STUDIES ON GENETIC DIVERSITY AND EVALUATION OF PROMISING GENOTYPES IN TAMARIND (*Tamarindus indica* L.)

S. I. HANAMASHETTI

DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
DHARWAD - 580 005

FEBRUARY, 1996

STUDIES ON GENETIC DIVERSITY AND EVALUATION OF PROMISING GENOTYPES IN TAMARIND (*Tamarindus indica* L.)

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfilment of the requirements for the
Degree of

Doctor of Philosophy

in

HORTICULTURE

By

S. I. HANAMASHETTI

DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
DHARWAD - 580 005

FEBRUARY, 1996

DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD

CERTIFICATE

This is to certify that the thesis entitled "**STUDIES ON GENETIC DIVERSITY AND EVALUATION OF PROMISING GENOTYPES IN TAMARIND (*Tamarindus indica* L.)**" submitted by Mr. S.I. **HANAMASHETTI** for the degree of **DOCTOR OF PHILOSOPHY** in **HORTICULTURE**, of the University of Agricultural Sciences, Dharwad, is a record of research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

DHARWAD
February, 1996

(G.S. SULIKERI)
Prof. and Head
Division of Horticulture

Approved by :

Chairman : _____
(G.S. SULIKERI)

Members : 1. _____
(N.C. HULAMANI)

2. _____
(M.B.CHETTI)

3. _____
(A.D. JANAWADE)

4. _____
(V.S. DODDAMANI)

AFFECTIONATELY DEDICATED
TO MY FATHER
LATE Shri. IRABASAPPA G. HANAMASHETTI
AND
Shri. MAUNA MALLIKARJUN SWAMIJI, MAMADAPUR

ACKNOWLEDGEMENT

I wish to express with utmost sincerity, my deep sense of gratitude to the esteemed chairman of my Advisory committee ***Dr. G.S. Sulikeri****, Professor of Horticulture and Head, University of Agricultural Sciences, Dharwad, for his guidance, valuable suggestions, and encouragement during the course of this research work. I accomplish his constructive criticism, close counsel, and critical advise with privilege and heartfelt gratitudeness, without which I could not have completed this work.*

I am grateful to the members of my Advisory committee ***Dr. N.C. Hulamani****, Director of Instruction (Horticulture), Kittur Rani Channamma College of Horticulture, Arabhavi,* ***Dr. M.B. Chetti****, Professor of Crop Physiology,* ***Dr. A.D. Janawade****, Associate Professor of Agronomy and* ***Dr. V.S. Doddamani****, Associate Professor of Soil Science, University of Agricultural Sciences, Dharwad for their valuable suggestions during the research and also for their critical review of the manuscript.*

I remain gratitude to ***Dr. R.S. Kulkarni****, Professor of Genetics and Plant Breeding and Head, University of Agricultural Sciences, Bangalore,* ***Dr. K.N. Ganeshaiah****, Associate Professor of Agricultural Botany, UAS, Bangalore, for their valuable suggestions and analysis of research data.* ***Dr.P.M. Salimath****, Professor of Genetics and Plant Breeding and Head,* ***Dr. C.S.P. Patil****, Professor of Forestry, University of Agricultural Sciences, Dharwad for their critical review of manuscript and help during my Ph.D. Programme. I am equally thankful to* ***Dr. Gangaprasad****, Assistant Professor of Agricultural Botany, for his help during the analysis work.*

I feel very happy to record my sincere thanks to ***Sr. G.V. Sugur****, Deputy Conservator of Forest, Aranya Bhavan, Bangalore, who was the source of constant inspiration to take up this research work. My sincere thanks are also due to* ***Dr.U.V. Singh****, Silviculturist, Northern Zone, Dharwad, Karnataka and their staff for their kind help during my research work.*

I place on record my humble respects to ***Dr. A.M. Chandrashekharaiah****, Professor of Forestry and Head, Dr. S.K. Patil, Associate Professor of Forestry, Forestry College, Sirsi, for providing necessary facilities to conduct the experiment.*

I wish to express my heartful thanks to the staff of Department of Horticulture for the co-operation extended to me. I am thankful to Mr. M.B. Madalgeri and Mr. V.S. Patil, for providing skilled gardeners namely Ajjappa, Gurashiddagouda and Mahadev during propagation work.

I feel very happy to record my sincere thanks to my friends Dr. S.L. Madiwalar, Mr. S.B. Devarnavadagi, Dr. B.N. Patil, who were the source of inspiration throughout my Ph.D. Programme.

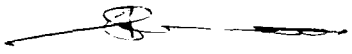
Above all, I want to express my deep appreciation to my wife ***Smt. Nagaratna****, and children, Roopa, Shilpa and Vinanthi, who patiently endured long period that were devoted to the course work, research and writing thesis. They helped and gave encouragement when it was most needed. Without their sacrifice, assistance, co-operation and kindness this work would not have been the light of the day.*

I have the pleasure to thank my beloved brothers, Basappa, Gurubasappa, who always co-operated with me and extended their full moral support throughout my career to come to this level.

I greatly acknowledge the University of Agricultural Sciences, Dharwad for the financial help in the form of merit scholarship.

It is pleasure to thank M/s. Shiva Computer Centre, Dharwad for his skillful and intelligent typing work. My thanks are also due to all those who directly and indirectly rendered their help and co-operation during the course of this investigation.

Place : Dharwad
Date : 12th February, 1996



(S.I. ***HANAMASHETTI****)*

CONTENTS

LIST OF TABLES

Contd. ..

Contd. ...

LIST OF FIGURES

LIST OF PLATES

Introduction

I. INTRODUCTION

Tamarind (*Tamarindus indica* L.) belongs to the family Leguminosae. Subfamily Caesalpinae. Although, its botanical nomenclature gives a false impression of its being native of India, it is a native of tropical Africa. It is distributed throughout the tropical countries of the world with the largest concentration in India. It has a somatic chromosome number of 2n=24 (Purseglove, 1981). The name tamarind was derived from the arabic word 'Tamar-E-Hind' meaning Date of India.

Tamarind is indigenous to tropical Africa and Southern India. However, Stephenson and Churchill (1931) opined that tamarind is native to Egypt and Arabia. Dry savannas of tropical Africa is also considered to be the native and believed to have been introduced to Asia in ancient times by the Arab traders, but the botanical and common names suggest its association with India (Anon., 1979).

Tamarind is a hardy tree which grows well under warm climatic conditions of tropics and subtropics. It is drought tolerant and found growing in sandy soil. Further it also performs well, in deep soils and tolerates poor or rocky terrain. In view of its ability to withstand heavy winds, it is preferred as a wind break.

Tamarind was introduced in the new world long ago with the first shipment of slaves from West Africa. In West Indies and Latin America the tree is much appreciated for the succulent sweet pulp, likewise in Africa and Asia. However, India is the only country to exploit tamarind extensively. Annual Production of pulp in India is over 3 lakh tonnes of which 4,000 tonnes are exported to Europe and North America and the rest is locally consumed. Nearly 20,000 tonnes of tamarind seed powder is produced annually in India. An annual production of double this quantity can easily be achieved if proper care is taken to pool all the seed material. Dry fruits are exported to various countries, viz., United States of America, Europe, Australia, Africa, Srilanka, Malaysia, Pakisthan etc.

Tamarind trees are generally raised on roadsides in back yards, on the bunds of field and in waste lands, which are either auctioned or utilized by the owners at the time of harvest. In India, tamarind has been in commercial demand. Presently, only seed propagated plantations are largely available in the country. However, in recent times, under social forestry schemes there has been an effort to raise tamarind in both private and government lands.

The tree can grow to a height of 30 m, it can be productive for more than 50 years and survives upto 200 years (Hernandez-Unzon and Lakshminarayan, 1982). Tamarind has a long juvenile period, the trees begin to bear fruits at the age of 13 to 14 years (Lewis and Neelakantan, 1964). Tamarind is a slow growing tree with an annual growth rate of about 0.5 to 0.8 metres in length. Half the pod weight is contributed by pulp. Pulp contains both sugars (30-40%) and organic acid (8-18%), predominantly tartaric acid. The pulp is also a rich source of vitamins (Savur, 1956).

All the parts of tamarind have some use. In India the fruit is used mainly for culinary purposes. While in other countries the fruit is processed into nectar, fruit punch, juice, glaceed and crystallized fruit and concentrates. The pulp is used to season many foods viz., chutneys, curries, preserves, confectioneries, ice-cream and syrups. The pulp possesses some medicinal value and is used to cure dysentery. The pulp can withstand thermal processing and maintains the original flavour profile. The pulp in descented form, can be stored well for extended periods without refrigeration due to its high acid content, which acts as a natural preservative.

The proteins of tamarind seeds are reported to be of high biological value and compare well with proteins of

cereals, but meagre in utilization (Savur, 1956). Tamarind seeds are ground to make delicious feeds for livestocks and also processed to prepare a purified gum used in preparing jellies from fruit juices and to stabilize other processed foods. The seeds also yield an amber coloured oil suitable for industrial use (Anon., 1979). The tamarind seed powder, commercially known as tamarind kernel powder (TKP) is used as a creaming agent in manufacturing of rubber and latex and as a substitute for cereal starch, which is used in cottage industry.

Tamarind is grown in India by seed origin, so high degree of variations and wide range of heterozygosity with respect to size and quality of fruits are evident. The aim of tree improvement in tamarind is to

1. Select the trees for higher growth rate and
2. Improvement in the quality of end use of tree like pulp, kernel, powder yield, etc.

Furthermore, it should be remembered that the aim of the whole programme is to provide the farmer with plant material that is well adapted to his specific planting site and that fulfills the purpose of planting which could be either for commercial plantation or to bring waste land under better utilization.

Many private companies in Tamil Nadu and Karnataka, have made small investments on orchard development, one can make an investment of Rs.1000/- and become a proud owner of a tamarind tree to be grown in a specified land and are promised a total return of more than Rs.50,000/- per hectare. However, such returns can be further enhanced by planting clonal elite materials.

The individual variation between the trees within a population is of paramount importance and it may be worthwhile concentrating only to the very best trees in relation to neighbouring ones and plus trees may be selected within ecological zones for increasing their frequencies. The magnitude of variability and its quantitative estimation for each character would indicate the potential of each tree and the scope for improving the desirable and economic characters through selection.

Multivariate analysis is a suitable statistical method, for analyzing various casuative factors, and their inter relationships operating within the tree populations, under natural and selection by man. It also helps in the identification of plus trees for specific breeding objectives. In order to improve the genetic characters of tamarind and thereby economic value of future generations, it is necessary

to use only the best trees for multiplication and for incorporating them in to the breeding population.

