

**Seed Source Variation for Seed and Seedling
Characters in Kair**
[*Capparis decidua* (Forsk.) Edgew.]

BY

KALU RAM
(2003A38M)

*Dissertation submitted to the Chaudhary Charan Singh
Haryana Agricultural University in the partial fulfillment
of the requirements for the degree of*

**MASTER OF SCIENCE
IN
FORESTRY**



**COLLEGE OF AGRICULTURE
CCS HARYANA AGRICULTURAL UNIVERSITY
HISAR - 125 004 (HARYANA)**

2006



CERTIFICATE – I

This is to certify that this dissertation entitled, “Seed source variation for seed and seedling characters in Kair [*Capparis decidua* (Forsk.) Edgew.]”, submitted for the **Master of Science** in the subject of **Forestry** of the Chaudhary Charan Singh Haryana Agricultural University, is a bonafide research work carried out by **Mr. Kalu Ram** under my supervision and that no part of this dissertation has been submitted for any other degree.

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

(Dr. K. S. Bangarwa)
Professor
Major Advisor
Department of Forestry
CCS Haryana Agricultural
University, Hisar

CERTIFICATE – II

This is to certify that this dissertation entitled, “Seed source variation for seed and seedling characters in Kair [*Capparis decidua* (Forsk.) Edgew.]”, submitted by **Mr. Kalu Ram** to Chaudhary Charan Singh Haryana Agricultural University, in the partial fulfillment of the requirement for the **Master of Science** in the subject of **Forestry** has been approved by the Student’s Advisory Committee after an oral examination of the same, in collaboration with the Advisory Committee.

MAJOR ADVISOR

HEAD OF THE DEPARTMENT

DEAN, POST-GRADUATE STUDIES

CONTENTS

CHAPTER	DESCRIPTION	PAGES
1	INTRODUCTION	1-3
2	REVIEW OF LITERATURE	4-11
3	MATERIAL AND METHODS	12-18
4	EXPERIMENTAL RESULTS	19-30
5	DISCUSSION	31-40
6	SUMMARY AND CONCLUSION	41-43
	BIBLIOGRAPHY	i-ix

LIST OF TABLES

Table No.	Description	Page
3.1	Details of provenances	12
3.2	ANOVA for provenance testing	15
4.1	Phenotypic variation for fruit size in various provenances of <i>Capparis decidua</i>	20
4.2	Analysis of variance for germination per cent and seedling characters at the age of 6 months in <i>Capparis decidua</i>	22
4.3	Variability, heritability and genetic advance for germination per cent and seedling characters at the age of 6 months in <i>Capparis decidua</i>	22
4.4	Mean performance of progenies for germination per cent and seedling characters at the age of 6 months in <i>Capparis decidua</i>	25
4.5	Seed viability of <i>Capparis decidua</i> during storage	27
4.6	Seed vigour of <i>Capparis decidua</i> during storage	29
5.1	Mean performance of provenances for seedling characters at the age of six months in <i>Capparis decidua</i>	36
5.2	Progenies significantly superior than general mean for germination per cent and seedling characters at the age of six months in <i>Capparis decidua</i>	37
5.3	Germination per cent of fresh seed along with per cent loss of germination and vigour index after 3 and 6 months of storage in various progenies of <i>Capparis decidua</i>	39

Chapter-I

INTRODUCTION

Capparis Linn. (Capparidaceae) is the major genus of climbing shrubs, bushes or small trees and 26 species of this genus are reported to occur in India (Anonymous, 1992). *Capparis decidua* (Forsk.) Edgew. Syn. *C. aphylla* Roth. commonly known as kair, is an important multipurpose tree/shrub of the genus *Capparis*. It is densely branched, spinous shrub or tree, up to 6 m in height (rarely 10 m), with a clear bole of 2.4 m, found chiefly in the dry, arid and semi-arid regions of India extending from Punjab southwards to Tamil Nadu. It is found in varied habitats and has very good soil binding capacity which can be propagated and cultivated on large-scale for checking wind erosion on sandy wastelands (Gupta *et al.*, 1989). It also improves the fertility of sand dunes and reduces alkalinity very sharply. In tropical and sub-tropical regions plant occurs within annual rainfall 100 to 400 mm and temperature 16 to 50°C.

Plants of this species grow on barren lands completely unattended and unprotected and are valuable source of nutrition for villagers in general and for low income and food-insecure people in particular. Poor people of rural areas used to collect its immature fruits from each and every plant repeatedly for selling in market, which is a source of their livelihood. Moreover, rural people eat mature fruits. These factors resulted into production of less or no seeds. Its

unripe fruits as green vegetable and pickle form an integral part of human diet in tropical and sub-tropical regions. Seeds of kair contain 20 per cent of high quality edible oil. The stem and root bark extracts are effective in treating asthma, inflammation and cough (Deora and Shekhawat, 1995). Wood obtained from this plant is hard, heavy and termite resistant. Every part of this versatile plant has multifarious uses. Due to these diverse uses of kair plant, it is called as the “Sandalwood of Indian Deserts” (Tyagi and Kothari, 1997).

Besides, immediate genetic gain, breeding strategies have several objectives like, genetic conservation, maintenance of continued genetic gain over several generations and supply of genetically improved reproductive material. Sufficient genetic diversity exists in Indian tree species, which is useful to attain substantial genetic gains. The greatest potential exists in the selection of desired trees from wild genetic resources. Success in the establishment and productivity of forest tree plantations is determined largely by the species used and source of seed within species. The largest, cheapest and fast gains in most forest tree improvement programme can be made by assuring the use of well adapted and isolated provenance (geographic region) seed. Quick and permanent genetic gains can be achieved by using preliminary basic information on natural variability for selection and provenance testing. The variability may be related to the distribution of continuous or disjunct environmental factors such as soil type and altitude, exposure or latitude with their associated factors of precipitation, temperature and photoperiod. Provenance test is desirable to screen the naturally available genetic variation

so as to utilize the best material for afforestation and reforestation in order to get maximum productivity.

Selection of best provenance and then selection of individual plus trees from the best provenance form the foundation for seed orchard. 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.

An adequate quantity of high quality seed is required for any afforestation programme. There is a rapid loss in seed viability of kair (Deora and Shekhawat, 1995), which hinders large-scale plantation of this important species. Almost no work has been carried out so far on provenance testing and seed storability of kair. Therefore, the present investigation has been planned with the following objectives:

1. To study the variation between provenances and within provenance for seed and seedling characters.
2. To determine seed storability and deterioration in seed quality during storage.

CHAPTER-II

REVIEW OF LITERATURE

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. Realizing the importance of this subject, Forest Research Institute, Dehradun established a Forest Genetics Section during 1959-60 attached to Botany branch under the then Directorate of Biological Research. In the year 1961, Professor J.D. Mathews, an expert from FAO visited India to give guidelines for the proposed work. He initially suggested the work on some priority species viz., *Tectona grandis*, *Bombax ceiba*, *Pinus* spp. and *Dalbergia sissoo*. However, no work aimed at genetic improvement of *Capparis decidua* has so far been undertaken.

2.1 VARIABILITY FOR SEED AND SEEDLING CHARACTERS

Genetic diversity found in tree species is a part of nature's strategy for defence and survival against all types of risks encountered in the long life spans of forest trees (Zobel and Talbert, 1984). The use of genetic diversity of wild species for gain is the basis of tree improvement work. Geographic variation associated with distinct climatic regions in which the species grows results

from genetic and environmental factors. By growing geographic variation under identical environment the inherent variation of a species is identified from environmental variation with the formula: Phenotypic variation = Genotypic + Environmental variation. It is the inherent genetic variation that is useful in achieving genetic gain (Bangarwa, 1996).

Srivastava *et al.* (2001) revealed that the seed source variation in the seeds collected from various candidate plus trees but the performance of CPTs varied greatly in *Dalbergia sissoo*. Seeds collected from 140 trees of *Prosopis cineraria* across Indian Thar desert revealed enough amount of genetic variability within the seeds (Kacker *et al.*, 1986).

The variation in seed and seedling traits have been studied in several tree species under controlled conditions and the phenotypic values have been assumed to be closer to genotypic values on the basis of environmental deviation being negligible. Singh *et al.* (2001) observed that all pod traits, seed characters and germination parameters varied significantly among different seed sources in *Dalbergia sissoo*. Gera *et al.* (1999) revealed significant variations among the provenances of *Dalbergia sissoo* for germination percentage, seedling height and collar diameter and field height and survival percentage.

