivariate analysis based on Mahalanobis' D^2 statistic and canonical analysis have the limitation for classifying huge germplasm collections studies for several attributes (Arunachalam, 1981). Beale (1969) suggested the use of non-hierarchical Euclidean analysis to overcome this limitation.

Garg and Gautam (1997) evaluated four hundred and fourty one wheat germplasm collections including important varieties and exotic and indigenous accessions, for 15 metric characters using non-hierachical euclidean cluster analysis. All the genotypes were grouped in to 12 different clusters showing the existence of high genetic diversity in the material. The intra-cluster distance was maximum (2.90) in cluster II and minimum (2.10) in cluster V. Cluster IV and X were highly diverse (6.66) from each other. Genotypes of cluster IV were highest yielders. Several collections which may serve as good genetic donors for high spikelet fertility, dwarfness, long ear, bold grain, high number of ears and good source for multiple resistance against rust and powdery mildew were identified.

Mani *et al.* (1996) observed genetic divergence among 100 accessions of maize. He grouped all the accessions in to eleven clusters. The seven accessions grouped in cluster VIII showed more heterogeneous population owing to highest intra cluster distance.

Surendran and Chandrashekharan (1988) illustrated the magnitude of genetic divergence among thirty five single tree selections of *Eucalyptus tereticornis* from different agro climatic zones of Tamil Nadu. Based on eight growth characters they applied mahalanobis D^2 statistic to identify eleven clusters among the 35 single tree selections. Three clusters were found highly divergent from each others.

Bagchi (1992) noticed very high genetic divergence among 42 provenances of *Acacia nilotica* for seed traits viz. seed length, width and thickness. Seed thickness contributed most (52.0%) to the total divergence followed by seed width (33.33%) and seed length (14.54%).

Singh (1993) studied genetic divergence among nineteen plus bamboo clumps selected from northern and southern parts of Assam and adjoining areas of Arunachal Pradesh. The plus bamboos were grouped into four clusters but the grouping of genotypes into clusters was not related to their geographical origin.

Panday *et al.* (1995) reported high genetic divergence for sixteen quantitative traits in twelve clones of *Populus deltoides.* The clones were divided into five clusters where the inter cluster distance varied from 1.13 to 19.3.

Chauhan *et al.* (2000) assessed the magnitude of genetic divergence among the progenies of 58 plus trees of *Pinus roxburghii* at 5 year age on the basis of five growth characters viz. plant height, collar diameter, current year growth, internodal length and spur dry weight to identify cluster pattern for future improvement programme in this species and the 58 progenies were grouped into 11 clusters.

MATERIALS AND METHODS

Chapter-3

MATERIALS AND METHODS

The present investigations entitled, "Evaluation of open-pollinated families of *Dalbergia sissoo*" were carried out in 1½ years old seedlings raised at Regional Horticultural Research Station, Jachh, District Kangra of Dr. Y.S. Parmar University of Horticulture and Forestry, Solan (HP) in the year 1999 under the ICFRE project entitled "Co-ordinated research project on genetic improvement of *Dalbergia sissoo*" Details about the experimental site, materials used and methodology adopted during the course of study are discussed in this chapter.

3.1 EXPERIMENTAL SITE

3.1.1 Location

The experimental site is located at 32°18′N latitude and 15°55′E longitude with an altitude of 428 m. above mean sea level. It is situated at a distance of 3 Km from Nurpur on Pathankor-Kullu road.

3.1.2 Climate

The study area falls in the sub-tropical zone representing low hills and valley areas of Himachal Pradesh. The average annual rainfall is about 1500 mm, a major portion of which is received during June-August (Monsoon period). The annual range of mean monthly temperature is 12.2 to 31.1°C with mean winter and summer temperature of 13.6 and 29.3°C, respectively. Meteorological data pertaining to the experimental site for the year 2000-2001 are presented in Table 1

3.2 EXPERIMENTAL PROCEDURE

The seed of 59 plus trees of *Dalbergia sissoo* was sown in the nursery in the year 1998, where the seedlings retained for one year. Then they were transplanted in the field under the ICFRE project entitled "Co-ordinated research project on genetic improvement of *Dalbergia sissoo* in Himachal Pradesh and Jammu & Kashmir" in August 1999 in a Randomized Complete Block Design. Details of the 59 half-sib families of *Dalbergia sissoo* are given in Table 2.

Details of the half-sib family trial are as under:

Number of half-sib families	=	59
Replications	=	3
Spacing	=	3x3 m
Experimental design	=	Randomized Complete Block Design
Number of plant of a family in one replication	=	25

Observations have been taken on 9 plant of each family (3 per replication).

3.3 METHODOLOGY ADOPTED AND OBSERVATIONS RECORDED

Nine plants from each family (3 per replication) were randomly taken and studied. The observations recorded were observed as follows:

3.3.1 Seedling growth and establishment

3.3.1.1 Seedling height

Total height of seedling from each source was measured from the base to the apex of the leading shoot.

3.3.1.2 Collar diameter

Collar diameter was measured with the help of digital caliper.

3.3.1.3 Leaf area

Leaf area was measured by using Leaf Area Meter (LICOR area meter model 3100).

Table 1. Meteorological data observed during the study period at RHRS, Jachh (Kangra)

Month	Temperature (°C)		Rainfall (mm)
	Maximum	Minimum	
1999			
October	26.50	20.00	15.50
November	21.70	16.30	-
December	22.50	16.80	-
2000			
January	15.80	9.30	48.00
February	19.80	13.60	55.00
March	26.50	19.70	-
April	31.80	24.40	-
May	38.20	32.00	100.00
June	36.60	30.10	145.00
July	26 60	21.70	130.00
August	25.30	18.30	253.00
September	26.50	17.20	178.00
October	27.70	15.90	-

Table 2. Description of 59 open pollinated families of *Dalbergia sissoo* selected for study from different districts of Himachal Pradesh and Jammu

Sr. No.	Name of Family	Family Number	Districts
1.	Nalagarh-1	1.	Solan
2.	Nalagarh-2	2.	Solan
3.	Nalagarh-3	3.	Solan
4.	Nalagarh-4	4.	Solan
5.	Nalagarh-5	5.	Solan
6	Nalagarh-6	6.	Solan
7.	Nalagarh-7	7.	Solan
8.	Nalagarh-8	8.	Solan
9.	Nalagarh-9	9.	Solan
10.	Nalagarh-10	10.	Solan
11.	Nalagarh-11	11.	Solan
12.	Rishikesh	12.	Bilaspur
13.	Bharari	13.	Bilaspur
14.	Dhar Tatoh-1	14.	Bilaspur
15.	Dhar Tatoh-2	15.	Bilaspur
16.	Dhar Tatoh-3	16.	Bilaspur
17.	Dhar Tatoh-4	17.	Bilaspur
18.	Dhar Tatoh-5	18.	Bilaspur
19.	Dhar Tatoh-6	19.	Bilaspur
20.	Dhar Tatoh-7	20.	Bilaspur
21.	Dhar Tatoh-8	21.	Bilaspur
22.	Balu	22.	Kangra
23.	Khajjian	23.	Kangra
24.	Baranda	24.	Kangra
25.	Jassur	25.	Kangra
26.	Pakka Tiala	26.	Kangra
27.	Lodhwan	27.	Kangra
28	Channi	28.	Kangra
29.	Khaber	29.	Kangra
30.	Nakroh	30.	Una

Contd....