Tamarind is highly cross-pollinated crop, hence wide variability is common in this species. It offers more avenues for establishing desirable clones by simple seedling selection. The same was successfully adopted in mango with the wide variation prevalent as a result of cross pollination, which helped in easy selection of new types (Singh and Singh, 1958; Daljith Singh, 1963).

Plus trees or the elite trees selected for stem form, biomass, total yield, size and quality of fruits etc., are the starting point of any tree improvement activity. Selection of a large number of elite trees servesas an immediate seed source, with fairly high genetic gain. They also provide scion material for vegetative propagation which can straightway go as improved planting material (Anon., 1989).

At present tamarind is commonly propagated through seeds. The traditional methods of plant improvement, apart from being time consuming, are cumbersome. Hence vegetative propagation seems to be an ideal answer to obtain and propagate genetically superior individuals for mass production within a short period.

Tree breeding programme essentially involves systematic selection of desirable clones for mass multiplication. Even though farmers are quite experienced and knowledgeable in maintaining of selected desirable types, very little progress has been made in the improvement of trees in general and tamarind in particular, which is an economically important multipurpose tree. Farmers have identified, selected and nurtured most important desirable tamarind trees but without the benefits of scientific methods of tree improvement. Modern breeding programmes can be adopted to obtain better quality products and physical forms. A certain amount of risk is involved in any tree breeding if it is initiated without prior information of the prevalent variations.

In recent years, with the recognition of commercial demand for the crop and its industrial significance, there is good scope for the selection of promising types and to know the response of different genotypes of tamarind with respect to air layering for clonal multiplication. However, rooting is complex physiological phenomenon, which is inherant character of plant

and also influenced by the climatic conditions, such as relative humidity and temperature. Exogenous application of growth regulators and some horticultural practices like girdling and etiolation are known to promote rooting.

Keeping in view the above facts, the present investigations were carried ut with the following objectives.

1. To estimate the extent of variability for growth, yield and quality of genotypes of tamarind.

2. To assess the extent of genetic divergence prevalent and identify the relative contribution of character towards divergence.

3. To know the flowering behaviour, plant type and pod character.

4. To assess the progeny performance of tamarind.

5. To study the genotypic response to air layering.

6. To identify the superior trees to be considered for conservation and mass multiplication.

Review of Literature

II. REVIEW OF LITERATURE

Tamarind is an economically important multipurpose tree species which is grown both as domesticated species in farmland and wild in forest lands. With increasing population pressure, demand for tamarind pulp has increased considerably. This has necessitated to identify superior elite trees for monoculture plantations, without causing genetic erosion. Establishing plantations using genetically improved clones will help to maximise production per unit area and leads to indirect economic and social benefits.

Tree improvement through the application of genetic principles is basically directed towards modifying the heredity of tree populations, so that trees are able to meet the needs of the farmer. A knowledge of the breeding systems and the inheritance of yield and associated characters is necessary in a successful breeding programme. Tamarind is a highly cross pollinated crop and significant improvement is possible by selecting the plus trees and further multiplication by clonal propagation. Wide variation for most of the attributes is observed in tamarind and there is much scope for identification of divergent types. Since research work on variability, multivariate, correlation studies and vegetative propagation is

limited in tamarind, similar work done in other crops is reviewed for better understanding of the problem. The literature related to various aspects is organised under the following main heads.

2.1 Variability studies

2.2 Flowering behaviour, fruiting and pod character

2.3 Chemical composition studies

2.4 Clonal multiplication by air layering

2.5 Post separation establishment of layers.

2.1 VARIABILITY STUDIES IN TAMARIND (*Tamarindus indica* L.)

According to Paules (1975), tamarind is mostly grown as self sown trees or by sowing seeds of unknown parentage, which has resulted in wide variation among seedling progenies. It is very desirable if proper selection of mother plants is made for the collection of seeds for planting purpose.

Thimmaraju *et al.* (1978) reported that *Tamarindus indica* L. is a highly cross pollinated tree and offers scope for selection of superior clones.

Samiullah (1984) assessed the variability in tamarind across 300 genotypes and noticed wide variability for all the characters studied. The variations observed for the characters, viz., trunk length, trunk volume, pod yield, pulp yield, seed yield, etc., were significant.

2.1.1 Variability studies in other tree species

There was maximum variation in sandal (*Santalam album*) leaves within (intra) and between (inter) trees. Rao and Badami (1930) reported the foliar variations as the important taxonomic character indicators that were discrenible even at the seedling stage. Further, the variation in leaf length and area were subjected to biometrical analysis by Kulkarni and Srimathi (1982). Second degree quadratic equations were computed and based on these equations, the occurance of six biotypes in sandal was confirmed. It was suggested that results of biometric analysis of leaf morphology would be helpful for delimiting different types of sandal. The length and width of leaf were significant between the trees studied except in a few plus trees, indicating that the trees would be genetically alike (Bagchi and Veerendra, 1985). It was concluded that they were governed by genetic factors based on the variation in the magnitude of standard error from tree to tree.

Half-sib seedlings belonging to eight *Santalum album* trees located at different places were quantitatively measured for nursery characters to assess variability and superiority in seedlings by Bagchi *et al.* (1987). The results revealed significant inter tree variability in another study (Bagchi and Veerendran, 1991). The variability of growth performances was

observed after pruning two years old even-aged *Santalum album* plants. It was found that "without host" treatment expressed lower mean and variability, whereas the 'with host' conditions showed higher mean and variability.

✓ Clonal variation for growth and morphological traits was observed in *Populus deltoides* (Ying and Bagley, 1976). Jha *et al.* (1991) reported that when data on poplar clones (*Populus deltoides* and *P. xeuramericana*) both exotic and indigenous were subjected to statistical analysis at half the rotation age the variation in height was insignificant, while in diameter and survival it was significant.

✗ The variability study in *Eucalyptus camaldulensis* provenances showed significant variation for eight morphological characters of leaves (Burley *et al.* 1977). A one per cent progeny test in *E. grandis* was assessed for plant height at four different ages (Kedharnath, 1982). It was noticed that there was a large magnitude of genetic variation in mean plant height between the families. Kapur and Dogra (1987, a) showed that provenances of *E. camaldulensis* and *E. tereticornis* varied significantly for the growth parameters viz., height, diameter and volume.

✗ Manaturagimath *et al.* (1991) observed significant variation in *E. cloeziana* provenances for survival percentage,

height, diameter at breast height (dbh) volume and mean annual increment.

The genetic variances among nine provenances of *E. tereticornis* were not significant at an age of three years. Just detectable (at the ten per cent level of probability) at an age of five years and highly significant (at one per cent level of probability) at an age six years (Otegbeye, 1991).

Teak (*Tectona grandis*) differed significantly for height and diameter at breast height (dbh) in provenance traits according to Suri (1984) and Krishnamoorthy (1989).

Kedharanath (1986) conducted a survey and evaluated teak plantations in India and identified 700 plus trees.

Rajaram (1990) reported that, significant variation was found with reference to height, basal diameter, number of branches, biomass, specific gravity and leaf nutrient content in *Gliricidia sepium* provenances. It was also observed that the phenotypic variability and genotypic variability expressed as PCV (%) and GCV (%) were the highest for number of branches and twig biomass. Puri *et al.* (1989) recorded variability for height as high in *Leucaena leucocephala*.

Falkenhages (1991) noticed no provenances differences for growth traits studied, viz., stem form, crown form, height and volume in pinus *(Pinus radiata)*.

Kumaran (1991) found significant variation between 28 (one per cent) families of *Pongamia pinnata* in seed parameters and seedling traits. Study also showed, the genotypic coefficients of variation for basal diameter and volume were 21.82 and 49.74 respectively.

Singh and Choudhary (1992) obtained maximum variation for plant height followed by number of branches, base diameter, leaf breadth and leaf length among 28 families of *Prunus armeniaca*.

In *Bambusa balcooa*, Singh and Beniwal (1993) found that genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for plant height and number of new shoots were maximum at the age of four and half years and three and half years and minimum at the age of two and half years.

Srivastava *et al.* (1993) observed that eight years old *Terminalia arjuna* recorded the highest genotypic coefficient of variation for leaf yield followed by length of leaf and number of leaves per branch. On the contrary, maximum phenotypic coefficient of variation in leaf yield was followed

by breadth of leaf, number of branches per plant and number of leaves per branch. The GCV values were lower in magnitude than PCV in all the seven characters studied except for length of leaf revealing that environment greatly influenced expression of these characters.

Half-sib seedlings belonging to 24 *Terminalia arjuna* trees showed high genetic coefficient of variation for seedling height indicating additive gene action for this character (Srivastava *et al.*, 1993a).

2.2 CORRELATION STUDIES AND PATH COEFFICIENT ANALYSIS

Correlation coefficient analysis helps to determine the nature and degree of relationship between any two measurable characters. It resovles the complex relations between important characters which is of immense help in the selection of suitable clones. But a measure of correlation does not consider the dependence of one variable on the other. The direct contribution of each component to the yield and the indirect effect it has through its association with other components can not be differentiated from mere correlation studies. A statistical device called the path coefficient analysis developed by Wright (1921) fulfills this lacuna. It is a tool in genetic analysis to partition the association of the components on yield and indirect effect of the characters through other components.

The path coefficient analysis is useful to study the cause and effect relationship, diagrammatically. However, such studies in tree species are scarce.

2.2.1 Correlation and path coefficient studies in tamarind (*Tamarinds indica* L.)

Samiullah *et al.* (1993) in a study involving 300 genotypes of tamarind, identified that characters like number of primary branches (0.459) length of pod (0.448), pulp yield per tree (0.712), trunk volume (0.816), seed yield (0.848) and tartaric acid (0.848), showed strong positive and significant association with pod yield. The path coefficient analysis of yield contributing characters revealed that pulp yield per tree and seed yield per tree had appreciable direct effect.

2.2.2 Correlation and path coefficient studies in other tree species

Kedharnath *et al.* (1969) reported that in teak (*Tectona grandis*) the genetic correlation of 0.90 was observed between stem girth and number of internodes.Also high positive correlation between height and diameter was reported by Lakshmikanthan *et al.* (1974).

Khosla *et al.* (1980) opined that there was a strong correlation between height and diameter and ratio of clear bole

to total height in *Populus ciliata*. A strong negative genetic correlation of green house height with second year height was noticed by Nelson and Tauer (1987) in *P. deltoides*.