Troup (1921) observed that seeds of *Albizia lebbek* Linn. Bentham were light brown, smooth, oblong, about 0.7-1.20 cm in length and 0.60-0.90 cm in width. Several workers have reported seed source variation with respect to seed size and weight in *Prosopis cineraria* (Kackar *et al.*, 1986), *Acacia nilotica* (Snieszko and Stewart, 1989) and *Acacia* species (Bagchi *et al.*, 1990).

Bangarwa *et al.* (1995) recorded data on pod and seed characters from twenty provenances of *Dalbergia sissoo*. Significant variation was observed among provenances for seed and pod characters. Variation was higher for seed and pod weight in comparison to seeds per pod, seed length, seed breadth, pod length and pod breadth.

Seed size has been found to regulate germination and subsequent seedling growth in many species (Baldwin, 1942; Langdon, 1958; Williams; 1967; Taylor, 1972; Kandya, 1978). The large seeds have been generally observed to produce faster germination and initial seedling growth. The size usually reflects the comparative nutrient pool and energy of a seed, which affects the further growth and development. *Leucaena leucocephala* produces a vast array of polymorphic seeds with variable scarification requirements (Pathak *et al.*, 1974).

Gera *et al.* (2000) recorded the presence of highly significant variations among twenty provenances for height, number of branches and survival per cent in *Dalbergia sissoo*. Doikov (1973) pointed out the seed source to be an essential feature for determining the seed quality of forest trees. Some seed sources perform better in certain locations than others, and the climatic and edaphic factors of such locations often result in varying performances (Read, 1971).

Pathak *et al.* (1984) have drawn an inference from their study that there exist highly significant differences between seed weight, germination,

cotyledonary leaf shape, height and basal diameter growth rate in 30 provenances of *Leucaena leucocephala* from India, Philippines and Australia.

Shiv Kumar and Banerjee (1986) have found significant correlation between seed weight and speed and uniformity in germination of *Acacia nilotica*. Bagchi *et al.* (1990) pointed out significant heritable differences in seed parameters among different *Acacia* spp. They suggested that seed size could be manipulated through breeding and selection, as assisted by strong correlation.

Vakshasya *et al.* (1992) studied seed and seedling characteristics of ten *Dalbergia sissoo* populations, scattered over almost the entire natural range in India. They concluded that multi-trait selection would be essential in ranking seed sources, with seed weight being an important variable. They also mentioned the possibility that *Dalbergia sissoo* seed sources might be divided into dry zone and wet zone populations. Yadav (1993) observed large amount of genetic variability in *Dalbergia sissoo* for seeds per pod, seed length, seed breadth, seed thickness, 100-seed weight and seed volume.

Hooda and Bahadur (1993) determined the extent of variability and correlation for seed characters in 12 varieties of Subabul. They reported significant differences among different genotypes. Hundred seed weight had high genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance. Seed length, breadth, thickness and weight were positively correlated with each other. Seed length had the highest direct effect on seed weight.

Sindhu (1995) collected seeds of neem (*Azadirachta indica*) from ten provenances in Karnataka and Andhra Pradesh and found seed amount of variability for seed length, width and weight.

Krishan and Toky (1996) studied variation in twenty one Indian provenances for seed characters of *Acacia nilotica*. Hundred seeds were measured for length, width, thickness and seed weight. Significant differences were noted in all the measured characters.

Thapliyal and Dhiman (1997) reported significant differences in seed weight, germination percentage, germination value (GV), root and shoot growth and seedling height of 16 chir pine seed sources. Seed weight significantly correlated with cotyledon numbers, germination per cent whereas GV significantly correlated with seedling height. Seed weight and cotyledon numbers correlated with longitude of the seed source.

Joshi *et al.* (1983) reported variation in germination capacity of seeds of *Acacia nilotica*. Gera *et al.* (2000) observed large extent of variation for germination characters as compared to other characters and highly significant variations were observed among seed sources for all characters studied in *Dalbergia sissoo*. Kuo (1984) studied seed germination and seedling growth of *Casuarina equisetifolia* and *Casuarina littoralis*. Suri (1984) reported that the seeds of *Tectona grandis* collected from moist localities were bigger than those collected from dry localities. Germination per cent appeared to depend on

the quality of seed rather than size, and height to be the function of site quality rather than the seed origin.

Vakshasya *et al.* (1992), while studying 10 *Dalbergia sissoo* populations, found significant genetic variation among seed sources for germination rate, shoot length and seedling dry weight, whereas, germination value, seed length and germination per cent were non-significant. Yadav (1993) observed large amount of genetic variability in *Dalbergia sissoo* for seed density, accelerated aging, electrical conductivity and vigour index.

A study carried out at Arid Forest Research Institute, Jodhpur, also revealed considerable variation in the per cent germination of seeds of *Acacia nilotica* from different sources (Dwivedi, 1993). Arya *et al.* (1995) studied provenance variation in seed germination of *Prosopis cineraria* and reported 5 to 74 per cent variation among 31 provenances.

Bangarwa *et al.* (1995) reported the results of progeny testing for seed quality parameters in *Dalbergia sissoo* and recorded significant differences in germination between the progenies of different locations but progenies from same location showed non-significant differences. They further stated that nursery germination and establishment under field condition could be predicted on the basis of laboratory germination and Tetrazolium test.

Ginwal *et al.* (1995) studied seed germination pattern of 30 provenances belonging to 5 sub-species of *Acacia nilotica* from 5 countries namely; India, Sudan, Pakistan, Yemen and Senegal in nursery condition. They observed

differences in seed germination percentage and noticed significant correlation between cumulative seed germination and number of days elapsed.

Kumar and Toky (1996) reported variation in seed germination and seedling growth for 12 provenances of *Albizia lebbek* collected from 9 to 32°N latitude and 72 to 85°E longitude. There were significant differences among most of the provenances and variation in germination ranged from 4 to 5 per cent in the incubator and 8 to 50 per cent in nursery.

2.2 VARIABILITY FOR SEED STORABILITY

Bangarwa (1993) reported seed storability of twenty provenances of *Dalbergia sissoo* from all over the northern India. Significant differences were found among provenances of low to medium rainfall and high rainfall areas and also between low to medium and high rainfall areas. In general, the germination per cent was relatively higher in provenances from low to medium rainfall areas. Earlier, Mathur *et al.* (1984), Shivkumar and Banerjee (1986) reported considerable variation for germination per cent in the provenances of *Acacia nilotica*.

Robbins (1988) found 87 per cent germination from fresh seeds and 70 per cent after two years of storage in *Dalbergia sissoo*. Variations were observed in the storage life of teak seeds within moist type and between moist to very moist type (Emmanuel and Dharmaswamy, 1991).

Kumar and Bhatnagar (1976) reported that maximum and quick germination was obtained at 30°C in between paper (BP) in nine days time for both fresh and one year old seed lot in *Dalbergia sissoo*. Robbins (1988)

observed 87 per cent germination from fresh seeds and 70 per cent after 2 years storage in *shisham*.

Yadav *et al.* (1986) revealed that in Sal, there was significant differences (variation) in germination among diameter classes, with the best results (53% germination, 69% viability) given by 81-90 cm in diameter and trees 136-150 cm in diameter gave the poorest results (22% germination, 40% viability). Kumar *et al.* (1988) conducted accelerated ageing test in Mung bean by exposing the seeds to approximately 100 per cent relative humidity at 40°C for 48 and 72 hrs separately followed by standard germination for seven days and then normal seedlings were counted according to rules for testing seeds.

Elam and Blanche (1989) reported the applicability and utility of the accelerated ageing technique (AA) as a mean of assessing the relative vigour of tree seeds. Bangarwa (1993) conducted accelerated ageing test to determine the storability of different collections of *shisham* and observed that the accelerated ageing at 42°C for 72 hrs significantly reduced the standard germination.

CHAPTER-III

MATERIAL AND METHODS

The present study on kair (*Capparis decidua*) comprised of collection of seeds and evaluation of provenances for seed germination, seedling characters and seed storability.

3.1 LOCATION OF PROVENANCES

Two sites each from Rajasthan (Hanumangarh and Bhadra) and Haryana (Sirsa and Hisar) were surveyed during September 2005. Latitude, longitude and average rainfall of the four provenances are given in table 3.1.

Table 3.1 Details of provenances

Provenance	Accession number	State	Latitude (N)	Longitude (E)	Altitude (m)	Rainfall (mm)
Hanumangarh	1-5	Rajasthan	29°65'	74°36'	185	400
Bhadra	6-10	-do-	29°05'	74°69'	212	420
Sirsa	11-15	Haryana	29°32'	75°02'	195	400
Hisar	16-20	-do-	29°10'	75°44'	215	400

3.2 SEED COLLECTION

Seed collections were made from five individual trees of each provenances, keeping an isolation of about 200 meters. Thus, the trees were selected at random so as to provide a sample of prevailing genetic variation in the population. Sufficient fruits of each individual tree were collected and kept separately. In this

way, seeds of 20 (4 x 5) progenies were collected. The fruit diameter was recorded on the individual tree of each site.