31.	Barsali	31.	Una
32	Dhuk	32.	Una
33.	Gagret	33.	Una
34.	Khurian	34.	Una
35.	Nadaun	35.	Hamirpur
36.	Pakhral	36.	Hamirpur
37.	Jagian-1	37.	Kathua
38.	Jagian-2	38.	Kathua
39.	Jagian-3	39.	Kathua
40.	Jagian-4	40.	Kathua
41.	Jagian-5	41.	Kathua
42.	Bijouta	42.	Kathua
43.	Daboh-1	43.	Jammu
44	Daboh-2	44.	Jammu
45.	Devak Bella-1	45.	Jammu
46.	Devak Bella-2	46.	Jammu
47.	Devak Bella-3	47.	Jammu
48.	17 Mile Depot-1	48.	Jammu
49.	17 Mile Depot-2	49.	Jammu
50.	Dudhla	50.	Sirmour
51.	Puruwala	51.	Sirmour
52.	Bata Mandi	52.	Sirmour
53.	Behral	53.	Sirmour
54.	Jammukhela	54.	Sirmour
55.	Matakmajri	55.	Sirmour
56.	Dhaulakuan	56.	Sirmour
57.	Dardanwala	57.	Sirmour
58.	Uttamwala	58.	Sirmour
59.	Teeb	59.	Sirmour

3.3.1.4 Fresh weight of the leaves (g)

Five leaves collected from each seedling ere weighed and their mean was taken as the fresh weight.

3.3.1.5 Dry weight of the leaves (g)

The leaves sampled for fresh weight were kept in oven at 55°C till the leaves attained a constant weight. The mean weight of five dry leaves was recorded.

3.3.1.6 Seedling survival per cent

For all 59 families survival per cent of the seedlings was noted in November, 2000 i e. at the age of one and half year in field.

The survival per cent per replication was worked out as follows:

$$\text{Survival (\%)} = \frac{\text{No. of plants of a family surviving in each replication}}{\text{Actual number of plants of that family that were planted i.e. 25}} \times 100$$

And the mean survival per cent was taken as family survival per cent.

3.3.2 Foliar nutrient composition

For determination of foliar nutrient composition, the leaf samples were thoroughly washed under tap water and then with 0.1 N HCl followed by distilled water. The washed samples were air dried and placed in an oven at 60°C till the sample attained a constant weight. The dried samples were ground thoroughly and stored in butter paper bags. Different nutrients were determines as follows:

3.3.2.1 Nitrogen (%)

Nitrogen content was estimated by micro-kjeldahl method (AOAC, 1980).

3.3.2.2 Phosphorus and Potassium (%)

Leaf sample weighing 2.5 g was digested in 20 ml of 4:1 Nitcro-perchloric acid (HNO_3: $HClO_4$) mixture. In order to have complete transfer of the digested material three washings of the digesting flask were done with distilled water and made up to 50 ml. Phosphorus in the extract was determined by Vanado-molybdate yellow colour method and potassium was determined by flame photometer method (AOAC, 1980).

3.3.3 Extraction of total sugars and total phenols

One gram of dried coarse powdered sample of leaves was placed in 20-25 ml of boiling 80 per cent ethanol for 10 minutes and filtered through a double layered muslin cloth. The residue was again extracted in 10-15 ml of boiling 80 per cent ethanol for 3-5 minutes. Thereafter, both the extracts were combined and the final volume was made to 50 ml to represent one gram tissue in 50 ml of alcohol extract. The extract was used for estimation of total sugars and total phenols as follows:

3.3.3.1 Total sugars

To estimate sugars, the alcohol extract was evaporated to dryness by keeping on a hot water bath at 60°C leaving alcohol free residues. The alcohol free residues were centrifuged at 5000 rpm for 10 minutes. The supernatant was used for estimation.

Total sugars in dried samples were estimated by the phenol sulphuric acid method of Dubois *et al.* (1951). One ml of the extract was taken in a test tube, to which one ml of 5 per cent phenol solution was mixed. To it 5 ml of concentrated H_2SO_4 was added, mixed thoroughly and cooled under the tap water. The intensity of yellow-orange colour was measured at 490 nm in spectronic 20. The total sugars were determined from a standard curve drawn using known strength of glucose solution and expressed as mg/g of dry weight.

3.3.3.2 Total phenols

Total phenols were estimated by Folin phenol reagent method of Bray and Thorpe (1954). One ml of alcohol extract was mixed with one ml of Folin reagent followed by addition of two ml of 20 per cent sodium carbonate. The mixture was kept on boiling water bath for one minute and than cooled under running tap water. The blue solution thus developed was diluted to 25 ml and the optical density was recorded after 30 minutes at 650 nm. Total phenols were calculated from the standard curve drawn using known strength of catechol and expressed as mg/g of dry weight.

3.4 STATISTICAL ANALYSIS

The entire data were analyzed statistically for the assessment of analysis of variance, variance components, heritability (narrow sense), correlation, genetic gain and genetic divergence. Zobel and Talbert (1984) described analysis of data in the Randomized Complete Block Design as under:

3.4.1 Analysis of variance

Source of variation	Degree of freedom (d.f.)	Mean Sum squares (MSS)	F cal.	Expected M.S.S. (EMS)
Replication	R-1	MS_4	MS_4/MS_2	$\sigma^2 w + T\sigma^2 RF + TF\sigma^2 R$
Families	F-1	MS_3	MS_3/MS_2	$\sigma^2 w + T\sigma^2 RF + RF\sigma^2 F$
Families x replications	(F-1) (R-1)	MS_2	MS_2/MS_1	$\sigma^2 w + T\sigma^2 RF$
Plants within plot	RF (T-1)	MS_1		$\sigma^2 w$

Where;

R = Number of replications
F = Number of families
T = Number of plant samples in each plot

$\sigma^2 RF$ = Replications x family variance component $= \dfrac{MS_2 - MS_1}{T}$

$\sigma^2 F$ = Variance among half sib families $= \dfrac{MS_3 - MS_2}{TR}$

$\sigma^2 R$ = Replication variance component $= \dfrac{MS_4 - MS_2}{FT}$

$\sigma^2 w$ = Within plot (error) variance = MS_1

The calculated "F' values were compared with tabulated 'F' values at appropriate degrees of freedom.

3.4.2 Critical differences (CD)

In order to compare the mean of various entries, the critical difference (CD) was calculated by the following formula:

CD = S.E. x 't'

Where;

S.E. is standard error of the difference of the treatment means to be compared and is equal to:

$$S.E. (2\ MSe/R)^{1/2}$$

With MSe as error mean sum of square and R as number of replications and 't' is the tabulated value of 't' at 5 per cent level of significant for the degree of freedom for error mean square.

$$\text{CD families} = \sqrt{\frac{2\ MS_2}{R}} \times t0.05 \text{ (error degree of freedom)}$$

$$\text{CD within families} = \sqrt{\frac{2\ MS_1}{RT}} \times t0.05 \text{ (error degree of freedom)}$$

If the mean difference between any two varieties is greater than calculated CD value than the difference is taken to be significant.

3.4.3 Variance components

i) Phenotypic variance among half sib families: $\sigma^2P = \sigma^2F + RF/T + \sigma^2w/RT$

ii) Phenotypic variance among individual: $\sigma^2P = \sigma^2w + RF + \sigma^2F$

iii) Additive genetic variance: $\sigma^2A = 4\sigma^2F$

3.4.4 Heritability (narrow sense)

Variance components those derived from the analysis can be used to estimate heritability (narrow sense)

$h^2F = \sigma^2F/\sigma^2p = \frac{1}{4}\sigma^2A/\sigma^2p$

$h^2w = 3\sigma^2F/\sigma^2w = \frac{3}{4}\sigma^2A/\sigma^2w$

$h^2I = 4\sigma^2F\sigma^2p = \sigma^2A/\sigma^2p$

Where;

h^2F = Heritability on a half sib family basis
h^2w = Heritability on a within family basis
h^2I = Heritability on an individual plant basis

3.4.5 Genetic gain

G_F = Genetic gain of family selection = $4iF\ h^2F\ \sigma F$, where $iF = 0.19$ (Zobel and Talbert, 1994, 90% selection intensity)

G_W = Genetic gain of within family selection = $4/3\ iw\ h^2w\ \sigma w$ where $iW = 1.12$ (Zobel and Talbert, 1994, 30% selection intensity)

G_T = Total genetic gain = $G_F + G_W$

G_F/G_W = Ratio of family and within family genetic gains

3.4.6 Calculation of correlation coefficients

Karl Pearson's correlation coefficients among morphological, biochemical and nutrient content were worked out in all possible combinations (Panse and Sukhatme, 1967).

The significance of correlation coefficient was tested against 'r' values as given by Fisher and Yates (1963) at n-2 degrees of freedom.