Casuarina equisetifolia recorded a significant and positive correlation between total biomass and other traits like girth at breast height, stem weight and volume in a study by Stephan Durairaj (1981) and Jambulingam (1989). Further, opined that maximum positive direct effect on wood yield was exerted by girth at breast height followed by total height, merchantable height, girth at stump level and weight of bark in that order in *Eucalyptus tereticornis* while bark thickness exerted negative indirect effect on yield.

Rathinam *et al.* (1981) observed a strong positive correlation between total height, girth at breast height and weight of green bark in *Eucalyptus tereticornis*. Further, opined that maximum positive direct effect on wood yield was exerted by girth at breast height followed by total height, merchantable height, girth at stump level and weight of bark in that order in *Eucalyptus tereticornis* while bark thickness exerted negative indirect effect on yield.

Volker *et al.* (1990) in *Eucalyptus globulus* reported a strong genetic (0.82) and phenotypic (0.66) correlation

between height and stem diameter. Volume showed very high genetic correlations with both height and diameter. The same trend was apparent in the phenotypic correlations between them.

Sukumaran *et al.* (1982) studied path coefficient analysis for 13 traits on 43 progeneis of eight high yielding West Coast Tall coconuts planted in 1953. Analysis of the data indicated that average number of female flowers at 21 to 24 years, number of functional leaves at 19 years and internodal distance at a fixed mark had the greatest direct effects on average yield at 21 to 24 years.

Ramanathan (1984) conducted correlation studies in 30 cultivars of coconut which were 23 years old and noticed significant and positive correlation of stem height (r=0.623) with nut yield.

Kovas and Burgetix (1984) indicated that chlorophyll content and dry matter content had positive correlation between initial yields of clones in a study involving ten selections of a cross between Jonathan and Egry types of apple.

Lebeder and Chucha (1984) noticed that leaf area per rosette in apple was an important character associated positively with yield and yield pattern of fruit bearing. The correlations found were of considerable use in selecting promising parents for yield.

Magdalita *et al.* (1984) studied character associations in 100 accessions of papaya and study revealed that fruit weight was positively and significantly correlated with fruit length, width, flesh thickness and cavity volume.

✓ Kumaran (1991) suggested height as the reliable character for selection in neem (*Azadirachta indica*) as it exhibited maximum correlation, both phenotypic and genotypic, for sturdiness quotient. Further opined that, in neem (*Azadirachta indica*) shoot length recorded the maximum positive direct effect followed by volume index, number of branches, and root length.

✓ Kumaran (1991) reported that height exhibited maximum positive genotypic and phenotypic correlation with sturdiness quotient in *Pongamia pinnata*. The study revealed that height could be the reliable character for selection.

✓ The correlation studies in *Dalbergia sissoo* (Dhillon *et al.*, 1992) revealed that diameter (dbh) showed positive and highly significant association with height of crown as well as total height. Further opined that, out of the component characters studied, total tree height and age had the maximum direct effect on diameter. However, height of crown had maximum negative direct effect and indirect effect by self pruning ability. It also had a strong positive indirect effect via total height and clear bole height.

2.2.3 Heritability studies in Tree Species

The concept of heritability is important and useful in quantitative genetics. It is the proportion of total variability which is due to heredity, the remainder being due to environmental causes. The broad sense heritability is the ratio of total genetic variation to phenotypic variation (Zobel and Talbert, 1986). They have also reported that generally in tree Crops volume and diameter growth expressed low (0.00-0.40), height and straightness moderate (0.41 - 0.60) and wood specific gravity, wood fibre, bark thickness etc. high (0.61-0.80) heritability (broad sense).

Kedharnath (1982) reported that heritability estimates for height of one parent progeny of *E. grandis* during ages one and half to three and half years varied from 0.19 to 0.21. While at age four and half year it was 0.34. The leaf length; leaf breadth ratio registered the maximum heritability percentage (44.85) followed by number of branches (42.69) and leaf breadth (31.80) in *E. tereticornis* as reported by Surendran (1982). Individual heritabilities of growth traits ranged from h^2=0.12 for height to h^2=0.24 for diameter in *Eucalyptus globulus* as reported by Volker *et al.* (1990). The heritability of volume was on par with diameter (h^2=0.19).

The heritability (broad sense) was found to be the highest for height (0.93) followed by number of branches (0.82), basal diameter (0.76) and wood biomass (0.49) in *Gliricidia sepium* as reported by Rajaram (1990).

Kumaran (1991) obtained maximum heritability (0.98) for height in the seedlings of *Pongamia pinnata*.

Singh and Beniwal (1993) estimated the heritability in bamboo (*Bambusa balcooa*). The heritability estimates during different age groups varied between 0.78 to 0.96, 0.82 to 0.99 and 0.40 to 0.89 respectively for height, girth and number of new shoots in *Bambusa balcooa*.

In eight year old plantations of *Terminalia arjuna* Srivastava *et al.* (1993a) found heritability in broad sense to be the highest for leaf yield (0.78) while height of plant exhibited heritability value of 0.51. On the contrary, breadth of leaves showed low heritability (0.21) and length of leaves recorded negative heritability (0.16).

2.3 MULTIVARIATE ANALYSIS

Genetic divergence study using Mahalanobis (1928) D^2 analysis, has been recognised as a powerful statistical tool to assess genetically divergent genotypes. Though much work has been reported on agriculture crops, very little work has been done on tree crops.

The exact distribution and movement of D^2 statistic was given by Bose (1936). Rao (1948) pointed out that D^2 statistic needed some mathematical and logical requirements such as

1. Distance between the two groups was not less than zero.

2. Sum of distances of a group from two other groups is not less than the distance between the two groups similar to that of differential geometry.

3. The distance should not decrease when additional characters were included and

4. The increase in the distance, by the addition of some characters to suitably chosen set was relatively small.

The multivariate studies help in isolating the genotypes that are distinctly related and bringing together the closely related genotypes. Earlier studies have shown genetic diversity in space and time (Thoday, 1953, Dacuncha and Dobzhansky, 1954),

Rao (1960) opined that D^2 concept lies at the heart of the morphometrics which has lead to many useful inferences and thus become an indispensable tool.

Multivariate analysis is useful in presenting more convincing evidence of the phenotypic relationships with the plant population under natural and artificial selection. It is also said to have a capacity of detecting unsuspected relationships between the populations (Sneath and Sokal, 1973). It has been successfully used to classify the biological populations and to identify the factors influencing their genetic divergence. (Anderson, 1958, Murthy *et al.*, 1965, Narayan and Macefield, 1976).

The choice of diverse parents with good general combining ability for components of yield has helped in substantial genetic advance in self as well as cross pollinated crops such as green gram, wheat, rice, barley, maize, tobacco, alfalfa, linseed and pearl millet (Gupta and Singh 1970, Griffing, 1956, Bhatt, 1970, Ram and Panwar, 1970, Whitemore *et al.*, 1958, Matzringer and Wensman, 1967, Carnaham and Caralson, 1963, Anand and Murthy 1968, Upadhya and Murthy, 1971). According to Beardmore and Shami (1976), the geographical diversity is positively associated with genetic diversity. However, such a correlation has not been observed in certain studies conducted by Arunachalam and Jawahar Ram (1967), Gupta and Singh (1970) and Bhatt (1973).

2.3.1 Multivariate analysis in other Tree Species

Khosla *et al.* (1979) reported a multivariate analysis in *Populus Ciliata* showing no difference between the male and female trees with respect to height, diameter and specific gravity.

Surendran and Chandrasekaran (1988) found highly divergent clusters in *Eucalyptus tereticornis*. The study revealed that the variability exhibited by the single tree at 24 months growth phase was primarily due to number of branches, number of leaves and plant height, and secondly due to internodal length, leaf length, breadth ratio and leaf length.

Rajaram (1990) studied the genetic divergence among 15 provenances of *Gliricidia sepium* resolved into two clusters at 24 months growth period of the eight characters studied height (58.09%), followed by number of branches (20.95%), contributed maximum to the divergence. The inter and intra cluster distance revealed that Cluster-II possessed higher values than Cluster-I.

Kumaran (1991) could find two clusters among 28, one parent families in neem (*Azadirachta indica*). Among the characters studied root length followed by height contributed maximum to the divergence. The intra cluster distance of Cluster-I was 27.46 and that of Cluster-II was 33.48.Cluster-II

recorded the maximum inter cluster distance of 112.1 followed by 753.88 of Cluster-I. In another study Kumaran (1991) opined that all the 28 one parent families were grouped into three clusters after D^2 analysis in *Pongamia pinnata*. The study revealed that height (36.24%) contributed maximum to the divergence followed by number of leaves (22.22%) and leaf length (20.11%). The intra and inter cluster distance values were maximum for Cluster-III.

Bagchi (1992) made a preliminary study on the genetic divergence of *Acacia nilotica*. It revealed that all the 42 provenances could be grouped into two clusters based on D2 values. This study also signified that all seed sources from a single cluster and the pattern of genetic nearness was not dependent on the geographical nearness.

Singh and Chaudhary (1992) made the multivariate analysis of genetic diversity among 28 single tree selections (plus trees) of *Prunus armeniaca* L. through their progenies for five developmental characters viz. plant height, basal diameter, number of branches, leaf length and leaf breadth at 12 months growth phase. The results revealed that they could be grouped into three clusters. Inter cluster distance (D value) ranged from 5.95 to 6.48. While intra cluster distance was found to be maximum (3.09) in Cluster-I. Plant height and

number of branches contributed considerably, accounting for 65 per cent of total divergence. The study also revealed that Cluster-II and Cluster-III were highly divergent and were likely to produce new genotypes with desired traits.

Gangaprasad (1993) reported that tamarind pod yield per tree is the most important character contributing for divergence across all the provenances followed by trunk length, pulp yield per tree and seed yield per tree.

2.4 CANONICAL VARIATE ANALYSIS, MAHALANOBIS D^2, STATISTIC, AND CLUSTERING ANALYSIS

For the purpose of discriminating any two populations having unknown origin, anthropologists were using Carl Pearson's Racial likeliness identity (C^2) (Trisdesley, 1921). But Mahalanobis (1936) opined that Pearson's C^2 was a test of divergence between two samples than a measure of actual magnitude of divergence between the two groups under comparison.

Mahalanobis generalised "distance (D^2 technique) considers the variations produced by any character and the co-joint effect that it bears on the other characters." The technique was first used by Mahalanobis *et al.* (1949) in an anthropometric survey of the united province of India.