3.3 LAYOUT OF EXPERIMENT IN NURSERY

The seeds of all the 20 progenies arising from four provenances, were sown in the nursery area of Department of Forestry, CCS Agricultural University, Hisar following randomized block design with four replications in February 2006. Five plants per progeny per replication were selected at random for recording data.

3.4 OBSERVATIONS RECORDED

3.4.1 Germination per cent:

Germination was recorded up to one month. Plant height and collar diameter were recorded during August 2006.

3.4.2 Plant height (cm):

Plant height was recorded in centimeter from the ground level to the apical bud of the leading shoot.

3.4.3 Collar diameter (mm):

Dial calliper was used to measure the collar diameter of the plant at ground level.

3.5 EVALUATION OF PROGENIES FOR SEED STORABILITY

Properly sun-dried and cleaned seeds, collected during September 2005, were stored at room temperature to find seed storability and loss of vigour index in storage. Standard germination and seed Vigour Index values of fresh seeds as well as three and six months after storage were worked.

The vigour index-I and vigour index-II were calculated as mentioned below in standard germination test.

Standard germination test:

Seeds of *Capparis decidua* were placed on sufficiently moist towel papers. Towel papers were spread on top of each other and then soaked in water. A waxy paper was kept below the towel paper. On rough side of the waxy paper, date of experiment and accession number were written. Fifty seeds were placed on the top of the uppermost sheet in fairly regular pattern so that they were approximately equidistant. Another towel was placed on top of the seeds. The towels could then be gently and loosely rolled to form a tube of about 50-60 mm and tied with rubber band kept in germinate at 25°C for a period of 7 to 10 days. All the germinated seeds were counted at the completion of germination and expressed in percent germination

(a) Seedling length (cm):

Seedling length was measured with the help of scale in all the four replications and expressed as centimeter.

(b) Seedling dry weight (mg):

Oven dried seedlings were weighed individually on Owalobor pan electric balance in all the four replications and expressed as mg.

(c) Vigour index-I:

Vigour index by length method was calculated by multiplying the sum of root and shoot length (cm) by germination percent.

(d) Vigour Index-II:

Vigour index by weight method was calculated by multiplying the mean dry weight per seedling in mg with standard germination.

3.6 STATISTICAL ANALYSIS**3.6.1 Phenotypic variation**

Data recorded on morphological characters were compiled and analyzed statistically to compute mean, range and coefficient of variation in different provenances.

3.6.2 Provenance testing**3.6.2.1 Analysis of variance:**

The replicated data of all the characters recorded for provenance testing were analyzed statistically (Panse and Sukhatme, 1978). The ANOVA for this trial is given in table 3.2.

Table 3.2 ANOVA for provenance testing

Source of variation	d.f.	Expectations of mean squares	
Blocks	(r-1)	$\sigma_e^2 + g \sigma_r^2$	
Progenies	(g-1)	$\sigma_e^2 + r \sigma_g^2$	MS ₂
Geographic source (provenance)	(s-1)	$\sigma_e^2 + rp \sigma_s^2$	
Within provenances	s (p-1)	$\sigma_e^2 + rs \sigma_w^2$	
Error	(r-1) (g-1)	σ_e^2	MS ₁

Whereas,

r = number of blocks

g = number of progenies

s = number of geographic source (provenances)

p = progenies in each provenance

e = error variance

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 progenies testing were calculated as:

$$\begin{aligned} \text{Error of variance } (\sigma^2_e) &= MS_1 \\ \text{Genotypic variance } (\sigma^2_g) &= (MS_2 - MS_1)/r \\ \text{Phenotypic variance } (\sigma^2_p) &= \sigma^2_g + \sigma^2_e \end{aligned}$$

3.6.2.2 Mean:

The mean values of each character were worked out by dividing the totals by corresponding number of observations

$$= \frac{\sum x_{ij}}{N}$$

Where $\sum x_{ij}$ = Any observation in i^{th} clone and j^{th} replication

N = Total number of observations

3.6.2.3 Range:

The lowest and highest values for each character were recorded.

3.6.2.4 Standard Error Difference

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

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

Where

EMS = Error mean square

r = Number of replications

3.6.2.5 Critical difference:

Critical difference for all the characters was calculated to compare the progenies means. Critical difference were calculated with the help of standard

error for the difference of two means and tabulated value of 't' at 5% level of significance for error degree of freedom like

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

3.6.2.6 Coefficient of variation:

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

$$\text{Genotypic coefficient of variance} = \frac{\sigma_g \times 100}{\bar{X}}$$

$$\text{Phenotypic coefficient of variance} = \frac{\sigma_p \times 100}{\bar{X}}$$

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

3.6.2.7 Heritability (broad sense):

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

$$\text{Heritability (broad sense) in percent} = h^2_{bs} = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

where σ^2_g = Genotypic variance
 σ^2_p = Phenotypic variance

3.6.2.8 Genetic advance expressed as a percentage of mean:

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

$$\text{Genetic advance (\% of mean)} = \frac{K \cdot \sigma_p \cdot h^2}{\bar{X}}$$

Where:

- K = selection differential (2.06)
 σp = phenotypic standard deviation
 h^2 = heritability in broad sense
 \bar{X} = general mean

CHAPTER-IV

EXPERIMENTAL RESULTS

Present study was resolved into two experiments as per the objectives of the study. Accordingly, the results obtained have been presented under different heads:

4.1 PROVENANCE VARIATION

4.2 SEED STORABILITY AND SEED QUALITY IN STORAGE

4.1 PROVENANCE VARIATION

4.1.1 Phenotypic variation in fruit size:

The data on fruit diameter was recorded at the time of seed collection in order to study the naturally occurring phenotypic variation. The mean, range and coefficient of variation for fruit diameter are presented in table 4.1. The highest average fruit diameter (20.74 mm) was observed in Hanumangarh provenance. The fruit diameter of individual accessions varied from 14.79 mm to 22.88 mm with a general mean of 17.83 mm. Fruit size of all the five accession from Hanumangarh was higher than 19.50 mm. The fruit size of almost all the accession from Hisar and Bhadra was in lower range. Variability for fruit diameter was comparatively higher in Hanumangarh and Sirsa regions.

Table 4.1: Phenotypic variation for fruit size in various provenances of *Capparis decidua*

Accession no.	Source	Fruit diameter (mm)	Mean	Range	CV
1	Hanumangarh	19.57	20.74	19.57-22.88	6.5
2	-do-	22.88			
3	-do-	20.98			
4	-do-	20.17			
5	-do-	20.10			
6	Bhadra	16.79	15.98	14.79-16.79	4.44
7	-do-	16.55			
8	-do-	15.58			
9	-do-	16.17			
10	-do-	14.79			
11	Sirsa	19.15	18.09	15.58-20.07	6.09
12	-do-	20.07			
13	-do-	15.58			
14	-do-	16.94			
15	-do-	18.73			
16	Hisar	16.03	16.5	15.68-17.57	4.34
17	-do-	15.68			
18	-do-	16.93			
19	-do-	17.57			
20	-do-	16.29			
	Mean	17.83			
	CV	12.11			
	Range	14.79-22.88			

High mean values with high coefficient of variation suggested the potential of Hanumangarh region for the selection of larger fruit size bearing trees of *Capparis decidua*. Sirsa region was also found to have trees of *Capparis decidua* with a fruit diameter up to 20.0 mm.

4.1.2 Evaluation of provenances in nursery:

4.1.2.1 Analysis of variance:

The analysis of variance for various seedling characters in six months old provenance-cum-progeny test has been presented in table 4.2. The mean squares due to progenies were highly significant for all the three characters viz., germination per cent, plant height and collar diameter indicating the presence of significant variation among progenies. Mean squares due to provenances were highly significant for plant height and collar diameter indicating the presence of sufficient variation among provenances. Within the provenance mean squares were also highly significant for all the three characters, which indicated the presence of variation among progenies within provenance. Significant mean squares due to provenances against within provenance variance for plant height indicated the preponderance of variation due to provenances. Non-significant mean squares due to provenances against within provenance variance for collar diameter indicated that provenance selection and selection of individual trees are equally important for the genetic improvement of collar diameter.