3.4.7 Genetic divergence

Genetic divergence was calculated by using non-hierarchical Euclidean cluster analysis (Beale , 1969; Spark, 1973).

EXPERIMENTAL RESULTS

Chapter-4

EXPERIMENTAL RESULTS

The results obtained from the present investigations are presented in this chapter. In all, 59 families were evaluated and coded as 1, 2, 3, 4, ... 59 for convenience of interpretation of results. The experimental results are presented under the following heads:

4.1 Analysis of variance/evaluation of families

4.2 Estimation of variability and genetic parameter

4.3 Estimation of simple correlation

4.4 Genetic divergence

4.1 ANALYSIS OF VARIANCE/EVALUATION OF FAMILIES

The analysis of variance of 59 half-sib families of Shisham indicated that these families differed significantly for all traits viz. height of seedling, collar diameter, fresh/dry weight of leaves, nitrogen, phosphorus and potassium content, total sugar and total phenol content under study. Within family differences were also significant for phosphorus and total sugar contents (Appendix - I).

4.1.1 Physical attributes

4.1.1.1 Survival percentage

The survival percentage for different half-sib families of *Dalbergia sissoo* varied from 11.37 to 94.87 per cent. The highest survival percentage was exhibited by family no. 17 followed by families 8, 10, 41, 27, 12, 36, 49 and 2 in descending order. The lowest survival percentage was observed for family no. 56 (Table 3).

4.1.1.2 Height of seedling

Significant differences were observed for average height of seedlings. The data revealed that the variation in average height ranged between 54.35 cm and 128.77 cm having the overall mean of 97.80 cm (Table 4). The maximum height was recorded for family no. 35, which was observed to be significantly higher than all other families. The minimum seedling height was recorded for family no. 59.

4.1.1.3 Collar diameter

The data presented in appendix I revealed significant differences for collar diameter between different families of *Dalbergia sissoo*. The data revealed that the variation for collar diameter ranged between 0.616 cm and 1.107 cm with overall mean of 0.97 cm (Table 4). The maximum value for this parameter was recorded for family no. 24 which was at par with family no. 26 and was superior to others. The minimum value was noticed for family no. 59 which was found to be at par with families 6, 39, 41, 5, 15, 52, 37, 47, 55, 54, 12, 40, 46, 4, 51, 45, 3, 20, 32, 1, 48, 38, 13, 14, 22, 53, 56, 57, 7, 58, and 21 in ascending order (Table 4).

4.1.1.4 Dry weight of leaves

Significant differences were observed for dry weight of leaves between the families (Appendix-I). The data revealed that the variation in dry weight of leaves ranged between 0.571 and 1.043 gm with overall mean of 0.79 gm (Table 4). The maximum value was recorded for family no. 25 followed by family no. 56 and was superior to families 18, 11, 21, 35, 45, 22, 34, 7, 27, 58, 37, 3, 39, 33, 20, 42, 36, 44, 16, 10, 8, 26, 41, and 19 in descending order. Whereas, the minimum value was recorded in family no. 59 and 52.

4.1.1.5 Leaf area

Appendix-I revealed significant differences for leaf area (cm^2) between families of Shisham. It is evident from the data that leaf area of the seedling ranged

Table 3. Name of family, family number and survival percentage of 59 open pollinated families of *Dalbergia sissoo*

Sr. No.	Name of Family	Family Number	Survival per cent
1.	Nalagarh-1	1.	57.88
2.	Nalagarh-2	2.	86.34
3.	Nalagarh-3	3.	83.81
4.	Nalagarh-4	4.	84.37
5.	Nalagarh-5	5.	64.30
6.	Nalagarh-6	6.	76.18
7.	Nalagarh-7	7.	77.63
8.	Nalagarh-8	8.	93.59
9.	Nalagarh-9	9.	58.05
10.	Nalagarh-10	10.	90.77
11.	Nalagarh-11	11.	52.93
12.	Rishikesh	12.	87.18
13.	Bharari	13.	67.00
14.	Dhar Tatoh-1	14.	84.09
15.	Dhar Tatoh-2	15.	82.42
16.	Dhar Tatoh-3	16.	77.49
17.	Dhar Tatoh-4	17.	94.87
18.	Dhar Tatoh-5	18.	76.46
19.	Dhar Tatoh-6	19.	70.34
20.	Dhar Tatoh-7	20.	45.35
21.	Dhar Tatoh-8	21.	67.13
22.	Balu	22.	19.23
23.	Khajjian	23.	26.26
24.	Baranda	24.	46.38
25.	Jassur	25.	50.13
26.	Pakka Tiala	26.	84.57
27.	Lodhwan	27.	87.79
28.	Channi	28.	84.99
29.	Khaber	29.	62.69
30.	Nakroh	30.	72.15

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31.	Barsali	31.	75.73
32.	Dhuk	32.	86.94
33.	Gagret	33.	52.68
34.	Khurian	34.	83.01
35.	Nadaun	35.	84.64
36.	Pakhral	36.	87.08
37.	Jagian-1	37.	60.69
38.	Jagian-2	38.	84.96
39.	Jagian-3	39.	78.00
40.	Jagian-4	40.	68.31
41.	Jagian-5	41.	87.88
42.	Bijouta	42.	76.18
43.	Daboh-1	43.	40.09
44.	Daboh-2	44.	63.17
45.	Devak Bella-1	45.	48.53
46.	Devak Bella-2	46.	47.59
47.	Devak Bella-3	47.	23.33
48.	17 Mile Depot-1	48.	33.37
49.	17 Mile Depot-2	49.	37.51
50.	Dudhla	50.	44.92
51.	Puruwala	51.	47.53
52.	Bata Mandi	52.	42.48
53.	Behral	53.	38.00
54.	Jammukhela	54.	45.89
55.	Matakmajri	55.	31.69
56.	Dhaulakuan	56.	11.37
57.	Dardanwala	57.	41.79
58.	Uttamwala	58.	46.00
59.	Teeb	59.	33.02

Table 4. Mean of various traits in open pollinated families of *Dalbergia sissoo*

Family No.	Seedling height (cm)	Collar diameter (cm)	Dry weight of leaves (g)	Leaf area (cm^2)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Sugar (mg/g)	Phenol (mg/g)
1.	87.949	0.757	0.783	58.97	2.774	0.218	1.111	22.96	10.408
2.	103.46	1.121	0.783	58.69	2.740	0.197	1.033	26.654	11.482
3.	95.41	0.801	0 857	65.31	2.676	0.180	1.181	31.012	12.973
4.	96.99	0.834	0.723	48.49	2.582	0.182	1.244	27.064	14.558
5.	94.11	0.870	0.729	63.75	2.570	0.197	1.079	22.158	15.992
6	100.26	0.972	0.774	54.48	2.684	0.184	1.066	24.103	11.368
7.	107.35	0.696	0.871	58.49	2.352	0.196	1.248	23.478	12.807
8.	105.04	0.943	0.832	59.81	2.660	0.251	1.297	32.85	14.302
9.	104.46	1.223	0.806	59.61	2.633	0.168	1.332	31.096	14.398
10.	104.58	1.170	0.838	60.47	2.600	0.184	1.246	29.471	13.497
11.	100.92	1.170	0.904	81.95	2.650	0.192	1.268	29.107	13.961
12.	108.11	0.846	0.719	78.46	3.000	0.214	1.268	31.003	13.993
13.	101.45	0.721	0.742	67.31	3.019	0.179	1.267	25.843	11.843
14.	107.85	0.787	0.689	60.94	2.779	0.190	1.307	28.909	12.888
15.	99.93	0.870	0.667	68.33	2.977	0.191	1.266	21.294	11.986
16.	95.29	0.894	0.839	72.25	2.722	0.204	1.220	28.374	15.494
17.	95.83	1.109	0.716	58.68	2.752	0.207	1.248	28.412	10.412
18.	107.27	1.104	0.943	85.85	2.998	0.198	1.168	27.481	12.582
19.	102.67	1.079	0.822	84.61	2.850	0.160	1.306	26.947	10.399
20.	106.36	0.798	0.850	57.44	2.850	0.184	1.220	29.656	10.800
21.	99.52	0.690	0.898	57.22	2.756	0.158	1.146	26.748	11.887
22.	108.17	0.768	0.880	61.43	2.820	0.182	1.121	25.290	15.766
23.	104.46	1.392	0.722	61.62	2.897	0.176	1.259	24.946	13.028
24.	106.40	1.707	0.804	59.53	1.866	0.183	1.169	29.238	10.271
25.	109.30	1.400	1.043	54.07	3.194	0.197	1.383	34.480	18.888
26.	99.37	1.620	0.828	77.34	2.977	0.173	1.249	25.838	10.560
27.	110.12	1.426	0.863	76.84	2.794	0.172	1.279	29.150	9.829
28.	96.961	1.076	0.751	59.23	2.898	0.197	1.288	35.417	11.034
29.	108.21	1.096	0.764	73.19	2.874	0.196	1.250	28.243	13.943
30.	97.16	1.139	0.763	63.57	2.710	0.183	1.239	24.891	10.821
31.	96.88	1.100	0.777	57.37	2.866	0.183	1.270	21.461	17.961

Contd........