Verma *et al.* (1973) studied the nature of genetic divergence and its relation to adaptability in seventy eight varieties of soybean from different countries. The D^2 analysis showed that these varieties formed eleven clusters which were heterogenous with respect to place of origin of the varieties. They observed a regular clustering pattern with respect to the early and late varieties. The Canonical analysis applied for the same data showed that days to flowering followed by 100 grain weight, days to maturity and plant height contributed more towards discriminating the groups. The congregates formed on canonical graphs supported the clusters formed through D^2 analysis.

Ganeshaiah (1979) studied the magnitude of genetic diversity and pattern of association among yield and other characters in a collection of 100 entries of horsegram and grouped them into 23 clusters. He also observed perfect agreement between canonical variate and D^2 analysis. The characters that contributed for the divergence are mainly associated with plant maturity. No perfect association was evident between geographic and genetic diversity.

Maluf *et al* (1984) assessed the tolerance for aluminium in leucaena and based on hierarchial cluster analysis, distinguished the population into 13 tolerant and 16 sensitive groups.

Melendreas and Ortuno (1984) analysed the data of several varieties of lemon on various root stocks and were able to group them into different clusters based on Dendrogram, soley depending on fruit characters and arranged them in hierarchial order of similarity.

Nema and Sharma (1986) studied the taxonomic relationships of 42 cultivars using data on 92 physical characters in grape. They were able to classify the cultivars into several groups based on weighed pair group and similarity and distance coefficient method.

Butenko *et al.* (1987) applied principal component analysis based on 18 quantitative characters in 20 cherry genotypes. Six principal components accounted for 86.2 per cent of the observed variation while the first principal component alone accounted for 35.9 per cent.

Hilling and Fezzoni (1987) analysed divergence in 16 cultivars of Sour Cherry using principal component analysis. They also revealed that genetically related cultivars tended to cluster, suggesting that there was a significant genetic component to the underlying pattern of morphological variation and has also contributed to the patterns. Selective forces may also have contributed to the patterns of morphological variation.

Singh *et al.* (1987) measured the genetic distance of twenty Indian cultivars of sugarcane using Mahalanobis D^2 statistics. The cultivars were grouped into nine clusters. There was no apparent link between geographic distribution and genetic diversity.

Illoh and olorode (1990) subjected 31 varieties of mango collected from all the ecological zones to single linkage cluster analysis. The varieties were grouped into four clusters mainly on the basis of reproductive characters.

Samiullah (1993) employed principal component analysis to study the genetic diversity for twenty yield and yield attributing characters across 300 genotypes of tamarind. The first 12 principal components accounted for 96.63 per cent of variation, while the first two principal components explained 42.37 per cent of variation. Pod yield per tree, trunk length and number of primary branches were the most important characters that contributed towards divergence. Clustering was done based on the principal component scores and all 300 genotypes studied were grouped into 16 clusters.

Gangaprasad (1993) studied the genetic divergence in tamarind clusters formed on the canonical graphs were well discriminated indicating the prevalence of appreciable amount of genetic divergence. Genotypes 4 and 10 from Shimoga, 18

and 10 from Chitradurga-I, 4 and 8 from Chitradurga-II, 14 and 34 from Bangalore, 8 and 33 from Tumkur, 13 and 9 from Mandya, 8 and 28 from Kolar-I, and 42 and 25 from Kolar-II were identified as the most divergent based on canonical variate analysis.

2.5.1 Flowering character

Burns and Prayag (1920) opined that the floral character were important only in the classification of the species at higher level and not at cultivar level.

However, Grubb (1955) reported that blossom characters were used to identify cherry varieties.

Tamarind flowers are in recemes at the end of branches, are inconspicuous and about half inch long appearing in April-June (Rao 1959, Randhawa, 1965).

Cowen (1970) noted that the petals of tamarind flowers are creamy or yellow in colour but covered by a fine network of deep red veins and these make pretty variation in colour. Thimmaraju *et al.* (1978) reported that tamarind trees flower from April to July and more profuse flowering was observed during May-June.

Shivanandam (1980) considered the floral characters in the classification of tamarind varieties. He studied the floral characters such as length of inflorescence and number of flowers per inflorescence and both the characters gave significant differences among the types of tamarind. The maximum length of inflorescence was observed in trees with fruits of curved and bulged type (5.58 cm). Maximum number of flowers per inflorescence was found in trees with fruits of curved and bulged type (15.46).

2.5.2 Flowering behaviour in other related crops

The relation of shoot growth to fruit bud formation has been extensively investigated in apple. The general conclusion has been that the time of shoot and spur growth cessation is, to some extent related with the fruit-bud formation (Roberts 1920, 1925). McCartney (1925) observed that the trees of regular bearing habit in apple presented a marked and positive correlation between the length and diameter of spurs and blossom bud formation. However, in biennial bearing trees, this correlation did not hold good, as the heavy crop prevented the blossom bud formation, irrespective of the length of shoot growth. In apple, the biennial bearing varieties produce flowers on spurs and the annual bearing varieties produce flowers mostly on the shoots.

In apple, spurs behave as independent units whereas, no such individuality exists in mango shoots. Thus, the growth pattern in these two types of fruits is different and biennality in bearing is more a problem in mango than in apple.

Galang and Lazo (1935) stated that the mango shoots must have certain length, diameter and number of leaves for producing flowers. On the contrary, Singh (1959) reported that the results on shoot size shown that there is no effect of shoot size on fruit bud differentiation. Flower buds have been seen to arise from tiny shoots measuring from 0.9 cm to 3.4 cm, having one or two leaves in the biennial as well as in the regular bearing varieties. He also opined that the age of the shoot does not govern fruit bud differentiation in mango. According to him, this may be due to the fact that the major role in the formation of fruit-buds is played by some other factor or factors and not by the maturity or age of the shoots.

2.5.3 Fruit shape of tamarind and other crops

David (1907) reported that tamarind fruit is a large flat pod measuring four to six inches in length, filled with acid pulp, seeds and fibrous matter. Fruit contains 55 per cent of pulp. 11.1 per cent of shell and fiber. Pulp content and fiber content in tamarind fruit is 55 and 12 per cent respectively. (Winton and Winton 1935, Lewis *et al.*, 1954).

Shivanandam (1980) recognised four types of tamarind based on fruit shape, viz fruit straight and bulged, fruits straight and flattened, fruits curved and bulged, and fruits curved and flattened. Straight and bulged type fruits have shown more length (16.35 cm) compared to other types of fruits. Most of the samples studied recorded pulp with light red colour.

Hernadez-Unzon and Lakshminarayana (1982) described the ripe fruit of tamarind as indehiscent fruit with curved pod of 12 to 15 cm length, weighing 10 to 20 g. It has a scurfy brown, Woody, fragile Peel (shell).

Kokate (1988) reported that through survey, MPAU, Rahuri has located six promising tamarind types, having large fruit size, 22.5 cm long, weighing 35 to 42 g with extra white endocarp membrance colour. The tamarind type 'Pratistan' developed at Fruit Research Station' Aurangabad, which is promising and regular bearer.

Cultivars were classified on shape, colour and quality of fruit in oranges (Corbos and Moscosa, 1958), mango (Singh, 1963), Jack (Guruprasad,1981), Pumello (Narayanamurthy, 1982).

2.5.4 Yield

The tamarind is a moderate size tree and can grow upto 24M in height and 7 M in girth. A full grown tree yields 180 kg to 225 kg of fruits per season. (Rao 1959, Lewis and Neelakantan 1964, Anon, 1976).

Hernandez and Lakshminarayan (1982a) reported that tamarind tree can grow to a height of 30 m and can be productive for more than 50 years. A well managed tree bears 100 to 250 kg of tamarind fruit and the yield depend on soil type (Kokate, 1988). Plus trees selected by Forest Department Govt. of Karnataka revealed that fruit yield in tamarind varies from 200 kg to 800 kg per tree per season. (Anon. 1989).

2.5.5 Seed character

Tamarind seeds are universally consumed by the poor people during the time of scarcity and famine, and are occasionally consumed by others during normal days. Seeds also have industrial importance.

Devid (1907) stated that the seeds are flattened and of irregular out line, being round, ovate or obtusely four sided and one hundered seed weight 75.8 grams.

Bailey (1947) recognised two types of tamarind viz., those with long pods containing seeds ranging from 6 to 12 named East Indian varieties and those with short pods containing seeds varing from 1 to 4 named West Indian varieties.

Cowen (1970) observed that in a tamarind fruit, number of seeds ranged from 1 and to 10 in a fibrous pulp and the pod is more or less constricted between these seeds. It has been reported that in tamarind fruit, the number of seeds varied from 3 to 12.

Haernandez-unzon and Lakshminarayana, (1982) stated that the seed number per pod seems to be the varietal character in tamarind. Sunderarajan and Madhava Rao (1967) opined that the seed number per fruit was varietal feature in Sapota.

2.5.6 Acid content of fruit

The fruit of tamarind is the most acidic of all the natural foods. The content of the chief acid present is tartaric. It is as high as 14-18 per cent (Lewis *et al.*, 1954; Lewis and Johar, 1956; Lewis *et al.*, 1957; Rao, 1959).

Haernandez-unzon and Lakshminarayan (1982a) reported that the ripe fruits were having tartaric acid content of 14.0 per cent and ascorbic acid content of 12 to 15 per cent.

However, Shivanandam (1980) reported that the highest per cent of tartaric acid was recorded in tamarind fruits which are curved and bulged type (3.16%) followed by straight and bulged type (2.99%).

Challapilli (1992) opined that the range of variation in tartaric acid varies from 8.94 to 14.98 per cent.

2.6 CLONAL MULTIPLICATION BY AIR LAYERING

Layering is one of the oldest techniques used to propagate many woody plants. It is a reliable and easy means of Propagation. When difficult to root plants are to be propogated vegetatively, use of chemical growth promoting substances help to get better and early rooting in layers.

Pre girdling of plants is known to increase the root initiation in layering. In this process the downward movement of Carbohydrates and other rooting co-factors are blocked and the consequent physiological and biochemical changes result in betters rooting.

Hegde (1987) opined that air layering done in cashew during monsoon season under Dharwad condition proved to be superior to summer season in respect of percentage of rooting.

The results of the work carried out on root induction in various tree crops briefly reviewed under the following headings.