Table 4.2: Analysis of variance for germination per cent and seedling characters at the age of 6 months in *Capparis decidua*

Source of variation	d.f.	Mean squares		
		Germination (%)	Plant height (cm)	Collar diameter (mm)
Replication	3	1.29	0.0241	0.0165
Progenies	19	254.7976**	2.1637**	0.0298**
Provenance	3	5.6766	6.9975**+	0.0541**
Within provenance	16	301.5078**	1.2785**	0.0267**
Error	57	6.94	0.104	0.0071

**Significant at 1 per cent level of significance

+ Significant at 1 per cent level of significance against within provenance variance

Table 4.3: Variability, heritability and genetic advance for germination per cent and seedling characters at the age of 6 months in *Capparis decidua*

Parameters of variability	Germination (%)	Plant height (cm)	Collar diameter (mm)
Mean	53.9	9.93	2.32
Range	41.9-67.0	7.75-12.0	1.94-2.46
Phenotypic coefficient of variation	15.39	13.59	10.77
Genotypic coefficient of variation	14.6	13.19	10.34
h^2 (broad sense)	89.92	94.50	88.88
Genetic advance as percentage of mean	31.72	28.01	22.19

4.1.2.2 Variability, heritability and genetic advance:

The data on phenotypic coefficient 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 4.3.

The highest phenotypic coefficient of variation (15.39%) was observed for germination per cent followed by plant height with 13.59 per cent phenotypic coefficient of variation. The phenotypic coefficient of variation was also more than 10 per cent for collar diameter. Regarding genotypic coefficient of variation (GCV), almost similar trend was observed with highest genotypic coefficient of variation of 14.60 per cent for germination per cent. The difference between PCV and GCV was observed low for all the characters under study.

Heritability estimates in broad sense were higher than 65 per cent for all the characters under study with highest heritability of 94.50 per cent for plant height. The estimates of genetic advance as percentage of mean were also high for all the characters under study which ranged from 22.19 for collar diameter to 31.72 for germination per cent. The range was observed higher for germination per cent (41.9 to 67.0) and plant height (7.75 to 12.0 cm) in comparison to collar diameter (1.94 to 2.46 mm).

Simultaneous consideration of all the parameters of variability indicated that characters like germination per cent, plant height and collar diameter had higher proportion of variation as heritable in the progenies of *Capparis decidua*.

4.1.2.3 Mean performance of progenies:

The mean performance of twenty progenies from four provenances at the age of 6 months for germination per cent and seedling characters have been presented along with values of critical difference in table 4.4.

4.1.2.3.1 Germination per cent:

The highest germination percentage (67.0) was observed in progeny no. 19 from Hisar region which was followed by progeny no. 1 (65.5) from Hanumangarh and progeny nos. 12 and 15 (63.8) from Sirsa region. Wide range was observed for germination per cent among progenies of all the provenances/sources. But average germination of all the four provenances was looking to be almost equal.

4.1.2.3.2 Plant height:

The highest plant height (12.00 cm) was observed in progeny no. 13 from Sirsa followed by progeny no. 8 (11.13 cm) from Bhadra, progeny no.2 (11.11 cm) from Hanumangarh and progeny no.1 from Hanumangarh. Three progeny nos. 1,2 and 5 from Hanumangarh region, two progeny nos. 6 and 8 from Bhadra and three progeny nos. 11, 12 and 13 from Sirsa were found significantly superior than general mean. In general, the performance of progenies from Hisar were found comparatively poor.

Table 4.4: Mean performance of progenies for germination per cent and seedling characters at the age of 6 months in *Capparis decidua*

Accession no.	Source	Germination (%)	Plant height (cm)	Collar diameter (mm)
1	Hanumangarh	65.5	11.10	2.09
2	-do-	41.9	11.11	2.10
3	-do-	55.4	8.85	2.42
4	-do-	54.2	10.12	2.46
5	-do-	51.3	10.57	2.33
6	Bhadra	56.2	10.53	2.35
7	-do-	54.5	10.00	2.35
8	-do-	60.6	11.13	2.35
9	-do-	51.9	10.23	2.19
10	-do-	43.5	9.25	2.27
11	Sirsa	47.5	10.72	2.22
12	-do-	63.8	10.68	2.32
13	-do-	56.0	12.00	2.14
14	-do-	41.9	9.25	2.13
15	-do-	63.8	10.05	2.30
16	Hisar	60.5	7.75	1.94
17	-do-	52.5	9.55	2.34
18	-do-	45.0	8.77	2.20
19	-do-	67.0	8.85	2.19
20	-do-	45.0	8.17	2.02
General mean		53.9	9.93	2.23
CD at 5%		3.31	0.45	0.11

4.1.2.3.3 Collar diameter:

The highest collar diameter (2.46 mm) was observed in progeny no. 4 from Hanumangarh followed by progeny no. 3 (2.42 mm) from Hanumangarh. These progenies were found significantly superior than general mean. Three progenies viz., progeny nos.6, 7 and 8 from Bhadra were also found significantly superior than general mean. Hanumangarh and Bhadra were found superior provenances whereas Hisar was found poor provenance.

4.2 SEED STORABILITY AND SEED QUALITY IN STORAGE

4.2.1 Standard germination:

Seeds of *Capparis decidua* were collected during September 2005 from five individual trees growing at Hanumangarh, Bhadra, Sirsa and Hisar regions. The standard germination and tetrazolium (TZT) of all the twenty progenies were worked out at the time of seed collection and thereafter at an interval of three months upto six months are presented in table 4.5.

Standard germination of fresh seeds varied from 53.74 per cent in progeny no. 17 from Hisar to 62.21 per cent in progeny no. 1 from Hanumangarh with a mean of 59.08 per cent. Progeny no.1 from Hanumangarh, the only seed lot was found significantly superior than general mean. Significant differences for standard germination per cent were observed among progenies of all the provenances except Sirsa. Majority of progenies showed germination per cent higher than 55 per cent. The highest reduction in germination from 61.05 to 41.45% three months after storage was observed in

Table 4.5: Seed viability of *Capparis decidua* during storage

Progeny no.	Provenance	Standard germination (%)			Tetrazolium test		
		Fresh	after 3 months	after 6 months	Fresh	after 3 months	after 6 months
1	Hanumangarh	62.21	46.71	35.05	63.30	45.63	33.12
2	-do-	58.71	42.98	31.77	59.62	45.82	32.80
3	-do-	59.70	46.00	35.49	60.79	47.00	36.43
4	-do-	59.38	48.56	29.62	58.76	50.56	30.52
5	-do-	58.22	44.05	35.04	60.23	47.05	34.03
6	Bhadra	59.34	43.13	29.62	62.17	44.11	30.42
7	-do-	60.06	46.86	35.49	61.13	43.56	36.44
8	-do-	58.71	41.69	29.46	57.16	40.69	30.36
9	-do-	56.63	46.43	35.79	54.73	45.43	34.62
10	-do-	59.02	42.41	29.98	58.07	40.43	30.88
11	Sirsa	60.54	47.15	35.19	61.54	46.15	34.20
12	-do-	58.54	42.70	29.98	57.22	43.17	30.52
13	-do-	59.54	48.30	33.97	62.52	49.31	32.88
14	-do-	59.39	43.56	33.10	58.40	42.56	36.11
15	-do-	59.25	47.01	30.13	58.24	47.01	30.12
16	Hisar	59.24	42.44	31.29	58.11	43.11	32.10
17	-do-	53.74	46.58	28.43	54.22	46.52	27.34
18	-do-	58.41	47.44	36.24	57.41	48.44	36.10
19	-do-	59.85	41.98	29.61	58.13	41.98	28.51
20	-do-	61.05	41.45	35.24	60.07	40.45	34.22
	General Mean	59.08	44.87	32.73	59.09	44.94	32.58
	CD at 5%	3.09	1.8	2.68	2.89	1.74	2.72

progeny no. 20 from Hisar followed by progeny no. 19 (59.85 to 41.98%) from Hisar. The minimum reduction from 53.74 to 46.58 per cent was observed in progeny no.17 from Hisar provenance. The average reduction in germination per cent after three months of storage was from 59.08 to 44.87 per cent. The germination per cent of all the progenies was more than 40 after three months of storage. The average germination of fresh seed was 59.08 which was reduced to 44.87 per cent three months after storage and further reduced to 32.73 per cent six months after storage.

The germination of all the progenies was more than 28 per cent six months after storage. Maximum reduction in germination per cent after six months of storage was observed in progeny no.19 from Hisar followed by progeny no.4 from Hanumangarh. The viability of seed by TZT was found very close to standard germination test in all the progenies at all the three stages.