32.	92.37	0.797	0.772	70.09	2.650	0.196	1.457	21.152	12.557
33.	92.46	0.919	0.851	73.33	2.854	0.211	1.247	26.817	10.100
34.	102.26	1.026	0.873	73.15	2.904	0.261	1.399	27.724	11.550
35.	128.77	1.091	0.892	69.87	2.469	0.213	1.366	29.124	11.078
36.	101.15	1.122	0.844	61.04	2.738	0.171	1.338	26.941	16.279
37.	84.42	0.864	0.860	64.61	2.714	0.189	1.327	21.033	10.367
38.	85.61	0.771	0.667	67.53	2.932	0.211	1.384	31.603	17.153
39.	102.88	0.891	0.856	65.35	2.728	0.216	1.308	29.071	10.144
40.	92.73	0.846	0.771	64.27	2.866	0.180	1.387	23.420	14.050
41.	95.72	0.880	0.827	76.02	2.976	0.186	1.449	27.349	11.731
42.	105.81	1.116	0.848	66.09	2.670	0.200	1.396	32.570	10.212
43.	105.70	1.182	0,787	73.54	3 000	0.200	1.338	26.177	15.373
44.	101.54	1.109	0.842	65.75	2.916	0.188	1.384	26.778	13.788
45.	94.69	0.828	0.892	72.87	2.340	0.210	1.320	30.176	12.331
46.	91.32	0.837	0.788	73.47	2.533	0.154	1.300	30.197	10.769
47.	97.14	0.866	0.714	54.61	2.489	0.202	1.333	28.073	13.733
48.	87.26	0.779	0.737	63.10	2.214	0.160	1.326	23.686	15.961
49.	96.71	1.088	0.698	65.17	2.777	0.183	1.252	27.084	16.536
50.	84.92	0.931	0.729	65.67	2.774	0.152	1.327	28.234	14.410
51.	90.13	0.828	0.626	56.31	2.736	0.198	1.341	32.747	10.988
52.	86.85	0.870	0.571	59.90	2.551	0.181	1.181	27.412	17.044
53.	85.66	0.724	0.640	67.72	2.511	0.206	1.232	26.744	10.819
54.	86.74	0.847	0.643	68.24	2.642	0.176	1.259	27.950	11.047
55.	84.41	0.878	0.754	58.87	2.863	0.154	1.304	31.947	14.916
56.	88.06	0.736	1.038	67.55	2.729	0.150	1.343	23.748	11.414
57.	83.266	0.794	0.717	57.13	2.482	0.216	1.294	19.682	12.023
58.	105.478	0.684	0.861	33.50	2.502	0.211	1.224	26.706	11.957
59	54.353	0.616	0.571	56.79	2.231	0.172	1.251	23.789	11.647
Mean	97.80	0.97	0.79	64.69	2.72	0.19	1.27	27.32	12.88
$CD_{0.05}$	17.48	0.28	0.24	16.33	0.35	0.08	0.20	10.37	3.76

between 33.50 and 85.85 cm^2 with an overall mean of 64.69 cm^2. The family no. 18 was observed to be superior to all other families. Family 18 was statistically at par with 19, 11, 12, 26, 27, 41, 43, 46, 33, 29, 34, 45, 16, 32 and 35. The minimum leaf area was recorded for family no 58 (Table 4).

4.1.2 Chemical/Nutritional attribution

4.1.2.1 Nitrogen (%)

Variation for nitrogen content (%) was also significant between family (Appendix-I). The nitrogen content varied between 1.866 and 3.194 per cent with overall mean of 2.72 per cent (Table 4). the maximum value was recorded for family no. 25 which was followed by 13, 12 and 43. The families 18, 15, 26, 41, 38, 44, 34, 28, 23, 29, 31, 40, 55, 33, 19 and 20 were at par with the maximum. The minimum value was observed for family no. 24(Table 4)

4.1.2.2 Phosphorus (%)

The data presented in Appendix-I revealed significant differences for phosphorus content among different families of *Dalbergia sissoo*. The variation for this parameters ranged between 0.150 and 0.261 per cent with overall mean of 0.19 per cent (table 4). The minimum value was recorded for family no. 34 and was at par with families 8, 13, 9, 57, 12, 35, 33, 38, 58, 45, 17, 53, 16, 47, 42, 43, 18, 51, 21, 5, 25, 28, 7, 29, 32, 11, 15, 14, 37, 44, 41, 6, 10, 20, 24, 30, 31, 49, 4, 22, 52, 3, 40, and 13 in descending order. The minimum value was recorded for family no. 56.

4.1.2.3 Potassium (%)

Significant differences occurred for potassium between families of Shisham (Appendix-I). The data presented in Table 4 revealed that the variation for potassium content ranged between 1.033 and 1.457 per cent with overall mean of 1.27 per cent. The maximum value was recorded for family no. 32 followed by 41 , 34 and 42. Families 40, 38, 44, 25, 35, 56, 51, 36, 43, 47, 9, 50, 37, 48, 45, 39, 14, 19, 55, 46, 8, 57, 28, 27, 31, 12, 11, 13, and 15 were at par with maximum. The minimum value was recorded for family no. 2.

4.1.2.4 Total sugars (mg/g)

Significant differences existed between families for total sugar content (mg/g) (Appendix-I). The value for this parameter ranged between 19.682 mg/g and 35.417 mg/g with overall mean of 27.32 mg/g (Table 4). The maximum total sugar content was recorded for family no. 28. Families 25, 8, 51, 42, 55, 38, 9, 3, 12, 46, 45, 20, 10, 24, 27, 35, 11, 39, 14, 17, 16, 29, 50, 47, 54, 34, 18, 52, 41, 49, 4, 19, 36, 33, 44, 21, 53, 58, 2, 43, 22, 13 and 26 were at par with the maximum value. The minimum total sugar content was recorded for family no. 57.

4.1.2.5 Total phenols (mg/g)

Significant differences were observed for total phenol content (Appendix-I). The data revealed that the variation in total phenol content ranged between 10.100 and 18.888 mg/g with overall mean of 12.88 mg/g. The maximum total phenol content was recorded for family no. 25 followed by 31, 38 and 52. Families 49, 36, 5, 48, 22, 16 and 43 were at par with maximum value. The minimum value was observed for family no. 33.