2.6.1 Genotypic response to air layering in other crops

Katagihallimath (1986) opined that *Mussaenda erythrophylla* Var 'Rosea' can be propagated most successfully by air layering with pre girdling the shoots thirty days before air layering and treating with IBA, 3000 ppm, under Dharwad conditions. Further he states that Mussaenda var white is difficult to root, whereas var. pink is easy to root.

Aravindakshan *et al.* (1986) reported that in cashew variety NLR-2-1 the layers-obtained by treating with IAA at 250 ppm and 1000 ppm were superior compared to the other treatments including control. But in case of variety BLA-139-1 IBA at 250 and 500 ppm, IAA at 100 and 200 ppm were found to be superior.

Rameshnaik (1988) studied the propagation of 40 bougainvillea cultivars by cutting under Dharwad conditions. Among the 40 cultivars selected for screening in the first phase, based on their rooting ability, 17 cultivars were found 'easy to root', ten cultivars were 'moderate to root', and 13 cultivars were difficult to root.

Hegde (1988) reported that among the 15 shrubs selected for screening on the rooting percentage of cuttings, nine shrubs viz. *Lantana camara* var.

Depressa and Nivea, *Acalypha hispida Euphorbia pulcherrima, Justicia carnea Tecoma stans, Nerium Olender* var. rosea, *Pentas lanceolata* var. cornea, and *Ixora Singapurensis* were found to be easy to root. The other six shrubs namely *Calliandra* brevipes, *Artabotyrs odoratissima, Thevetia nerefolia, Gardenia florida, Hamelia petans, and Holmskoldia eanguinea* were found to be difficult to root

2.6.2 Post separation establishment of layers

Layerage as a method of propagation can hold importance, only if the establishment of rooted shoots is substantial. Attempts were made to improve rooting of shoots and also better establishment after separation.

Bid and Mukherjee (1969) reported that 100 per cent rooting and establishment of layers of 'Langra' variety of mango as a result of treatment of etiolated shoots with 1000 ppm of IBA and NAA in equal parts. In 'Chawsa' variety 98.6 per cent rooting with 90 per cent survival was obtained with etiolated shoots treated with IBA plus NAA (1:1) at 500 ppm. Bhujbal (1972) found that IBA at 3000 ppm produced 86.6 per cent rooting and 76.6 per cent survival of air layers of guava.

III. MATERIAL AND METHODS

Studies were conducted at the Forest Research Centre, Gungargatti, which is 5 km away from the Main Campus of University of Agricultural Sciences, Dharwad towards north. Investigationswere made during 1992-1995.

3.1 EXPERIMENTAL SITE

Gungargatti Forest Research Centre comes under transitional zone of Karnataka State at 15° -26′ North latitude, 76° -07′ East longitude at an elevation of 667 metres from the mean sea level. The average annual rainfall of the area is about 800 mm and is evenly distributed from April to November. The maximum temperature seldom goes beyond 37° C in the month of April and the minimum below 12° C during the month of December (1992). The relative humidity fluctuates between 65 and 87 per cent. The experimental site consisted red soil of the sandy clay type.

3.1.1 EXPERIMENTAL MATERIAL

Recognising the importance of plus trees, efforts were made in northern zone of Karnataka, to identify plus trees. In the last six years a total of 72 trees of tamarind were identified and documented. This task involved lot of

PLATE.1 GENERAL VIEW OF THE EXPERIMENTAL PLOT

preliminary listing. Verification, deleting inferior ones, collecting lot of details on each tree (Anon., 1989). The details of plus trees of tamarind is given in Appendix-I.

Forty plus trees of tamarind selected by the Forest Department Dharwad from Dharwad, Belgaum, Bijapur, Shimoga and Uttar Kannada districts in Karnataka have formed the experimental material for the study. Ramets (grafts) of all the plus trees were planted at Gungargatti. The meteorological data of the experimental location is given in Appendix-II.

Gene bank of tamarind (*Tamarindus indica* L.) was established by planting ramets of various plus trees, marked by the Silviculturist, Northern Zone, Government of Karnataka, Forest Research Centre, Dharwad on June 1989 at Gungargatti. Trees from gene bank were utilised for the present investigation.

3.1.2 Evaluation of genotypes of tamarind (*Tamarindus indica* L.) in respect of growth and yield

The data were collected on 40 tamarind genotypes during the fruiting season of 1991-92, 1992-93 and 1994-95. In each genotype five ramets (grafts) were selected for the study. In all 200 ramets were included in the study.

The spacing given was 6m x 6m. During the investigation period weeding, protective watering and other cultural operations were done regularly. The list of plus trees and their location is given in Table-1.

3.1.3 Recording of observation

The following morphological traits and number of fruits were recorded in five plants in each of the genotype (clone).

1. Plant height

The height of each ramet was measured from the ground level to the tip of the leading shoot and expressed in metres.

2. Basal diameter

The diameter at the collar region was measured using wooden calipers and expressed in centimetres.

3. Spread of the plant

The spread of the plant was recorded with the help of measuring tape, in the east to west as well as north to south direction, and expressed in metres.

Table 1 : List of plus trees and their location

Sl.No.	Designation	Location
1.	NTI- 1	Bommasagar beat, Badami range, Bagalkot Division
2.	NTI- 2	Chinchwad beat, Golihalli range, Belgaum Division
3.	NTI- 5	Vasan beat, Indi range, Bagalkot Division
4.	NTI- 6	Chinchwad beat, Golihalli range, Belgaum Division
5.	NTI- 7	Gudolli beat, Golihalli range, Belgaum Division
6.	NTI-14	Chinchwad beat, Golihalli range, Belgaum Division
7.	NTI-15	Chinchwad beat, Golihalli range, Belgaum Division
8.	NTI-16	Chinchwad beat, Golihalli range, Belgaum Division
9.	NTI-17	Chinchwad beat, Golihalli range, Belgaum Division
10.	NTI-19	Yellapur Road, S.No.416, Dundashi range, Dharwad Division
11.	NTI-21	Bommasagar beat, Badami range, Bagalkot Division
12.	NTI-31	Arsingeri beat, Mundgod range, Yellapur Division
13.	NTI-32	Arsingeri beat, Mundgod range, Yellapur Division
14.	NTI-54	Hosalli beat, Ayanur range, Shimoga Division
15.	NTI-55	Dummwad beat, Kalghatagi range, Dharwad Division
16.	NTI-56	Chinchwad beat, Golihalli range, Belgaum Division
17.	NTI-57	Chinchwad beat, Golihalli range, Belgaum Division
18.	NTI-58	Chinchwad beat, Golihalli range, Belgaum Division
19.	NTI-59	Chinchwad beat, Golihalli range, Belgaum Division
20.	NTI-60	Chinchwad beat, Golihalli range, Belgaum Division
21.	NTI-61	Chinchwad beat, Golihalli range, Belgaum Division
22.	NTI-62	Gudolli beat, Golihalli range, Belgaum Division
23.	NTI-70	Parasapur beat, Dundsi range, Dharwad Division
24.	NTI-71	Parasapur beat, Dundsi range, Dharwad Division
25.	NTI-73	Not mentioned
26.	NTI-74	Not mentioned
27.	NTI-75	Not mentioned
28.	NTI-76	Not mentioned
29.	NTI-77	Not mentioned
30.	NTI-78	Not mentioned
31.	NTI-79	Not mentioned
32.	NTI-80	Not mentioned
33.	NTI-82	Not mentioned
34.	NTI-83	Not mentioned
35.	NTI-84	Not mentioned
36.	NTI-85	Not mentioned
37.	S-3	Shimoga Division
38.	S-4	Shimoga Division
39.	S-7	Shimoga Division
40.	S-13	Shimoga Division

NTI - Northern Zone *Tamarindus* indica. S - Shimoga.

4. Crown size

Crown size was calculated by adding spread of the plant from east to west and north to south direction and average was worked out and expressed in metre.

5. Number of shoots per 30 x 30 cm area

In each ramet, number of shoots per 900 cm^2 canopy area was counted and recorded to assess the compactness of tree canopy.

6. Flowering

Time of flowering and extent of flowering were studied in different genotypes.

7. Yield of tamarind

From each ramet the matured fruits were harvested, during 1993, 1994 and 1995 season in the month of April. The number of pods harvested per plant and yield per plant in kilogram were recorded.

3.1.4 Statistical analysis

The data collected on various parameters were subjected to statistical analysis as suggested by Panse and Sukhatme (1978) and Singh and Chaudhary (1985). The significance test was carried out by referring to the standard 'F' table of Snedecor (1961).

3.1.5 Correlation coefficient

The phenotypic correlations for all the combinations of characters were computed according to the methods suggested by Robinson *et al.* (1957) by adopting Regre-1 in programme by using VAX-VMS, $V_{4.5}$ Micro-system, Computer Centre, University of Agricultural Sciences, GKVK, Bangalore. The phenotypic correlation was calculated by the formula

$$r_p\,(x,y) = \frac{Cov.P(x.y)}{[\sigma^2(x)\ \sigma^2(y)]}$$

Where,

Cov.P(xy) = Phenotypic covariance of x and y

$\sigma^2(x)$ = Phenotypic variance of x

$\sigma^2(y)$ = Phenotypic variance of y

The phenotypic correlation calculated.

3.1.6 Canonical variate analysis

This variate was made to represent the number of correlated variables by lesser number of canonical variates, which were obtained as linear variables. The principal components were found out by adopting MVS programme by using personal computer, as suggested by Sneath and Sokal (1973).

The principal components 1, 2,.... k are obtained by solving the equation

$$(R-\lambda I)V = 0$$

Where,

R = The correlation coefficient vector

λ = Eigen root of matrix R

I = Identity matrix

V = Eigen vectors

The solution of the above equation gives us the eigen values (characteristic roots or canonical roots), a set of r non-zero positive scalar quantities. 1, 2 ..... k, where 'r' is less than or equal to 'n'. There will be equal number of associated orthogonal vectors. V_1, V_2, ...V_r called eigen vectors. The importance of these vectors is that they are orthogonal and they describe the relation between genotypes with economy. In other words by k characters over the n genotypes may be accounted for by k is less than r dimensions. That means a frame work of low dimensionality would account for a large proportion of the variation of the original data. When the vectors are normalised (that is $\sum_{xi}^{k} V^2 = 1$, which obtained by transforming the original values V into $V/\sum_{xi}^{k} V^2$), they can be assembled as principal component matrices of n x k dimensions, which is designated as V. It can be shown that $V^1RV = A$ (where A is the diagonal matrix of eigen values).