4.2.2 Vigour index-I:

Seeds of *Capparis decidua* were collected during September 2005 from five individual trees growing at Hanumangarh, Bhadra, Sirsa and Hisar regions. The vigour index-I of all the twenty progenies were worked out at the time of seed collection and thereafter at an interval of three months upto six months (Table 4.6). Vigour index-I of fresh seeds varied from 134.89 in progeny no. 14 from Sirsa to 341.02 in progeny no. 18 from Hisar with an average of 211.81. In total, four progenies viz., progeny nos. 1 and 3 from Hanumangarh and progeny nos. 18 and 19 from Hisar were found significantly superior than

Table 4.6: Seed vigour of *Capparis decidua* during storage

Progeny no.	Provenance	Vigour index-I			Vigour index-II		
		Fresh	after 3 months	after 6 months	Fresh	after 3 months	after 6 months
1	Hanumangarh	300.69	212.40	146.01	2.14	1.42	0.90
2	-do-	145.87	132.23	88.40	2.06	1.34	0.83
3	-do-	268.19	184.01	131.10	3.01	2.16	1.49
4	-do-	218.03	154.13	82.84	2.80	2.17	1.16
5	-do-	163.98	115.24	84.59	3.23	2.34	1.60
6	Bhadra	246.37	162.01	103.06	3.69	2.41	1.45
7	-do-	215.09	142.54	95.60	3.09	1.99	1.30
8	-do-	242.37	146.32	93.97	3.44	2.20	1.40
9	-do-	193.55	142.46	97.00	3.43	2.96	1.71
10	-do-	209.81	137.29	84.84	3.26	2.12	1.31
11	Sirsa	239.41	174.64	112.70	2.50	1.82	1.24
12	-do-	263.14	173.14	105.13	3.05	2.14	1.30
13	-do-	207.89	154.81	93.09	3.02	2.21	1.34
14	-do-	134.89	117.76	86.00	2.12	1.30	0.96
15	-do-	220.98	120.38	70.00	3.19	2.35	1.29
16	Hisar	190.18	144.60	90.38	2.89	2.06	1.32
17	-do-	202.41	182.61	43.60	2.92	2.19	1.14
18	-do-	341.02	198.74	118.70	3.65	2.67	1.81
19	-do-	269.32	173.36	107.01	3.31	2.12	1.38
20	-do-	163.17	111.34	58.80	2.39	1.49	0.88
General Mean		211.81	154.25	94.64	2.96	2.05	1.29
CD at 5%		54.45	47.62	34.03	0.28	0.22	0.14

general mean for vigour index-I. Progenies within provenance as well as between provenances were found significantly different for vigour index-I. The highest reduction (220.98 to 120.38) in vigour index-I after three months of storage was observed in progeny no. 15 from Sirsa. The lowest reduction (145.87 to 132.23) in vigour index-I was observed in no.2 from Hanumangarh. The average vigour index-I of fresh seed was 211.81 which was reduced to 154.25 three months after storage and further reduced to 94.64 six months after storage. The maximum reduction in vigour index-I six months after storage was observed in progeny no. 17 from Hisar whereas minimum reduction in vigour index-I six months after storage was observed in progeny no.14 from Sirsa.

4.2.3 Vigour index-II:

Seeds of *Capparis decidua* were collected during September 2005 from five individual trees growing at Hanumangarh, Bhadra, Sirsa and Hisar regions. The vigour index-II all the twenty progenies were worked out at the time of seed collection and thereafter at an interval of three months upto six months are presented in table 4.6. Vigour index-II of fresh seed varied from 2.06 in progeny no.2 from Hanumangarh to 3.69 in progeny no.6 from Bhadra with an average of 2.96. Six progenies viz., progeny nos. 6, 8, 9 and 10 from Bhadra and progeny nos. 18 and 19 from Hisar were found significantly superior than general mean. The average vigour index-II was 2.96 which was reduced to 2.06 three months after storage and further reduced to 1.29 six months after storage. The minimum reduction from 3.43 to 2.96 in vigour index-II was observed in progeny no. 9 from Bhadra. The maximum reduction in vigour index-II was observed in progeny no.20 from Hisar.

Chapter-V

Discussion

Capparis decidua (Forsk.) Edgew. Syn. *C. aphylla* Roth commonly known as kair is an important naturally growing medicinal plant with a valuable source of nutrition and high economic value. It is densely branched, spinous shrub or tree up to 6 m in height and found in varied habitats including sand dunes and alkaline conditions of tropical and sub-tropical region within annual rainfall of 100 to 400 mm and temperature of 16 to 50°C. Poor people of rural areas used to collect its immature fruits from each and every plant repeatedly for selling in market, which resulted into production of less or no seeds. Domestication and cultivation of useful plant like *Capparis decidua* by gathering from natural populations is an effective method of ensuring their survival and conservation.

Provenance, geographic source or geographic race in tree species denotes the original geographic area from where seed or other propagation material is obtained (Callaham, 1964; Jones and Burley, 1973). It is generally true that tree species with a wide geographical distribution exhibit considerable provenance variation in anatomy, morphology and physiology. They vary genetically as well.

In four diverse populations of *Capparis decidua* from Rajasthan and Haryana, the fruit diameter ranged from 14.79 to 22.88 mm with a general mean of 17.83 mm. The average as well as extent of variability were observed higher in Hanumangarh and Sirsa. High mean values with high coefficient of variation

suggest the potential of Hanumangarh region for the selection of larger fruit size bearing trees of *Capparis decidua*. Dogra (1981) emphasized on survey of phenotypic variation for silvicultural characteristics of tree species in their naturally distributed ranges. Kacker *et al.* (1986) reported variation for morphological characters of *Prosopis cineraria* in natural stands from various adaphic sites and rainfall zones of western Rajasthan. Jindal *et al.* (1987) in their studies of natural population of *Tecomella undulata* reported wide variation for various morphological characters.

The tree populations under natural forest are generally genetically variable. They must be so in order to survive, grow and reproduce under the differing conditions including some hazardous ones and numerous environments that are encountered during a single generation and over generations (Antonovics, 1971; Nienstaedt, 1975). The value of this 'gift' of great variability in forest trees is often under estimated. The proper kind of genetically controlled variation provides the needed conditions for a tree improvement programme, giving the necessary tools for large and quick gains from the use of genetics in forestry. As compared to agricultural crops, forest tree populations have been little influenced by human activities until now. In fact, even now, many important forest tree species like *Capparis decidua* have not been paid desired attention for their genetic improvement. Tree Breeders are working essentially with wild populations that contain the genes and gene complexes needed for breeding programmes. As a matter of fact, most forest tree species have greater variability than species of other organisms; it is reported to be almost double that of other plants (Hameric *et al.*,

1979). Forest tree breeders, therefore, are at a huge advantage by being able to draw on this variability in their breeding programme. However, it is also equally important to maintain and enhance the great store of variation for future use. Success in the establishment and productivity of forest tree plantations is determined largely by the species used and source of seed within species (Larsen, 1954; Callaham, 1964; Lacaze, 1978). The need to use the best adapted seed source has been recognized in the early years by Tozawa (1924), Wakeley (1954) and Langlet (1967). Till more sophisticated, expensive and long-term breeding techniques for further improvement are employed, the use of best seed source is the only available improvement method for fastest, cheapest and immediate gains. The provenance testing is very well developed area in forestry, which indicates that there exist considerable differences between populations and between trees within populations growing at different sites and even between trees of a single stand. The relative contribution of heredity and environment in the expression of variation may be evaluated by raising seedlings from various seed sources under relatively uniform conditions.

In the present study on six months old provenance-cum-progeny test of *Capparis decidua*, large variation was observed for germination per cent, plant height and collar diameter in twenty progenies of four provenances. Significant variations were also observed among provenances for plant height and collar diameter. In earlier reports, seed sources of *Acacia nilotica* made large differences in growth characters (Shiv Kumar and Banerjee, 1986; Rehman *et al.*, 1988). Progenies within provenances were also observed variable for all the three

characters viz., germination per cent, plant height and collar diameter. Non-significant mean squares due to provenances against within provenance variance for germination per cent and collar diameter indicated that provenance selection and selection of individual trees are equally important for genetic improvement of these traits in *Capparis decidua*. Bangarwa (1993) also reported the equal importance of provenance selection and selection of individual tree for the improvement of stem form, main stem height and clear bole height in *Dalbergia sissoo* Roxb. In the present study, contribution of provenance variation was found comparatively more than individual plant variation for plant height. Bangarwa (1993) reported the pre-dominance of provenance variation for plant height in *Dalbergia sissoo*.

In present study, medium values of phenotypic coefficient of variation in six months old twenty progenies and little difference from genotypic coefficient of variation for germination per cent, plant height and collar diameter suggested the existence of higher proportion of variation as heritable. High estimate of broad sense heritability (88.88 to 94.50%) and genetic advance as percentage of mean (22.19 to 31.72) for all the three characters under study further confirmed high breeding value of the test material. High heritability accompanied by high genetic advance for growth parameters have been reported by Solanki *et al.*, (1985) in *Prosopis cineraria*. Gains from tree breeding programmes depend on the type and extent of genetic variability. The best gains are for characters which are under genetic control and have a wide range of variability (Zobel, 1971).