4.2 ESTIMATION OF VARIABILITY AND GENETIC PARAMETERS

4.2.1 Components of variation

Different components of variation were used for the calculation of heritabilities, which were utilized for calculation of genetic gains. Different components of variation viz. within plot (6^2w), replication x family (6^2 RF), family (6^2F) have been presented in Table 5. Within plot variance (6^2w) was estimated directly from the mean sum of squares for trees within plots. The highest half-sib family variance (6^2F) was observed for seedling height (94.1397) whereas, the lowest half-sib family variance was found for phosphorus (0.0001). The within plot

Table 5. Variance of different characters under study for 59 open-pollinated families of *Dalbergia sissoo*

Characters	σ^2_{RxF}	σ^2_F	σ^2_W	$\sigma^2_{\bar{P}}$	σ^2_P	σ^2_A
Seedling height	-116.7484	94.1397	469.6681	107.409	447.0595	376.5590
Collar diameter	-0.0745	0.0487	0.2540	0.0521	0.2283	0.1951
Dry weight of leaf	-0.0047	0.0060	0.0358	0.0084	0.0371	0.0243
Leaf area	-84.2943	68.9033	356.9527	80.4666	341.5616	275.6131
Nitrogen	-0.0722	0.0456	0.2650	0.0509	0.2383	0.1825
Phosphorus	0.0005	0.0001	0.0010	0.0004	0.0017	0.0006
Potassium	-0.0114	0.0061	0.0493	0.00785	0.0440	0.0247
Total phenols	-5.6447	4.5160	22.5047	5.1350	21.3760	18.0643
Total sugars	0.2272	7.3166	41.2989	11.9811	48.8427	29.2663

Here:

σ^2_F = Variance among half-sib families

σ^2_{RxF} = Variance of replication x family interaction

σ^2_W = Variance within plot

$\sigma^2_{\bar{P}}$ = Phenotypic variance among half-sib families

σ^2_P = Phenotypic variance among individual

σ^2_A = Additive genetic variance

variance ranged from the highest value of 469.6681 for seedling height to the lowest value of 0.0010 for phosphorus. Variance for replication x family ranged from the highest (0.2272) for total sugars to the lowest value (116.7484) for seedlings height. The highest phenotypic variance among the half-sib families was observed for seedling height (107.409) whereas, the lowest value was observed for phosphorus content (0.0004). In case of phenotypic variance among individual, the seedling height showed the highest value of variance (447.0595) and phosphorus content had the lowest variance (0.0017). Additive genetic variance (6^2A) being 4 x 6^2F corresponded with the highest and lowest values of family variance (6^2F). Highest additive variance was found for the character seedling height (376.5590) whereas the lowest value was observed in case of phosphorus content (0.0006).

4.2.2 Narrow sense heritability study

The narrow sense heritability (half-sib family basis, within family basis and individual plant basis) was calculated for all the characters under study as presented in Table 6.

Maximum heritability on half-sib family basis (h^2_F) was noticed for collar diameter (0.9350) followed by nitrogen (0.8950), total phenol (0.8794) and seedling height (0.8764) whereas, the minimum value was computed for phosphorus content (0.3446). The maximum heritability on within family basis (h^2_W) was computed for total phenol content (0.6020) followed by seedling height (0.6013). The minimum value was worked out for potassium content (0.3615). Heritability on individual plant basis (h^2_I) ranged between 0.8546 to 0.3638 and the maximum was noticed for collar diameter whereas phosphorus content accounted for the lowest value.

4.2.3 Genetic gain studies

The genetic gain of family selection at 90 per cent selection intensity, genetic gain of within family selection at 30 per cent selection intensity, total genetic gain and ratio of family and within family genetic gain were calculated for all the characters under study. The values are presented in Table 7.

The highest genetic gain on half-sib family basis (G_F) was 6.463 for seedling height followed by leaf area 5.400. The minimum genetic gain on half-sib family basis was noticed for phosphorus (0.003).Highest genetic gain of within family selection (G_W) was observed in seedling height (19.410) while the minimum genetic gain of within family selection was observed for phosphorus (0.021). The highest total genetic gain (G_T) was recorded for seedling height (25.873) and the lowest value was noted for phosphorus content (0.025). However the ratio of family and within family genetic gain (G_F/G_W) was ranged between 0.246 and 0.377. The minimum value was noticed for total sugar content whereas potassium content depicted the highest value (Table 7).

4.3 ESTIMATION OF SIMPLE CORRELATION

An attempt has been made in this section to see the inter-relationship between different parameters which influence growth rate. The correlation coefficient data is tabulated in Table 8. The correlation studies were undertaken on all possible combinations of all characters measured.

Out of all these correlation coefficients computed in present study, only 8 were significant.

Plant height was found to be highly significantly and positively associated with collar diameter, (r=0.4571), dry weight of leaves (r=0.5501) and nitrogen content (r=0.4819) and significantly associated with total sugar content (r=0.2883).

Collar diameter was found to be positively and significantly correlated with nitrogen content (r=0.2899).

Dry weight of leaves exhibited positive and significant association with nitrogen content (r=0.3075).

Table 6. Estimates of heritability of different characters under study for 59 open pollinated families of *Dalbergia sissoo*.

Characters	h^2_F	h^2_W	h^2_I
Seedling height	0.8764	0.6013	0.8423
Collar diameter	0.9350	0.5760	0.8546
Dry weight of leaves	0.7166	0.5093	0.6543
Leaf area	0.8562	0.5790	0.8069
Nitrogen	0.8950	0.5165	0.7656
Phosphorus	0.3446	0.4663	0.3638
Potassium	0.7871	0.3761	0.5611
Total phenols	0.8794	0.6020	0.8450
Total sugars	0.6106	0.5314	0.5991

Where:

h^2_F = Heritability on half-sib family basis
h^2_W = Heritability on within family basis
h^2_I = Heritability on individual plant basis

Table 7. Genetic gain of pertinent comparisons and related information for 9 characters, based on a sample of 59 open-pollinated families of *Dalbergia sissoo*.

Characters	G_F	G_W	G_F+G_W	G_F/G_W
Seedling height	6.463	19.410	25.873	0.332
Collar diameter	0.157	0.432	0.589	0.363
Dry weight of leaves	0.042	0.143	0.185	0.293
Leaf area	5.400	16.298	21.698	0.331
Nitrogen	0.145	0.396	0.541	0.366
Phosphorus	0.003	0.021	0.025	0.151
Potassium	0.047	0.124	0.171	0.377
Total phenol	1.420	4.254	5.674	0.333
Total sugar	1.255	5.088	6.343	0.246

Where,

G_F = Genetic gain of family Selection (90%)
G_W = Genetic gain of within family Selection (30%)
G_T = Total Genetic gain
G_F/G_W = Ratio of family and within family genetic gain

Table 8. Simple correction coefficient of nine characters studied for open-pollinated families of *D. sissoo*

	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1.0000								
X2	0.4571**	1.0000							
X3	0.5501**	0.2114	1.0000						
X4	0.1248	0.2264	0.2251	1.0000					
X5	0.4819**	0.2899*	0.3075*	0.3196*	1.0000				
X6	0.2348	-0.0576	0.0562	-0.0109	0.1116	1.0000			
X7	-0.0215	0.0181	0.0725	0.2175	0.1911	0.0657	1.0000		
X8	-0.0051	-0.0048	-0.1164	-0.1569	0.1314	-0.0730	0.0772	1.0000	
X9	0.2883*	0.2563	0.0907	0.0426	0.2602*	0.1125	0.1827	0.0253	1.0000

* Significant at 5% level

** Significant at 1% level

Where;

X1 = Seedling height, X2 = Collar diameter, X3 = Dry weight of leaves, X4 = Leaf area, X5 = Nitrogen, X6 = Phosphorus content, X7 = Potassium content, X8 = Phenol content and X9 = Sugar content

Similarly, leaf area was found to be positively and significantly associated with nitrogen content (r=0.3196).

Nitrogen content was significantly and positively associated with total sugar content (r=0.2602). All other associations were found to be non-significant.

Negative association was found between height and potassium content and height and total phenol content but they were non-significant.

4.4 GENETIC DIVERGENCE

The 59 open pollinated families were grouped into nine clusters using non hierarchical Euclidean cluster analysis (Table 9).

Cluster IV exhibited the highest number of families (10) and included families 9, 10, 14, 17, 23, 24, 28, 30, 47 and 51. Cluster V included only one half-sib family. Cluster VII included nine families (4, 31, 38, 40, 48, 49, 50, 52, 55) cluster VIII eight families (12, 16, 25, 29, 36, 41, 43, 44) whereas clusters III and IV included seven each. Cluster II included 5 families (11, 18, 19, 26, 27) while cluster I and IX included six families each (Table 9).