The r is normalised vector of V given the direction of a set of r orthogonal axes in A space are known as principal axes. The ordinates of these axes are linear combinations and summarise the major dimensions of variations. The ordinate points in the new A space are computed by the equation.

$$P = V^1x$$

Where,

P = r x n matrix of the co-ordinates of n individuals of r principal axes.

Thus, the principal axis corresponding to the largest unit eigen value is the dimension that accounts for the greatest amount of variances from the sample and so forth. It is customary to extract only enought eigen vectors to remove the majority (75%) of the total variance of the data matrix.

By using the first two principal axes of differentiation, the genotypes are distributed on two dimension graph. Two values were computed for each genotypes corresponding to 1 and 2, respectively, using their corresponding vectors. The clusters are formed based on the proximity of the points on the graph.

3.1.7 Mahalanobis D^2 analysis and dissimilarity coefficient

In the present study, Mahalanobis D^2 analysis was used to estimate dissimilarity coefficients and cluster the

genotypes by using Dendrogram. The dissimilarity coefficients were estimated by using VD^2 values as suggested by Sneath and Sokal (1973) by adopting MVS programme on a personal computer.

Dissimilarity coefficient between the genotypes can be arranged into a reasonable hierarchial system and the diagrams called Dendrograms representing the genotypes that connect the most similar entries were constructed.

By the above procedure, we obtain objectively delimited groups of which some are of higher rank than others. A horizontal line drawn across a Dendrogram at a given level of dissimilarity indicates the groups of given rank. The horizontal line must be drawn straight and parallel to the abscissa, so that a given rank is equivalent to any where within any one study. Using this technique, by drawing a horizontal line at a desired level of dissimilarity, we can obtain various genotypes grouped into clusters.

3.2 STUDY OF POD CHARACTERISTICS AND ITS COMPONENTS

The observations for nine quantitative characters were recorded on all those genotypes selected for the study, which flowered and fruited. A total of 10 pods were collected and average was computed for the pod characters studied. The characters studied and techniques adopted to

record the observations are given below. The per cent of pulp, seed, shell and vein are workedout.

1. Pod length

The length of the pod was measured from the tip of the pod to the point of attachment of the pod to the stalk and expressed in centimetre.

2. Pod width

The width was measured with the help of slide calipers and expressed in centimetre.

3. Pod thickness

The thickness was measured with the help of slide calipers and expressed in centimetre.

4. Pod weight

The weight of the pods was recorded by weighing in electrical balance and average value was calculated and expressed in grams.

5. Number of seeds per pod

The seeds seperated from the pods and were recorded as number of seeds per pod.

6. Seed weight per pod

The seeds separated from the pods were weighed, and the average value was recorded as the seed weight per pod.

7. Pulp weight per pod

The pulp separated from the pods was weighed and the average value was recorded as pulp weight per pod.

8. Shell weight per pod

The shell separated from the pods was weighed and the average value was recorded as shell weight per pod.

9. Vein weight per pod

The vein separated from the pods was weighed and the average value was recorded as vein weight per pod.

10. Per cent of pulp, seed, shell, vein and 100 seed weight

The pulp, seed, shell and vein from the pods were obtained by the known quantity of pod and was expressed in percentage. Hundred seeds of each genotype were weighed and weight was recorded in grams. The data were of two seasons only viz., 1994 and 1995.

11. Plant type and pod shape

Plant type viz., orthotropic and plageotropic nature was recorded and pod shape was studied in different genotypes.

3.3 PER CENT OF TARTARIC ACID

The mature pods were harvested during 1994 and 1995 season and subjected for estimation of tartaric acid content in different genotypes of tamarind.

3.3.1 Sample preparation and determination of tartaric acid

Tartaric acid was determined as per the procedure suggested by A.O.A.C.(1975) by using the formula mentioned below.

$$\% \text{ organic acid} = \frac{T \times E \times N}{1000 \times W} \times 100$$

Where,

T = Titre value

E = Equivalent weight of the acid (g) based on which the organic acid is expressed

N = Normality of NaOH

W = Weight equivalent (g) of the sample in the aliquot used for the titration.

3.4 VARIABILITY STUDIES IN HALF-SIB FAMILIES OF TAMARIND (*Tamarindus indica* L.)

Tamarind seeds were collected from the different genotypes during 1994 season (April, 1994), in order to estimate phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV), heritability (h^2) with respect to germination, height, number of leaves among the progenies.

3.4.1 Experimental details

Tamarind seeds from 20 genotypes, were taken for the study. Sowing was done in sand bed on 30.8.1994. In each case ten seeds were sown and they were replicated three times. Later the seedlings were transplanted to polythene bags. The polythene bags were filled with potting mixture of soil : sand : FYM in 2:1:1 proportion. The poly bags were kept in glass house at Forestry College, Sirsi. Regular watering to seedlings, weeding operation were attended during the course of investigation.

3.4.2 Observations recorded

1. Seed weight

Hundred seeds collected from each genotype were weighed by using electric balance and weight was expressed in grams.

2. Germination

The germination started 5 days after sowing and completed within 15 days. The per cent of germination was worked out.

3. Height of seedling

Height of the seedling was recorded from the base of the plant to tip of the shoot by measuring scale and expressed in centimetre at the age of one month and six month.

4. Number of leaves

The number of leaves per plant was recorded and average was calculated at the age of one and six month.

5. Diameter of tamarind seedlings

The diameter at the collar region of tamarind seedling was recorded by using vernieer calipers at the age of six monthsand expressed in centimetre.

6. Leaf length

Leaf length was measured by measuring scale at the age of six months and expressed in centimetre.

7. Leaflet length

In each progeny leaflet length was measured at the age of six months and average was worked out.

Details of progenies

Treatment (Genotype)	Tree number
T_1	NTI-6
T_2	NTI-15
T_3	NTI-19
T_4	NTI-57
T_5	NTI-60
T_6	NTI-61
T_7	NTI-62
T_8	NTI-70
T_9	NTI-71
T_{10}	NTI-73
T_{11}	NTI-74
T_{12}	NTI-75
T_{13}	NTI-77
T_{14}	NTI-78
T_{15}	NTI-79
T_{16}	NTI-82
T_{17}	NTI-83
T_{18}	NTI-84
T_{19}	NTI-85
T_{20}	Shimoga-4

3.4.3.1 Components of variance

The variance due to genotype and phenotype, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and heritability in broad sense (h^2), genetic advance (GA) and genetic advance as percentage of mean were worked out as suggested by Singh and Chaudhary (1985).

1. Environmental variance (VE)

VE = Error mean sum of square

2. Genotypic variance (VG)

$$VG = \frac{M_2 - M_3}{r}$$

Where,

M_2 = Treatment mean sum of square

M_3 = Error mean sum of square

r = Replications.

3. Phenotypic variance (VP)

$$VP = VG + VE$$

4. Heritability (b.s) = h^2 (b.s)

$$h^2 = \frac{VG}{VP}$$

5. **Phenotypic coefficient of variance (PCV)**

$$PCV = \frac{VP}{\bar{X}} \times 100$$

Where,

VP = Phenotypic variance

$\bar{X}$ = Grand mean

6. **Genotypic coefficient of variance (GCV)**

$$GCV = \frac{VG}{\bar{X}} \times 100$$

Where,

VG = Genotypic variance

$\bar{X}$ = Grand mean

7. **Genetic advance (GA)**

$$GA = \frac{\text{Genotypic variance}}{(\text{Phenotypic variance})^{1/2}} \times k$$

Where,

k = 2.06, a selection differential at 5 per cent selection intensity

8. **Genetic advance as percentage of mean**

$$\text{GA (as percentage of mean)} = \frac{GA}{\text{Grand mean}} \times 100$$

3. GENOTYPIC RESPONSE TO AIR LAYERING IN TAMARIND

All the genotypes which were evaluated for yield and quality were included in the study. Layers were prepared from these five year old plants. In each plant five layers were prepared after selecting the shoots of uniform maturity. These shoots ranged from 0.80 to 1.20 cm in thickness at the point where the ring of bark was to be removed. Shoots were 40 to 45 cm long. It consisted 5 replications. Twenty days before layering, girdling was done on each shoots. About 1.5 cm bark was removed (20.5.1994). Then the layering was done on 11.6.1994. Indole butyric acid (IBA) at 500 ppm was used, as an aid for early and enhanced rooting. The growth regulator on powder form was smeared for the girlded porition of the shoots after moistening. Immediately after the application of growth regulator, girdled porition was covered with chopped and presoaked sphagnum moss and firmly secured in a place with a polythene film of 250 gauge.

The details of treatments were as follows.

Treatment	Genotype	Tree number in each genotype
T_1	NTI-1	29/6, 33/3, 36/1, 39/1, 43/1
T_2	NTI-2	2/1, 3/1, 4/1, 5/1, 18/1
T_3	NTI-5	8/2, 17/2, 18/2, 19/2, 23/2

Treatment	Genotype	Tree number in each genotype
T_4	NTI-6	24/3, 25/3, 26/3, 30/3, 31/3
T_5	NTI-7	9/3, 13/3, 18/3, 21/3, 23/3
T_6	NTI-14	7/4, 10/4, 20/4, 21/4, 24/4
T_7	NTI-15	5/5, 11/5, 13/5,26/5, 37/5
T_8	NTI-16	24/6, 32/6, 35/6, 39/6, 42/6
T_9	NTI-17	5/6, 6/6, 9/6, 10/6, 16/6
T_{10}	NTI-19	2/7, 6/7, 7/7, 14/7, 17/7
T_{11}	NTI-21	27/8, 28/8, 29/8, 30/8, 31/8
T_{12}	NTI-31	33/9, 34/9, 35/9,36/9, 40/9
T_{13}	NTI-32	2/9, 4/9,6/9, 9/9, 10/9
T_{14}	NTI-54	7/10, 13/10, 17/10, 22/10, 39/10
T_{15}	NTI-55	13/11, 20/11, 27/11, 31/11, 33/11
T_{16}	NTI-56	2/11, 4/11, 5/11, 6/11, 7/11
T_{17}	NTI-57	9/12, 16/12, 17/12, 22/12, 27/12
T_{18}	NTI-58	9/13, 10/13, 12/13, 15/13, 17/13
T_{19}	NTI-59	2/13, 3/13, 4/13, 5/13, 6/13
T_{20}	NTI-60	2/14, 6/14, 7/14,20/14, 25/14
T_{21}	NTI-61	34/15, 36/15, 38/15, 39/15, 40/15
T_{22}	NTI-62	6/15,18/15, 24/15, 29/15, 30/15
T_{23}	NTI-70	23/16, 24/16, 25/16, 27/16, 28/16
T_{24}	NTI-71	10/16, 11/16, 13/16, 19/16, 20/16
T_{25}	NTI-73	13/17, 16/17, 17/17, 23/17, 25/17
T_{26}	NTI-74	44/18, 45/18, 46/18,47/18,48/18