The data presented in table 5.1 clearly suggested the best performance of Sirsa provenance for plant height followed by Hanumangarh and Bhadra provenances. The performance of Hisar provenance was very poor for plant height and collar diameter. Hanumangarh and Bhadra provenances ranked at top for collar diameter with a mean of 2.28 mm. The mean performance of these provenances was significantly superior than general mean. Hanumangarh and Bhadra provenances were significantly superior than general mean for both plant height and collar diameter.

The data presented in table 5.2 clearly suggested the overall superiority of progeny no.8 from Bhadra. This progeny was found significantly superior than general mean for all the three characters viz., germination per cent, plant height and collar diameter. Progeny no. 6 from Bhadra was found significantly superior than general mean for plant height and collar diameter, whereas progeny no.1 from Hanumangarh was found significantly superior than general mean for germination per cent and collar diameter. All the five progenies from Hanumangarh were found significantly superior than general mean for at least one of the characters under study. None of the progeny from Hisar provenance was found superior for either of the growth characters.

Table 5.1: Mean performance of provenances for seedling characters at the age of six months in *Capparis decidua*

Provenance	Plant height (cm)	Collar diameter (mm)
Hanumangarh	10.35	2.28
Bhadra	10.23	2.28
Sirsa	10.54	2.22
Hisar	8.62	2.14
General mean	9.93	2.23
CD at 5%	0.19	0.05

Table 5.2: Progenies significantly superior than general mean for germination per cent and seedling characters at the age of six months in *Capparis decidua*

Accession No.	Source	Germination (%)	Plant height (cm)	Collar diameter (mm)
1	Hanumangarh	Yes	Yes	No
2	-do-	No	Yes	No
3	-do-	No	No	Yes
4	-do-	No	No	Yes
5	-do-	No	Yes	No
6	Bhadra	No	Yes	Yes
7	-do-	No	No	Yes
8	-do-	Yes	Yes	Yes
11	Sirsa	No	Yes	No
12	-do-	Yes	Yes	No
13	-do-	No	Yes	No
15	-do-	Yes	No	No
16	Hisar	Yes	No	No
19	-do-	Yes	No	No
General mean		53.9	9.93	2.23
CD at 5%		3.31	0.45	0.11

A critical examination of table 5.1 and table 5.2 clearly suggested the need of survey and testing of more progenies from Hanumangarh and Bhadra regions which may lead to the identification of faster growing material of *Capparis decidua*.

The standard germination test, vigour index-I and vigour index-II of all the twenty progenies were worked out at the time of seed collection and thereafter at an interval of three months up to six months. Standard germination per cent of fresh seeds varied from 53.74 per cent in progeny no. 17 from Hisar to 62.21 per cent in progeny no. 1 from Hanumangarh with a mean of 59.08 per cent. Significant differences for standard germination per cent were observed among progenies of all the provenances except Sirsa. Majority of progenies showed germination per cent higher than 55 per cent. The average germination of fresh seed was 59.08 which was reduced to 44.87 per cent three months after storage and further reduced to 32.73 per cent six months after storage. The germination of all the progenies was more than 28 per cent six months after storage.

The average vigour index-I of fresh seed was 211.81 which was reduced to 154.25 three months after storage and further reduced to 94.64 six months after storage. The average vigour index-II was 2.96 which was reduced to 2.06 three months after storage and 1.29 six months after storage.

Germination per cent of fresh seed along with per cent loss of germination, vigour index-I and vigour index-II after 3 and 6 months of storage

Table 5.3: Germination per cent of fresh seed along with per cent loss of germination and vigour index after 3 and 6 months of storage in various progenies of *Capparis decidua*

Progeny no.	Provenance	Germination per cent of fresh seed	Loss in percentage					
			Standard germination (%)		Vigour index-I		Vigour index-II	
			3 months	6 months	3 months	6 months	3 months	6 months
1	Hanumangarh	62.21	24.90	43.65	29.36	51.44	33.64	57.94
2	-do-	58.71	26.79	45.89	9.35	39.39	34.95	59.70
3	-do-	59.70	22.94	40.54	29.52	51.11	28.23	50.49
4	-do-	59.38	18.22	50.11	29.30	61.98	22.50	58.57
5	-do-	58.22	24.33	39.81	29.72	48.41	27.55	50.46
6	Bhadra	59.34	27.32	50.09	34.24	58.16	34.68	60.70
7	-do-	60.66	21.98	40.90	33.73	55.55	35.59	57.92
8	-do-	58.71	28.99	49.81	39.62	61.22	36.04	59.30
9	-do-	56.63	18.01	36.80	26.39	49.88	13.70	50.14
10	-do-	59.02	28.15	49.19	34.56	59.56	34.96	59.81
11	Sirsa	60.54	22.11	41.87	27.05	52.95	27.20	50.40
12	-do-	58.54	27.06	48.78	34.20	60.04	29.83	57.37
13	-do-	59.54	18.88	42.94	25.53	55.22	26.82	55.62
14	-do-	59.39	26.65	37.52	12.69	36.24	38.67	54.71
15	-do-	59.25	20.66	49.13	45.52	68.32	26.33	59.56
16	Hisar	59.24	28.36	47.17	23.97	52.47	26.95	53.19
17	-do-	53.74	13.32	47.08	9.78	78.45	25.00	60.95
18	-do-	58.41	18.78	37.95	41.72	65.19	26.84	50.41
19	-do-	59.85	29.86	50.51	35.63	60.26	35.95	58.30
20	-do-	61.05	32.11	42.28	31.76	63.96	37.65	63.17
Average		59.07	23.94	44.60	29.18	56.49	30.15	56.43

in various progenies of *Capparis decidua* are presented in table 5.3. The reduction in germination per cent varied from 13.32 per cent in progeny no. 17 from Hisar to 32.11 per cent in progeny no. 20 from Hisar with a mean of 23.97 per cent three months after storage, whereas reduction in germination per cent six months after storage ranged from 36.80 per cent in progeny no. 9 from Bhadra to 50.51 per cent in progeny no. 19 from Hisar with a mean of 44.60 per cent. Reduction in vigour index-I ranged from 36.24 per cent in progeny no.14 from Sirsa to 78.45 per cent in progeny no.17 from Hisar with a mean of 56.49 per cent six months after storage, whereas reduction in vigour index-II varied from 50.14 per cent in progeny no. 9 from Bhadra to 63.17 per cent in progeny no. 20 from Hisar with a mean of 56.43.

Lot of variability exist in twenty progenies from four provenances for germination per cent, vigour index-I and vigour index-II. All the progenies showed variable response for loss of viability and loss of seedling vigour during storage. The germination of all the 20 progenies was higher than 50 per cent at the time of

seed collection. A critical examination of table 5.3 clearly suggested that loss in vigour index-I and vigour index-II was higher than reduction in germination at both the interval of storage in almost all the progenies. These results clearly suggested the paramount importance of vigour index-I and vigour index-II for prediction of quality of seed during storage. Therefore, seeds of *Capparis decidua* should be used immediately after collection or at the earliest for the production of quality seedling stock. Kumar and Bangarwa (2005) reported that the rate of decrease in seed vigour was higher with the advancement of storage period in *Azadirachta indica*.

Chapter-VI

Summary and Conclusion

Large amount of seeds were collected from five randomly selected trees of *Capparis decidua* from each of two sites from Rajasthan (Hanumangarh, Bhadra) and Haryana (Sirsa, Hisar) provenances during September 2005. Data on fruit diameter were recorded from each tree at the time of seed collection in order to study the phenotypic variation in natural population. The seeds of all the twenty progenies arising from four provenances were sown in the nursery area of Department of Forestry, CCS Haryana Agricultural University, Hisar following randomized block design with four replications in February 2006. The seed quality tests were conducted in laboratory of Seed Science and Technology Department, CCS Haryana Agricultural University, Hisar. The results so obtained are summarized as under:

- Fruit diameter ranged from 14.79 to 22.88 mm with a general mean of 17.83 mm. Fruit size of all the five accessions from Hanumangarh was higher than 19.50 mm. Variability for fruit diameter was comparatively higher in Hanumangarh and Sirsa.
- Analysis of variance showed the presence of significant variation among progenies for germination per cent, plant height and collar diameter, whereas significant variation among provenances were observed for plant height and collar diameter. For the exploitation of plant height, provenance selection was

found more important whereas for improvement of collar diameter, both provenance and individual tree selections were equally important.