4.4.2 Inter and intra cluster distances

The generalized inter-cluster distance was found to be the highest between cluster II and cluster V (6.327) which were followed by cluster V and cluster VIII (5.139) and cluster III and V (4.683). The minimum inter-cluster distance was observed between cluster IV and cluster VIII (2.378) (Table 10). It is evident from the above results that all the half-sib families within a cluster were genetically closer since these have low intra-cluster distance (<2.287). On the contrary, inter cluster distance was as high as 6.327 (between II and V) indicated presence of higher order of divergence among families.

4.4.3 Contribution of different traits to total divergence

Contribution of different characters to total divergence illustrated in Table 11 indicated that seedling height contributed to the highest extent (24.99%) followed by collar diameter (13.81%), dry weight of leaves (12.88%) and leaf area (12.13%). The least contribution was for total phenol content (4.01%).

4.4.4 Mean values of cluster for different traits

Mean values of cluster for different traits is appended in Table 12.

The average seedling height was found to be the highest in cluster V (105.49) followed by cluster II (104.06). While the minimum value was recorded in cluster III (83.82).

The highest value for collar diameter was recorded in cluster II (1.28 cm) followed by cluster VI (1.13 cm), cluster VIII (1.07 cm), cluster IV (0.97 cm) and cluster VII (0.90 cm). The minimum value was recorded in cluster V (0.68).

The maximum value for dry weight of leaves was observed in cluster II (0.87 g) followed by cluster IV, V and IX (0.86 g) and minimum value was observed in cluster III and VII (0.71 g).

The highest value for leaf area was recorded in cluster II (81.82 cm^2) followed by cluster VIII (69.29 cm^2) and cluster IV (68.64 cm^2), whereas, the minimum value was observed for leaf area in cluster V (33.50 cm^2).

The maximum value for nitrogen content was recorded in cluster VIII (2.93%) followed by cluster II (2.85%), cluster IX (2.76%) and cluster VII (2.71%), while the minimum value was recorded in cluster V (2.50%).

For phosphorus content, the cluster IV exhibited the highest value (0.22%) followed by cluster V (0.21%), cluster I (0.20%), Cluster III (0.19%), cluster VI

Table 9. Composition of euclidean clusters in *Dalbergia sissoo* families

Cluster	Number of family	Family
I	6	1, 2, 5, 6, 7, 22
II	5	11, 18, 19, 26, 27
II	7	15, 32, 37, 53, 54, 57, 59
IV	7	8, 33, 34, 35, 39, 42, 45
V	1	58
VI	10	9, 10, 14, 17, 23, 24, 28, 30, 47, 51
VII	9	4, 31, 38, 40, 48, 49, 50, 52, 55
VIII	8	12, 16, 25, 29, 36, 41, 43, 44
IX	6	3, 13, 20, 21, 46, 56

Table 10. Estimates of inter and intra cluster distances

	I	II	III	IV	V	VI	VII	VIII	IX
I	1.819								
II	3.940	1.644							
III	3.001	4.301	2.242						
IV	3.626	3.104	3.697	1.953					
V	3.599	6.327	4.683	4.516	0.000				
VI	2.810	3.153	2.941	2.563	4.049	2.287			
VII	3.085	4.114	2.529	3.850	4.710	2.413	2.115		
VIII	3.050	2.571	3.743	2.378	5.139	2.441	2.590	2.203	
IX	2.601	3.057	2.869	3.098	4.298	2.507	2.763	2.759	1.968

Underlined figures are intra cluster distances

Table 11. Contribution of different traits to total divergence among *D. sissoo* seed sources

Traits	Per cent contributions
Seedling height	24.99
Collar diameter	13.81
Dry weight of leaves	12.88
Leaf area	12.13
Nitrogen	10.16
Phosphorus	9.02
Potassium	7.21
Sugar	5.79
Phenol	4.01

Table 12. Cluster mean values for different traits among *D. sissoo* families

Traits	I	II	III	IV	V	VI	VII	VIII	IX
Seedling height (cm)	100.21	104.06	83.82	104.56	105.49	100.50	90.26	103.13	97.02
Collar diameter (cm)	0.86	1.28	0.79	0.97	0.68	1.13	0.90	1.07	0.76
Dry wt. Of leaves (g)	0.80	0.87	0.71	0.86	0.86	0.74	0.71	0.83	0.86
Leaf area (cm^2)	59.30	81.82	64.70	68.64	33.50	59.46	61.15	69.29	64.72
Nitrogen (%)	2.66	2.85	2.60	2.70	2.50	2.64	2.71	2.93	2.76
Phosphorus (%)	0.20	0.18	0.19	0.22	0.21	0.19	0.18	0.19	0.17
Potassium (%)	1.11	1.25	1.30	1.33	1.22	1.28	1.30	1.33	1.24
Total sugars (mg/g)	24.11	27.70	23.09	29.76	26.71	29.32	26.88	28.67	27.97
Total phenols (mg/g)	12.97	11.47	11.49	11.39	11.96	12.11	15.83	14.94	11.61

(0.19%) and cluster VIII (0.19%). The minimum value was recorded in cluster IX (0.17%).

Cluster IV and VII showed highest potassium content (1.33%) whereas, lowest value was recorded in cluster I (1.11%).

Total sugar content was the maximum in cluster IV (29.76 mg/g) followed by cluster VI (29.32 mg/g) and VIII (8.67 mg/g). The minimum value was exhibited by cluster III (23.09 mg/g).

Total phenol content was the highest in cluster VII (15.83 mg/g) and the lowest was in cluster IX (11.39 mg/g).

DISCUSSION

Chapter-5

DISCUSSION

Geographical variation is quite common in living organisms including plants and animals. This variation, however, is more in geographically widespread tree species, and is important from the breeding point of view, as wide range of variability always increases the chances of selection for desirable traits and of desirable type (Vavilov, 1951). Thus, in order to screen and capture the productive natural variation, provenance research is of fundamental importance in tree breeding/improvement programmes. Besides its usefulness in afforestation and reforestation, provenance variation studies also provide useful information on the basic material breeding and evolving improved planting stock within a provenance and for inter provenance hybridization which may be useful for combining breeding for productivity and adaptation (Wright, 1976). A good number of provenance variation studies have been carried out or are under way to select best provenances/ sources within the species (Wright and Baldwin, 1957; Zobel and Talbert, 1984).

The results presented in the previous chapter are discussed under the following heads in the light of available literature.

5.1 Evaluation of families
5.2 Heritability and genetic gain
5.3 Simple correlation
5.4 Genetic divergence

5.1 EVALUATION OF FAMILIES

5.1.1 Physical attributes

A persual of (Table 3) reveals that the variation in survial per cent varied between 11.37 to 94.87 per cent. The survival of the reading is result of numerous factors i.e. interaction of a particular phenotype with the local environment, quality of site in which is grown, pest/disease etc. All the families were grown in uniform site conditions. The low survival per cent was not due to disease/pest but may be because of illicit grazing and competition with weeds.

Growth parameters among the different genotypes showed a wide range of variation viz. seedling height (54.35 to 128.77 cm), collar diameter (0.616 to 1.707 cm), dry weight of leaves (0.571 to 1.043 g) and leaf area (33.50 to 85.85 cm^2) (Table 4). In overall performance the families 35, 24, 25 and 18 from Nadaun, Baranda, Jassur and Dhar-tatoh-5 were found to be best for these traits respectively and families 59 and 58 showed the lowest value for these traits. So these families should not be used in further selection and improvement programme.

Since all the families selected come originally from different seed sources of *Dalbergia sissoo* distributed all over Himachal Pradesh and Jammu and Kashmir over a variety of sites differing with regard to altitude, climate and edaphic conditions, and in the present study these families were grown at one site under environmental conditions so the differences in the performance of all the genotype are due to genetic factors.

Similar variation among the seed sources in growth parameter has been reported by several workers in different species. The present result supports the findings of Whittmore (1971) in *Cedrela* species, Shiv Kumar and Banerjee (1986) in *Acacia nilotica*, Salazar (1989) in *Acacia mangium*, Kumar (1989) in *Pinus roxburghii*, Veerendera and Sharma (1990) in *Santalum album*, Jha and Gupta (1992) in *Populus* species, Sehgal and Jaswal (1996) in *Grewia optiva*, Rathore (1997) in *Grewia optiva*, Bhat (1999) in *Albizia lebbek* and Choudhary (2000) in *Toona ciliata*.