Treatment	Genotype	Tree number in each genotype
T_{27}	NTI-75	24/18, 25/18, 27/18,29/18,34/18
T_{28}	NTI-76	2/18,3/18,6/18, 15/18, 16/18
T_{29}	NTI-77	9/19, 6/19, 20/19, 23/19, 26/19
T_{30}	NTI-78	3/20, 9/20, 18/20, 20/20, 30/20
T_{31}	NTI-79	2/21, 3/21, 18/21, 19/21, 32/21
T_{32}	NTI-80	27/22, 29/22, 31/22, 32/22, 35/22
T_{33}	NTI-82	2/22, 3/22, 19/22, 20/22, 26/22
T_{34}	NTI-83	13/23, 14/23, 27/23, 28/23, 35/23
T_{35}	NTI-84	2/23, 3/23, 4/23, 6/23, 8/23
T_{36}	NTI-85	15/24, 20/24, 26/24, 29/24, 36/24
T_{37}	Shimoga-3	21/25, 25/25, 26/25, 27/25, 28/25
T_{38}	Shimoga-4	7/25, 10/25, 12/25, 13/25, 14/25
T_{39}	Shimoga-7	15/26, 17/26, 18/26, 22/26, 30/26
T_{40}	Shimoga-13	3/26, 4/26, 5/26, 7/26, 12/26

3.5.1 Observation recorded

Tamarind layers were separated after 90, 120 and 150 days from the mother tree from the date of air layering. Number of layers rooted at different interval as indicated by the emergence of roots as seen through the polythene film was considered as success of layers.

1. **Number of layers rooted**

The number of air layers rooted after third, fourth, and fifth month was recorded in each genotypes. The average and per cent of rooting weveworked out.

2. **Number of roots per layers**

The number of roots measuring more than 0.5 cm was counted.

3. **Length of the longest root**

The length of the longest root in each layer was measured with the help of measuring scale and expressed in centimetre.

4. **Dry weight of the root**

The roots were separated from the layer and weighed with the help of electronic balance and expressed in gram per layer.

3.6 **Separation of rooted layers**

The layers were separated at 90, 120 and 150 days after layering. The separated layers were defoliated retaining the petiole intact and were carefully carried to the site of transplanting. The polythene bags were filled with mixture of

soil : sand : FYM in 2:1:1 ratio. The layers planted in the polythene bags were watered regularly.

3.7.1 Post separation establishment

The bagged layers started sprouting within 30 days. The number of layers survived after 180 days was recorded and expressed as per cent of layers established.

Experimental Results

IV. EXPERIMENTAL RESULTS

The experimental results obtained from the analysis of the present investigation are presented below.

4.1 EVALUATION OF GENOTYPES OF TAMARIND FOR GROWTH AND YIELD

4.1.1 Morphological characters and plant type

The data on morphological character of different genotypes are presented in Table-2.

4.1.1.1 Growth parameters

For evaluation, 40 genotypes of tamarind were selected. From each tree the data were collected on height of plant, diameter, number of shoots per 900 cm^2 area, spread of plant in east to west and north to south direction and crown size.

a. Height of plant (m)

Height of the plants in tamarind genotypes varied from 1.47 m in NTI-74 to 2.99 m in NTI-2 at the age of five years. Nineteen progenies recorded height more than plot average (2.18 m). There was significant difference among the treatments in respect of height of the plant. Maximum height was recorded in NTI-2 (2.99 m) and it was followed by S-4 (2.90

Table 2 : Growth parameters of different genotypes of tamarind at fifth year

Sl. No.	Treatment (Genotypes)	Plant height (m)	Basal plant diameter (cm)	No. of shoots/cm^2 area (30x30cm)	Canopy spread of pl(m)		Crown size (m)
					East to west	North to south	
1	NTI- 1	1.99	8.26	5.00	2.22	2.26	2.24
2	NTI- 2	2.99	11.40	4.40	2.99	2.93	2.96
3	NTI- 5	2.21	7.80	4.20	2.14	2.18	2.16
4	NTI- 6	1.96	8.76	5.40	1.86	1.90	1.88
5	NTI- 7	2.82	11.24	4.20	3.10	2.98	3.04
6	NTI-14	2.26	9.26	7.00	2.82	2.74	2.78
7	NTI-15	2.62	10.32	6.80	2.34	2.30	2.32
8	NTI-16	2.31	8.66	5.80	1.96	1.92	1.94
9	NTI-17	2.56	9.04	6.00	2.50	2.38	2.44
10	NTI-19	2.23	8.62	7.20	2.16	2.22	2.19
11	NTI-21	2.46	8.56	4.40	2.14	1.98	2.06
12	NTI-31	1.93	8.44	6.40	1.86	1.72	1.79
13	NTI-32	1.89	10.74	6.80	2.12	2.16	2.14
14	NTI-54	2.22	8.14	4.80	2.24	2.00	2.12
15	NTI-55	1.98	8.24	6.40	1.98	1.84	1.91
16	NTI-56	2.06	8.00	5.00	2.02	2.04	1.95
17	NTI-57	2.22	9.00	4.80	2.34	2.20	2.27
18	NTI-58	1.65	8.02	5.40	1.52	1.28	1.40
19	NTI-59	2.51	8.40	5.20	2.00	1.92	1.96
20	NTI-60	2.31	9.50	3.60	2.30	2.26	2.28
21	NTI-61	1.58	7.32	5.60	1.78	1.68	1.73
22	NTI-62	2.15	7.46	5.20	2.00	1.92	1.96
23	NTI-70	1.83	9.36	5.00	2.26	2.36	2.31
24	NTI-71	2.07	8.84	6.40	1.92	1.76	1.84
25	NTI-73	2.09	10.14	5.80	2.26	2.08	2.17
26	NTI-74	1.47	6.94	7.60	1.34	1.43	1.38
27	NTI-75	1.86	8.60	5.20	1.90	1.96	1.93
28	NTI-76	2.35	8.76	6.00	2.00	2.02	2.01
29	NTI-77	2.32	10.12	5.60	2.00	2.12	2.43
30	NTI-78	2.15	8.24	6.40	2.10	2.14	2.12
31	NTI-79	2.63	8.74	6.20	2.04	2.02	2.03
32	NTI-80	1.94	8.12	6.80	2.26	1.78	2.02
33	NTI-82	2.09	8.30	6.60	2.30	2.04	2.17
34	NTI-83	1.92	9.76	6.60	1.70	1.68	1.69
35	NTI-84	2.05	8.24	7.40	1.82	1.70	1.76
36	NTI-85	1.57	7.34	6.80	1.68	1.68	1.68
37	Shimoga-3	1.75	8.84	7.20	1.76	1.64	1.70
38	Shimoga-4	2.90	11.08	6.40	2.56	2.38	2.47
39	Shimoga-7	2.75	9.62	6.60	2.48	2.52	2.50
40	Shimoga-13	2.61	11.58	7.20	1.98	2.00	2.02
	Mean	2.18	8.92	5.89			2.10
	S.Em	0.04	0.13	0.13	0.04	0.04	0.04
	C.D. (5%)	0.11	0.36	0.36	0.11	0.11	0.11

	Height	Range	Crown size	Range
Vigorous	: >2.50 m	2.56 m - 2.99 m	> 2.02 m	2.02 m - 3.04 m
Medium	: >2.05 m	2.05 m - 2.51 m	> 1.76 m	1.76 m - 2.78 m
Low vigoured	: >1.47 m	1.47 m - 1.99 m	> 1.40 m	1.40 m - 2.31 m

m), NTI-7 (2.82 m), S-7 (2.75 m), NTI-15 (2.62 m), S-13 (2.60 m). Whereas values for height of plant recorded were low in NTI-74 (1.47 m), 85 (1.57 m), 61 (1.58 m), 58 (1.65 m). S-3 (1.75 m) NTI-2 (2.99 m) and S-4 (2.90 m) were found to be superior over others.

The minimum height was observed in NTI-74 (1.47 m) and this was followed by NTI-85 (1.57 m), 61 (1.58 m), 58 (1.64 m) and S-3 (1.75 m).

b. Diameter

Diameter of the plant ranged from 6.94 cm (NTI-74) to 11.58 cm (S-13). There was significant difference among the different genotypes in respect of diameter. Fifteen progenies registered the diameter more than the plot average (8.92 cm). However, highest diameter was recorded by S-13 (11.58 cm), followed by NTI-2 (11.40 cm), 7 (11.24 cm), S-4 (11.08 cm), NTI-32 (10.74 cm), 15 (10.32 cm), 73 (10.14 cm), 77 (10.12 cm), respectively. The value for diameter of the genotype was minimum in case of NTI-74 (6.94 cm) and this was followed by NTI-61 (7.32 cm), 85 (7.34 cm), 62 (7.46 cm) and 5 (7.80 cm).

Based on the growth of plant the genotypes were grouped into three categories viz.,

Vigorous : NTI-2, 7, 15, 17, 79, S-4, S-7 and S-13.

Medium : NTI-5, 14, 16, 19, 21, 54, 56, 57, 59, 60, 62, 71, 73, 76, 77, 78, 82 and 84.

Low vigoured : NTI-1, 6, 31, 32, 55, 58, 61, 70, 74, 75, 80, 83, 85 and S-3.

c. Number of shoots per 900cm^2 canopy area of plant

The range of variation for number of shoots per 30 cm^2 area was from 3.6 (NTI-60) to 7.6 (NTI-74). There was significant difference among the treatments (genotypes) in respect of number of shoots per 30 cm^2 area. Higher number of shoots was recorded in NTI-74 (7.6), 84 (7.4), S-13 (7.2), NTI-19 (7.2)and 14(7.0) respectively. Whereas, number of shoots was lower in NTI-60 (3.6), 5 (4.2), 7 (4.2), 2 (4.4), 21 (4.4), 54 (4.8) and 57 (4.8). The mean value of the plot in respect of number of shoots per 900cm^2 canopy area of the plant was 5.89 and 50 per cent of the progenies recorded higher values than the plot average (Table-2).

d. Spread of plant

The range of variation for the spread of the plant in east to west direction was from 1.34 m (NTI-74) to 3.10 m (NTI-7). There was significant difference among the genotypes in respect of spread of plant in east to west direction.