- Medium values of phenotypic coefficient of variation and little difference from genotypic coefficient of variation were observed for all the three characters, viz., germination per cent, plant height and collar diameter. Heritability estimates and genetic advance were also found high for all the characters under study.
- Progeny number 8 from Bhadra provenance was found overall best on the basis of mean performance which were significantly superior than general mean for all the three characters viz., germination per cent, plant height and collar diameter. Progeny number 6 from Bhadra was found significantly superior than general mean for plant height and collar diameter whereas progeny number 1 from Hanumangarh was found significantly superior than general mean for germination per cent and plant height.
- In general, the provenances like Hanumangarh and Bhadra were found superior for seedling characters.
- Standard germination of fresh seeds varied from 53.74 per cent in progeny no.17 from Hisar to 62.21 per cent in progeny no.1 from Hanumangarh with a mean of 59.08 per cent. The average germination per cent of fresh seed (59.08) was reduced to 44.87 per cent three months after storage and which was further reduced to 32.73 per cent six months after storage.
- The reduction in both vigour index-I and vigour index-II were observed higher than standard germination for all the progenies up to six months of storage.

Conclusions

Hanumangarh region has potential for larger size fruit bearing trees of *Capparis decidua*. Progenies from Hanumangarh and Bhadra provenances were found superior for germination per cent and seedling characters. The germination of all the progenies at the time of seed collection was higher than 50 per cent. The loss during storage was observed higher in vigour index-I and vigour index-II than germination in all the progenies. Therefore, seed of *Capparis decidua* should be used at the earliest for quality planting stock.

Bibliography

- Anonymous. (1992). *The Wealth of India*, Vol.3, Council of Scientific and Industrial Research publication, New Delhi, India: 210-212.
- Antonovics, J. (1971). The effects of a heterogeneous environment on the genetics of natural populations. *Am. Sci.* **59**: 593-595.
- Arya, S., Toky, O.P., Bisht, R.P., Tomar, R., Harris, P.J.C. (1995). Provenance variation in seeds, germination and seedling growth of *Prosopis cineraria*. *Silvae Genetica* **44**: 55.
- Bagchi, S.K., Joshi, D.N. and Rawat, D.S. (1990). Variation in seed size of *Acacia* spp. *Silvae Genetica* **39**: 107-110.
- Baldwin, H.I. (1942). *Forest tree seed of the north temperate region with special reference to North America*. Chronica Botanica Co. Waltham, Mass, 240 p.
- Bangarwa, K.S. (1993). Studies on provenance variation, progeny testing and reproductive biology in *Dalbergia sissoo* Roxb. Ph.D. Thesis, Ch. Charan Singh Haryana Agricultural University, Hisar.
- Bangarwa, K.S. (1996). *In: Sissoo Breeding*. Agriculture and Forestry Information Centre, 345, Sector 15-A, Hisar 125 001 (Haryana), India.
- Bangarwa, K.S., Singh, V.P. and Tomer, R.P.S. (1995). Progeny testing for seed quality parameters in *Dalbergia sissoo* Roxb. *Seed Science and Technology* **23**: 253-257.

- Burton, G.W. (1952). Quantitative inheritance in grasses. *Proc. 7th Int. Grassland Congress* **1**: 277-283.
- Callahan, R. Z. (1964). Provenance research: investigation on genetic diversity associated with geography. *Unasylva* **18**: 40-50.
- Deora, N.S. and Shekhawat, N. S. (1995). Micropropagation of *Capparis decidua* (Forsk.) Edgew. – A tree of arid horticulture. *Plant Cell Reports* **15**: 278-281.
- Dogra, P. D. (1981). Forest genetics research and application in Indian forestry-1, II. *Ind. For.* **107**: 190-219, 263-288.
- Doikov, G. (1973). Determination of phenotype forms in *Abies alba*. *Gorskostopanstvo (For. Abstr.)* No.9, **20, 25, 35**: 2181.
- Dwivedi, A.P. (1993). *Babul (Acacia nilotica): A multipurpose tree of dry areas*. Scientific Publishers, Jodhpur. pp.69.
- Elam, W.W. and Blanche, C.A. (1989). Accelerated ageing: a potential vigour test for multipurpose tree seeds, pp. 21-24 in Turnbull, J.W. (ed.) *Tropical Tree Seed Research* Gympie, Old Australia.
- Emmanuel, C.J.S.K. and Dharamaswamy, S.S. (1991). Short note: Seed source variation in storage life of teak seeds. *Silvae Genetica* **40**: 249-250.
- Emmanuel, C.J.S.K., Kapoor, M.L. and Sharma, V.K. (1992). Three decades of forest genetics and tree improvement. *Indian Forester* **118**: 489-500.
- Fisher, R.A. and Yates, Y. (1963). *Statistical Tables for Biological, Agricultural and Medical Research*. Oliver & Boyd. Ltd., Edinburgh: 146.

- Gera, M., Gera, N. and Ginwal, H.S. (1999). Seed source variation in germination and early growth among ten indigenous populations of *Dalbergia sissoo* Roxb. *Indian Journal of Forestry* **125**:1190-1197.
- Gera, M., Gera, N. and Ginwal, H.S. (2000). Seed trait variation in *Dalbergia sissoo* Roxb. *Seed Science and Technology* **28**: 467-475.
- Ginwal, H.S., Rawat, P.S., Gera, M., Gera, N. and Srivastava, R.L. (1995). Study on the pattern of seed germination of various sub-species cum provenances of *Acacia nilotica* Willd. Ex. Del. under nursery conditions. *Indian Forester* pp.29.
- Gupta, I.C., Harsh, L.N., Shankaranaryana, K.A. and Sharma, B.D. (1989). Wealth from wastelands. *Indian Fmg.* **38** (11): 18-19.
- Hameric, J. L., Metton, J. B. and Linhard, Y. B. (1979). Levels of genetic variation in trees: Influence of life history characteristics. *Proc. Symp. On Isozymes of N. Amer. For. Trees*, Berkeley, Calif. 35-41.
- Hooda, M.S. and Bahadur, R. (1993). Variability correlation and path coefficients analysis for some seed traits in Subabul. *Seed Research* **21**: 49-51.
- Jindal, S. K., Kackar, N. L. and Solanki, K. R. (1987). Germplasm collection and genetic variability in Rohida [*Tecomella undulata* (Sm.)] in western Rajasthan. *Ind. J. For.* **10**: 52-55.
- Johnson, H.W., Robinson, H.F. and Comstock (1955). Estimates of genetic and environmental variability in Soybean. *Agronomy Journal* **47**: 314-318.
- Jones, N. and Burley, J. (1973). Seed certification, provenance nomenclature and genetic history in forestry. *Silvae Genetica* **22**: 53-58.

- Joshi, H.B., Logoney, R.N., Patnaik, L.K., Chaudhari, D.C. and Chauhan, R.S. (1983). *The Silviculture of Indian Trees*, Vol. IV. Revised and enlarged by the Editorial Board, FRI and Colleges, Dehradun.
- Kacker, N.L., Solanki, K.R. and Jindal, S.K. (1986). Variation in fruit and seed characters of *Prosopis cineraria* (L.) MacBride in the Thar Desert. *Indian Journal of Forestry* **9**: 113-115.
- Kandya, A.K. (1978). Relationship among seed weight and various growth factors in *Pinus oocarpa* Schiede seedlings. *Indian Forester* **104**: 560-567.
- Krishan, B.K. and Toky, O.P. (1996). Provenance variation in seed characters of *Acacia nilotica*. **105**: 37-38.
- Kumar, A. and Bhatnagar, H.P. (1976). Effect of temperature and substratum on the germination of *Dalbergia sissoo* Roxb. seed. *Indian Forester* **102**: 608-613.
- Kumar, N. and Toky, O.P. (1996). Variation in seed germination and juvenile growth of 12 provenance of *Albizia lebbek* (L.) in arid India. *Indian Journal of Forestry* **19**: 123-128.
- Kumar, R. and Bangarwa, K. S. (2005). Influence of storage periods and storage conditions on vigour of neem (*Azadirachta indica*) seeds. *Environment and Ecology* **235**: 428-437.
- Kumar, R., Tyagi, C.S. and Ram, C. (1988). Relationship of standard germination, accelerated ageing and electrical conductivity to field performance in Mung bean, pp. 135-140. In: T.P.Yadav and C. Ram (Ed.) *Seed Science and Technology*, HAU Press, Hisar.