5.1.2 Leaf nutrient contents

Variance analysis of different foliar nutrients viz. Nitrogen, phosphorus and potassium depicted highly significant differences among families of *Dalbergia sissoo* (Appendix-I).

Persual of Table 4 revealed that families 25, 34 and 32 excelled for nitrogen, phosphorus and potassium content in leaves which suggests for selection of these families for nutritious leaf fodder. The minimum values for nitrogen, phosphorus and potassium content were found respectively for family no. 24, 56 and 2.

Variation in foliar nutrient content seems mainly due to genetic control. However, environmental conditions specially temperature, rainfall and edaphic condition of families may also have control over these traits. The present study supports the finding of Nakamura (1977); Kaushal (1986) and Bhat (1999). The range of nutrient content was something higher than the finding of Bhola (1993). It may be due to microorganism activity. Microorganisms may also have deciding role in foliar nutrient composition as evidenced in *Acacia albida* by Sneizko and Stewart (1989).

5.1.3 Biochemical contents

The use of biochemical technique to measure genetic variation in forest trees generally has lagged behind especially in the use of quantitative characters. Therefore, preliminary study was made to have a broad idea of the few biochemical parameters at the seedling stage. Analysis of variance revealed significant differences for total sugar and total phenol contents. A perusal of table 4 revealed the highest value of total sugars content for family no. 28 and the highest total phenols content was recorded for family no. 25 while the lowest values were observed for families no. 57 and 33, for total sugars and total phenols, respectively. Similar type of variation in *Pinus roxburghii* provenances for biochemical traits were reported by Singh and Puri (1987) and Kumar (2000).

5.2 HERITABILITY AND GENETIC GAIN

5.2.1 Heritabilities

Heritability values express the proportion of variation in the population that is attributable to genetic differences among individuals. It is therefore, a ratio indicating the degree to which parents pass their characteristics along to their off spring. Heritability is of key importance in estimating gains that can be obtained from a selection programme.

Toda (1958) gave a clear explanation of the differences between the broad sense and narrow sense heritabilities. He stated that when the material is propagated by sexual means, the non-additive effect of individual genotypes can not be passed on to their progenies, so the term heritability must be employed in the narrow sense. But when vegetative propagation is used, the dominance and epistasis are passed on to the next generation because the genotype does not change. So, the term heritability be employed in its broad sense. In the present study also, the narrow sense heritability has been employed as the material was propagated by sexual means. The discussion here will focus on half-sib family, within family and individual free heritabilities.

All the characters under study exhibited quite high heritability values (Table 6). The highest h^2 (heritability in narrow sense) values based upon analysis of progency data was the result of lower phenotypic variance. The environment of the site where the progenies were grown, was rather uniform and therefore, the phenotypic variance in the denominator of the heritability formula was reduced, resulting in higher heritability estimates.

Half-sib family heritabilities (h^2_F) for seedling height collar diameter, dry weight of leaves, leaf area, nitrogen content, potassium content, total phenols and total sugars were found to be higher than within family heritabilities (h^2_W) and heritabilities on an individual plant basis (h^2_I). these results are in line with the studies conducted by Kumar (1989) on chir pine progenies and Choudhary (2000) conducted on *Toona ciliata* families. Zobel and Talbert (1994) reported that family heritabilities are usually higher than individual tree heritabilities because they are based on average estimated with a sample of many progenies.

But the half-sib family heritability for phosphorus was found to be less than the within family heritabilities which might be due to more phenotypic variance among half-sib families (Kumar, 1989 and Choudhary, 2000).

5.2.2 Genetic gain

In the present study, genetic gain of family selection (G_F) at 90 per cent selection intensity, genetic gain of within family selection (G_W) at 30 per cent selection intensity, total genetic gain (G_T) and ratio of family and within family genetic (G_F/G_W) were computed (Table 7). The highest total genetic gain was observed in seedling height followed by leaf area.

For all the characters genetic gain of within family selection was higher than family selection. These results are not in line with Choudhary (2000) at 50 per cent selection intensity, but are in line with Kumar (1989) at 90 per cent selection intensity. As reported by Zobel and Talbert (1984) the genetic gain expected by adopting a particular breeding procedure is conditional by selection intensity. It can be varied by selection intensity. It can be varied to determine that how many individuals be chosen to obtained a desired genetic gain.

Family selection by itself is rarely used in forestry as it leads to an increased rate of inbreeding; on the other hand within family selection also leads to slow rates of inbreeding. So, to avoid inbreeding, the family and within family selection methods are almost combined. Similar recommendations have been made by Yeh and Resmussen (1985). The high heritabilities and genetic gains revealed that the phenotypes are indicative of predominant expression of their genotype. The heritability estimates, however, indicate only the effectiveness with which selection of genotype can be based on phenotypic performance, but fail to indicate the real genetic progress (Johnson *et al.*, 1955). In the present study maximum heritability was observed for collar diameter whereas maximum genetic gain was noticed for seedling height. Therefore, high heritability need not always be accompanied by greater genetic gain. Seedling height, nitrogen content and total phenols recorded high heritability and also depicted high genetic gain. Based on these results, the above characters with high heritabilities and genetic gain may be considered for selection. Panse (1957) attributed it to predominance of additive effects. Hence, selection for these characters would be more useful to gain worthy results in *Dalbergia sissoo.*

5.3 SIMPLE CORRELATION

Correlation is one of the important biometrical tools which measures the degree and magnitude of association between various traits. In tree improvement programme a clear understanding of association among different traits is of great importance as it illustrates whether the choice of one character confirms to appearance our disappearance of the other.

A close examination of table 8 revealed that a positive and highly significant correlation was around between seedling height and collar diameter. (0. 4571. Seedling height is positively and highly significantly associated with the dry weight of leaves (0.5501), nitrogen content (0.4819) and total sugars content (0.2883). Collar diameter, dry weight of leaves and leaf area were found to be positively and significantly associated with nitrogen content. Nitrogen content is responsible for the biomass production the collar diameter, seedling height, leaf area and dry weight of leaves are the result of biomass production. Due to these reasons they may be showing significant correlation.

The above results support the finding of Verendra and Sharma (1990) in *Santalum album,* Kumar (2000) in *Pinus roxburghii,* and Patil *et al.* (1997) in *eucalyptus* species and Hosalli (1997) in *Leucaena* species.

The correlation studies indicates that seedling height had highly significant positive correlation with collar diameter, dry weight of leaves and nitrogen content, therefore, these characters may be given proper emphasis during selection programme.

5.4 GENETIC DIVERGENCE

In all, 59 families of *Dalbergia sissoo* studied, were grouped in to 9 clusters by using non-hierachical euclidean cluster analysis (Table 9). The distribution of families in different clusters indicated that, even though the genotypes were selected from different ecogeographic areas, the genetic make-up along with breeding system, heterogeneity, natural and unidirectional selection pressure must be the cause of such genetic diversity among different families, besides geographic to same extent. The cluster pattern proved that geographical diversity need not necessarily be related to genetic diversity. Therefore, selection of genotype for hybridization should also be based on genetic diversity rather than geographic diversity. However, due attention should be paid to geographic diversity, if sufficient genetic diversity has to be accumulated in the germplasm (Ram and Panwar, 1970).

Similar findings were reported by Singh (1993) in *Bambusa tulda*, Pandey *et al.* (1995) in *Populus deltoides*, Thiru selvan (1995) in *Dendrocalamus hamiltonii*, Mohapatra (1996) in *Acacia catechu*, Bhat (1999) in *Albizia lebbek* and Kumar (2000) in *Pinus roxburghii.*

Inter and intra cluster distances among various clusters revealed that intra cluster distance was the lowest for cluster II i.e. 1.644 (Table 10). Intra cluster distance for single family (cluster V) was zero. Occurence of low intra cluster distances indicated that the chances of getting good segregates by crossing the genotype of the same cluster is remote. Therefore, intra cluster distances must duly be considered to avoid monoclonal plantation as the risk of failure and inbreeding depression is more under such cases.