- Kuo, S.R. (1984). Studies on the seed germination seedling growth of *Casuarina*. *Technical Bulletin, Experimental Forest, National Taiwan University* **154**: 11-12.
- Lacaza, J. F. (1978). Advances in species and provenance selection. *Unasyva* **30**: 17-20.
- Langdon, O.G. (1958). Cone and seed size on South Florida slashpine and their effects on seedlings size and survival. *Indian Journal of Forestry* **56**: 122-127.
- Langlet, O. (1967). Regional Intraspecific variousness. IUFRO Congress, Munchen, Germany, Vol. III: 435-458.
- Larsen, C. S. (1954). Provenance testing and forest tree breeding. *Proc. 11th Congress IUFRO*, Rome: 467-473.
- Lush, J. L. (1949). Heritability of quantitative characters in farm animals. *Proc. of the 8th Int. Genet. Cong. 1948, Hereditas (Supple)*. pp.356-357.
- Mathur, R.S., Sharma, K.K. and Rawat, M.M.S. (1984). Germination behaviour of provenances of *Acacia nilotica* sp. *indica*. *Indian Forester* **110**: 435-449.
- Nlenstaedt, H. (1975). Adaptive variation – Manifestations in Tree species and uses in forest management and tree improvement. *Proc. 15th Can. Tree Improv. Assoc.*, Part 2: 11-23.
- Panse, V.G. and Sukhatme, P.V. 1978. Statistical methods for agricultural workers. 3rd ed. ICAR, New Delhi.

- Pathak, P. S., Debroy, R. and Rai, P. (1974). Autecology of *Leucaena leucocephala* (L.) de Wit. I. *Seed Polymorphism and Germination*. *Tropical Ecology* **15**: 1-10.
- Pathak, P. S., Gupta, S. K. and Roy, R. D. (1984). Autecology of *Leucaena leucocephala* lever de wit III. Meterograph analysis of seedling characteristics. *Journal of Tree Sciences* **3**: 15-19.
- Read, R. A. (1971). Scot pine in eastern Nebraska: a provenance study. U.S. For. Serv. Res. Pap. Rocky Mt. *Forest Range Experimental Station* **RM-78**: 13.
- Rehman, S. A., Hussain, A. and Ameen, S. (1988). Results of early selection of *Acacia* and *Prosopis* species/seed sources. *Pakistan J. For.* **38**: 109-117.
- Robbins, A. M. J. (1988). Storage of sissoo seeds. Kathmandu, Nepal, Forest Res. and Information Centre, Forest Survey and Research Office, Department of Forest. *Banko Jankari* **2**: 57-59.
- Shiv Kumar, P. and Banerjee, A. C. (1986). Provenance trials of *Acacia nilotica*. *Journal of Tree Sciences* **5**: 53-56.
- Sindhu, Veerendra, H. C. (1995). Variation studies in provenances of *Azadirachta indica* (The Neem Tree). *Indian Forester* 1053-1056.
- Singh, N. B., Kumar, D., Rawat, G. S., Gupta, R. K., Singh, K. and Negi, S. S. (2001). Clonal evaluation of poplar (*Populus deltoides* Bartr.) in eastern Uttar Pradesh II – Estimates of genetic parameters in field testing. *Indian Forester*, **127**: 163-172.

- Snieszko, R.A. and Stewart, H.T.L. (1989). Range wide provenance variation in growth and nutrition of *Acacia nilotica* seedling propagated in Zimbabwe. *Forest Ecology and Management* **27**: 179-197.
- Solanki, K. R., Jindal, S. K., Muthana, K. D. and Kackar, N. L. (1985). Performance of *Acacia senegal* and *Prosopis cineraria* in Western Rajasthan. *Nitrogen Fixing Tree Research Reports* **3**: 27-28.
- Srivastava, S.K., Verma, N., Mishra, C.M., Dubey, P. and Burfal, B.S. (2001). Evaluation of seed source variation on different seed parameters of *Dalbergia sissoo* Roxb. *Indian Forester* 358-362.
- Suri, S.K. (1984). Analytical study of teak provenance tests in North Raipur Division of M.P. *Indian Forester* **110**: 345-363.
- Taylor, G.B. (1972). The effect of seed size on seedling growth in subterranean clover (*T.subterraneum* L.). *Australian Journal of Agricultural Research* **231**: 4595-4603.
- Thapliyal, R.C. and Dhiman, R.C. (1997). Geographic variation in seed and seedling characteristics in *Pinus roxburghii* Sarg. from Himachal Pradesh. *Annals of Forestry* **5**: 140-145.
- Tozowa, M. (1924). Necessity of provenance test and the urgent need of a test plantation network. *J. Korean For. Assoc.* **22**: 1-5.
- Troup, R.S. (1921). *Silviculture of Indian Trees*. Clarendon Press, Oxford **1**: 164-166.

- Tyagi, P. and Kothari, S.I. (1997). Micropropagation of *Capparis decidua* through vitro shoot proliferation on nodal explants of mature tree and seedling explants. *J. Plant Biochemistry and Biotech.* **6**: 19-23.
- Vakshaya, R.K., Rajora, O.P. and Rawat, M.S. (1992). Seed and seedling traits of *Dalbergia sissoo* Roxb.: Seed source variation studies among ten sources in India. *Forest Ecology and Management* **48**: 265-275.
- Wakeley, P. C. (1954). The relation of geographic race to forest tree improvement. *J. For.* **52**: 653.
- Williams, W.A. (1967). Seedling growth of a hypogeal legume, *Vicia dasycarpa* in relation to seed weight. *Crop Science* **7**: 163-164.
- Yadav, S.S. (1993). *Studies on extent of variation and associationship among various seed parameters in relation to tree girth in Dalbergia sissoo*. M.Sc. Thesis submitted to CCS Haryana Agricultural University, Hisar. 56 p.
- Yadav, V.K., Khare, P.K. and Mishra, G.P. (1986). Effect of tree girth on seed viability and germination in Sal (*Shorea robusta*). *Journal of Tropical Forestry* **2**: 213-216.
- Zobel, B. J. (1971). The genetic improvement of Southern Pines. *Sci. Amer.* **225**: 94-103.
- Zobel, B.J. and Talbert, J.T. (1984). *Applied Forest Tree Improvement*. New York: John Wiley and Sons. 505 p.

Abstract

- a) Title of the thesis : **Seed Source Variation for Seed and Seedling Characters in Kair [*Capparis decidua* (Forsk.) Edgew.]**
- b) Full name of degree holder : **KALU RAM**
- c) Title of degree : **Master of Science in Forestry**
- d) Name and address of the Major Advisor : Dr. K. S. Bangarwa
Professor
Department of Forestry
CCS HAU, Hisar-125 004, Haryana
(India)
- e) Degree awarding university : CCS Haryana Agricultural University
Hisar –125 004 (India)
- f) Year of award of degree : 2006
- g) Major subject : **FORESTRY**
- h) Total number of pages in dissertation : 52
(Text: 43, Bibliography: ix)
- i) Number of words in the abstract : 322

Key words: *Capparis decidua*, kair, provenance evaluation, progeny testing, standard germination

Seeds were collected from five randomly selected trees of *Capparis decidua* from each of two sites from Rajasthan (Hanumangarh, Bhadra) and Haryana (Sirsa, Hisar) provenances during September 2005. The seeds of all the twenty progenies arising from four provenances were used for provenance testing in nursery and seed storage up to six months. Fruit diameter ranged from 14.79 to 22.88 mm with a general mean of 17.83 mm. Variability for fruit diameter was comparatively higher in Hanumangarh and Sirsa. Analysis of variance showed the presence of significant variation among progenies for germination per cent, plant height and collar diameter, whereas significant variation among provenances were

observed for plant height and collar diameter. Medium values of phenotypic coefficient of variation and little difference from genotypic coefficient of variation were observed for all the three characters, viz., germination per cent, plant height and collar diameter. Heritability estimates and genetic advance were also found high for all the characters under study. Progeny number 8 from Bhadra provenance was found overall best for all the three characters viz., germination per cent, plant height and collar diameter. Progeny number 6 from Bhadra was found significantly superior than general mean for plant height and collar diameter whereas progeny number 1 from Hanumangarh was found significantly superior than general mean for germination per cent and plant height. In general, the provenances like Hanumangarh and Bhadra were found superior for seedling characters.

Standard germination of fresh seeds varied from 53.74 per cent in progeny no.17 from Hisar to 62.21 per cent in progeny no.1 from Hanumangarh with a mean of 59.08 per cent. The average germination per cent of fresh seed (59.08) was reduced to 44.87 per cent three months after storage and which was further reduced to 32.73 per cent six months after storage. The reduction in both vigour index-I and vigour index-II were observed higher than standard germination for all the progenies up to six months of storage.

Major Advisor

Signature of the Student

Professor & Head