The highest inter cluster distance was found between cluster II and cluster V (6.327) suggesting that, maximum hybrid vigour and eventually desirable segregates could be obtained if individuals of families of these two clusters are hybridized.

The average cluster mean value for different traits (table 12) revealed that cluster II and IV recorded highest value for most of the traits. Thus, it suggests that crosses involving single tree selection from the families falling under cluster II and cluster IV may result in substantial spectrum of variability.

Contribution of different characters in the total divergence depicted in Table 11, revealed that seedling height gave the highest contribution followed by collar diameter, dry weight of leaves and leaf area.

Therefore, the present study suggested that, these characters contributing towards most of the divergence be given more emphasis for prioritisation of parents in hybridization programme.

These studies support the results obtained by various workers in different species viz. Burley and Burrows (1972) in *Pinus kesiya*, Andrew (1973) in *Eucalyptus camaldulensis*, Khosla *et al.* (1979) in *Populus ciliata*, Bagchi (1992) in *Acacia nilotica*, Singh (1993) in *Bambusa tulda*, Thiru Selvan (1995) in *Dendrocalamus hamiltonii*, Mohapatra (1996) in *Acacia catechu*, Rathore (1997) in *Grewia optiva*, Bhat (1999) in *Albizia lebbek* and Kumar (2000) in *Pinus roxburghii*.

SUMMARY AND CONCLUSIONS

Chapter-6

SUMMARY AND CONCLUSIONS

The present investigation entitled "Evaluation of open-pollinated families of *Dalbergia sissoo*" were carried out in one and a half year old seedlings of *Dalbergia sissoo* raised under ICFRE project entitled "Co-ordinated research project on genetic improvement of *Dalbergia sissoo*" at Regional Horticulture Research Station, Jachh, district Kangra of Dr. Y.S. Parmar University of Horticulture and Forestry, Solan (H.P.) during 2000-2001. Fifty-nine open pollinated families of *Dalbergia sissoo* distributed in Himachal Pradesh and Jammu and Kashmir were selected in order to study the extent of variation among families, to select the best family, to see the correlation among different traits under study and to study genetic divergence.

The seed of 59 plus trees of *Dalbergia sissoo* had been sown in the nursery in the year 1998. After one year, the nursery raised seedlings were transplanted into the field in August 1999 in a Randomized Block Design. The observations in the field were recorded in October 2000 and the leaf samples were collected and brought to the laboratory of the Department of Tree Improvement and Genetic Resources of the university to study the nitrogen, phosphorus, potassium, total sugars and total phenols content.

Analysis of variance revealed highly significant differences among different families for all traits under study viz., seedling traits, foliar nutrient contents and biochen..cal contents.

The highest survival percentage was exhibited by family no. 17 (Dhar Tatoh-4) whereas lowest percentage (11.37) was portrayed by family no. 56 (Dhaulakuan).

For physical attributes family no. 35 (Nadaun) showed highest seedling height and family no 24 (Baranda) showed the highest collar diameter. Family no. 25 and 18 (Jassur and Dhar Tatoh 5) exhibited the highest value of dry weight of leaves and leaf area respectively. Family no. 59 (Teeb) showed the lowest value for seedling height, collar diameter and dry weight of leaves whereas family no. 58 (Uttamwala) depicted the minimum value for leaf area.

For leaf nutrient content, nitrogen, phosphorus and potassium content were found to be the highest in family no. 25 (Jassur), 34 (Khurian) and 32 (Dhuk), respectively. Family no. 24 (Baranda), 56 (Dhaulakuan) and 2 (Nalagarh) showed the minimum value for these characters.

For biochemical traits, total sugars was found to be the maximum for family no. 28 (Channi) and the minimum for family no. 57 (Dardanwala). Total phenols were found to be the highest for family no. 25 (Jassur) and the lowest for family no. 33 (Gagret).

All the nursery traits exhibited high heritabilities (narrow sense). The higher heritability value based on analysis of progeny revealed that characters are likely to be controlled by additive gene action and for any tree improvement, it is additive gene effect which responds to selection.

The genetic gain for within family selection was higher than family selection for all the characters. The maximum heritability on half-sib family basis was recorded for collar diameter whereas total phenols content depicted maximum within family heritability. The highest genetic gain for within family and family selection was observed for seedling height while these were minimum for phosphorus content.

Correlation studies illustrated highly significant positive correlations of seedling height with collar diameter, dry weight of leaves and nitrogen content and significant correlation of nitrogen content with collar diameter, dry weight of leaves and leaf area. Significant correlation was also observed between total sugar content, nitrogen and seedling height.

Divergence studies indicated remarkable diversity among the 59 families of *Dalbergia sissoo*. Based on non-hierarchical euclidean analysis, 9 clusters were obtained with the highest number of families (10) falling under cluster IV. Intra cluster distances were quite low. However, inter cluster distances varied from 2.378 to 6.327. Seedling height contributed the highest (24.99%) toward the divergence. Among the 9 clusters formed, cluster II the maximum cluster mean value for all the morphological traits and cluster IV for nutritional attributes.

CONCLUSIONS

On the basis of the present findings, the following conclusions may be drawn:

i) Analysis of variance revealed significant variation for all the characters under study viz., seedling height, collar diameter, dry weight of leaves, leaf area, nutritional attributes (N, P, K contents) and biochemical attributes (total phenols and total sugars).

ii) For higher growth performance and biomass production, family no. 35 (seedling height), family no. 24 (collar diameter), family no. 25 (dry weight of leaves) and family no. 18 (leaf area) were found to be the best.

iii) Family no. 25 (Jassur) was found best for nitrogen content, family no. 34 (Khurian) for phosphorus content and family no, 32 (Dhuk) for potassium content; family no. 28 and 25 were superior for total sugars and total phenols content.

iv) Seedling height showed higher heritability coupled with high genetic gain. So this character should be used in selection programme.

v) The highly significant correlation between seedling height and collar diameter, dry weight of leaves and nitrogen content suggests that these characters can also be utilized for indirect selection.

vi) Inter-cluster distances show that hybridization between families in cluster II i.e. family no. 11, 18, 19, 26 and 27 and cluster V i.e. family no. 58 would be the better option for getting high heterotic vigour.

vii) The present investigation suggests the preponderance of genetic diversity than that of geographic diversity of the families.

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APPENDIX

Appendix-I

ANOVA for different characters under study for 59 open pollinated families of *Dalbergia sissoo*

Character	Mean sum of square			
	Source of Variation			
	Replication	Family	Family x Replication	Plants within plot
df	2	58	116	354
Seedling height	201.2189	966.6810**	119.4230	469.6680
Collar diameter	0.0381	0.4695**	0.0305	0.2540
Dry weight of leaf	0.0124	0.0763**	0.0216	0.0358
Leaf area	139.0565	724.1992**	104.0697	356.9527
Nitrogen	0.0568	0.4588**	0.0481	0.2650
Phosphorus	0.0092*	0.0041**	0.0027**	0.0010
Potassium	0.0198	0.0707**	0.0150	0.0493
Total phenols	2.4894	46.2153**	5.5705	22.5046
Total sugars	30.3599	107.8299**	41.9805**	41.2989

df = Degree of freedom
* = Significant at 5 per cent level of significance
** = Significant at 1 per cent level of significance

CURRICULUM VITAE

Name	:	Sumankumar Jha
Father's Name	:	Sh. Shivnath Jha
Date of Birth	:	08.06.1976
Sex	:	Male
Marital Status	:	Unmarried
Nationality	:	Indian

Educational Qualifications :

Certificate/ degree	Class/ grade	Board/ University	Year
Matric	Second	Gujarat Board	1990
10+2	Second	Gujarat Board	1992
B.Sc. (Forestry)	Second	GAU, Navasari, Gujarat	1998

Whether sponsored by some state/ Central Govt./Univ./SAARC	:	ICAR
Scholarship/ Stipend/ Fellowship, any other financial assistance received during the study period	:	University stipend