Higher spread was recorded in NTI-7 (3.10 m), 2 (2.99 m), 14 (2.82 m), S-4 (2.56 m). Plant spread in other genotypes ranged from 1.34 m (NTI-74) to 2.34 m (NTI-15).

The range of variation for the spread of plant from north to south was from 1.28 m (NTI-58) to 2.98 m (NTI-7). There was significant difference among the genotypes in respect of plant spread in north to south direction. NTI-7 recorded the highest spread in north to south direction (2.98 m) and this was followed by NTI-2 (2.93 m), 14 (2.74 m), S-7 (2.52 m) and S-4 (2.38 m). Minimum spread of 1.28 m was observed in NTI-58.

e. Crown size

The range of variation for the crown size of plant was from 1.38 m (NTI-74) to 3.04 m (NTI-7). Sixteen genotypes have recorded the crown size more than the plot mean (2.10 m). There was significant difference among the genotypes in respect of crown size of plant. Among these sixteen genotypes, NTI-7 (3.04 m), 2 (2.96 m), 14 (2.78 m), S-7 (2.50 m) were found to be more promising.

f. Correlation studies

The degree of correlation among the different growth parameters in tamarind was studied separately and their

Table 3 : Correlation matrix (r) among the different growth parameters in tamarind genotypes

Characters	Plant height	Plant diameter	No.of shoots per 900cm^2 area	Plant spread		Crown size	Number of pods
				East to West	North to South		
Plant diameter	0.658**	1.000					
No. of shoots/30 cm^2 area	-0.241	-0.048	1.000				
Plant spread East to West	0.743**	0.615**	-0.340*	1.000			
Plant spread North to South	0.731**	0.629**	-0.342*	0.947**	1.000		
Crown size	0.749**	0.650**	-0.343*	0.979**	0.978**	1.000	
Number of pods	0.148	0.108	0.032	0.188	0.234	0.238	1.000
Weight of pod	0.169	0.162	0.069	0.242	0.328*	0.294	0.860**

* - Singnificant at five per cent level
** - Significant at one per cent level

results were expressed in terms of correlation coefficient (r). The data are presented in Table-3. Plant height was positively and significantly correlated with plant diameter, plant spread east to west, north to south and crown size. Pod weight was positively associated with plant height, whereas, number of shoots per 30 cm^2 area was negatively correlated with plant height.

Plant diameter was positively and significantly correlated with plant spread east to west, north to south and crown size. Plant diameter was positively correlated with pod weight, whereas, number of shoots per 30 cm^2 area was negatively correlated with plant diameter.

Number of shoots per 30 cm^2 area studies have shown negatively and significantly correlated with plant spread east to west, north to south, and crown size. Positively and non significantly correlated with number of pods and pod weight.

Plant spread, east to west was positively and significantly correlated with plant spread north to south, and crown size. Similarly plant spread north to south was positively and significantly correlated with crown size and positively correlated with pod weight.

Crown size was positively and non significant association with number of pods and pod weight. Number of pod was positively and significantly associated with pod weight.

4.1.2 Plant type

Two types of plant growth habit were observed in tamarind, genotypes included in the study viz., orthotropic and plageotropic (Table-4).

In case of NTI-1, 2, 5, 6, 7, 15, 16, 17, 21, 31, 55, 56, 58, 59, 62, 71, 73, 74, 77, 79, 83, 84, S-4, S-13, the plant growth habit observed was orthotropic nature indicating their suitability for high density planting.

Whereas in case of NTI-14, 19, 32, 54, 57, 60, 61, 70, 75, 76, 78, 80, 82, 85, S-3, S-7, the plant growth habit observed was plageotropic.

Among the 40 genotypes, 24 genotypes exhibited orthotropic and 16 genotypes exhibited plageotropic growth habit.

4.1.3 Flowering pattern

The extent of flowering was observed for all the 4 years (1992, 1993, 1994 and 1995) and data are presented in Table-4.

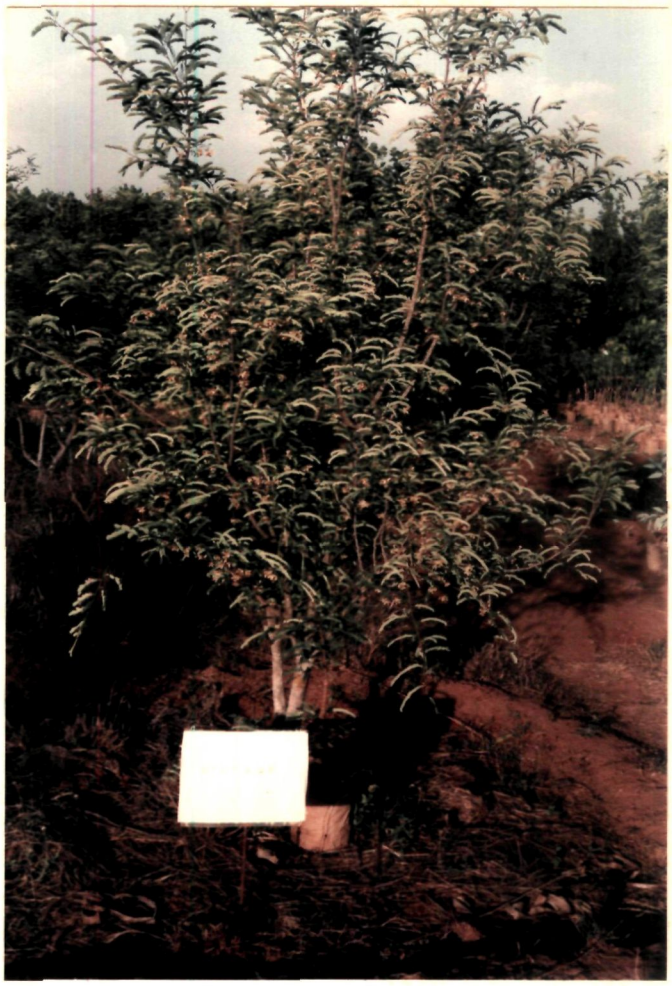


PLATE.2 TAMARIND PLANT WITH PROFUSE FLOWERING (S-4)

PLATE. 2a TAMARIND PLANT WITH PROFUSE FLOWERING (NTI-14)

PLATE.3 TAMARIND PLANT WITH ORTHOTROPIC NATURE

PLATE.4 TAMARIND PLANT WITH PLAGEOTROPIC NATURE (NTI-14)

Table 4 : Growth habit, flowering behaviour and pod shape of tamarind genotypes

Sl. No.	Treatment (Genotypes)	Growth habit	No. of trees flowered out of 5 in different years				Per cent of flowered trees in different years					Pod shape
		Orthotropic/ Plageotropic	1992	1993	1994	1995	1992	1993	1994	1995	Mean	
1	NTI- 1	Orthotropic	3	4	5	5	60	80	100	100	85	Straight and semicurve
2	NTI- 2	Orthotropic	4	2	2	5	80	40	40	100	65	Semi curved
3	NTI- 5	Orthotropic	3	4	4	5	60	80	80	100	80	Straight and semicurve
4	NTI- 6	Orthotropic	5	3	4	5	100	60	80	100	85	Semi curved
5	NTI- 7	Orthotropic	5	2	5	5	100	40	100	100	85	Straight and semicurve
6	NTI-14	Plageotropic	5	5	5	5	100	100	100	100	100	Semi curved
7	NTI-15	Orthotropic	5	5	4	4	100	100	80	80	90	Semi curved
8	NTI-16	Orthotropic	5	4	5	5	100	80	100	100	95	Straight
9	NTI-17	Orthotropic	5	3	4	5	100	60	80	100	85	Straight and semicurve
10	NTI-19	Plageotropic	5	5	5	5	100	100	100	100	100	Straight and semicurve
11	NTI-21	Orthotropic	1	0	0	3	20	0	0	60	20	Straight and semicurve
12	NTI-31	Orthotropic	5	4	2	1	100	80	40	20	60	Straight and semicurve
13	NTI-32	Plageotropic	0	1	2	5	0	20	40	100	40	Straight and semicurve
14	NTI-54	Plageotropic	3	1	1	4	60	20	20	80	45	Straight and semicurve
15	NTI-55	Orthotropic	4	4	4	5	80	80	80	100	85	Straight and semicurve
16	NTI-56	Orthotropic	0	0	0	5	0	0	0	100	25	Not available
17	NTI-57	Plageotropic	5	5	5	5	100	100	100	100	100	Straight and semicurve
18	NTI-58	Orthotropic	0	0	0	4	0	0	0	80	20	Not available
19	NTI-59	Orthotropic	0	2	3	5	0	40	60	100	50	Straight and semicurve
20	NTI-60	Plageotropic	3	1	2	5	60	20	40	100	55	Straight and semicurve
21	NTI-61	Plageotropic	5	4	5	5	100	80	100	100	95	Straight and semicurve
22	NTI-62	Orthotropic	5	5	4	4	100	100	80	80	90	Straight
23	NTI-70	Plageotropic	2	4	4	5	40	80	80	100	75	Straight and semicurve
24	NTI-71	Orthotropic	5	3	4	5	100	60	80	100	85	Straight and semicurve
25	NTI-73	Orthotropic	5	5	4	5	100	100	80	100	95	Straight and semicurve
26	NTI-74	Orthotropic	0	2	2	4	0	40	40	80	40	Straight and semicurve
27	NTI-75	Plageotropic	5	4	3	5	100	80	60	100	85	Straight and semicurve
28	NTI-76	Plageotropic	3	1	1	5	60	20	20	100	50	Straight and semicurve
29	NTI-77	Orthotropic	5	5	4	5	100	100	80	100	95	Straight and semicurve
30	NTI-78	Plageotropic	5	5	5	5	100	100	100	100	100	Straight and semicurve
31	NTI-79	Orthotropic	5	5	4	5	100	100	80	100	95	Semicurve
32	NTI-80	Plageotropic	5	4	0	5	100	80	0	100	70	Straight and semicurve
33	NTI-82	Plageotropic	3	4	4	5	60	80	80	100	80	Straight and semicurve
34	NTI-83	Orthotropic	5	5	5	5	100	100	100	100	100	Straight
35	NTI-84	Orthotropic	4	5	2	5	80	100	40	100	80	Straight and semicurve
36	NTI-85	Plageotropic	5	5	5	5	100	100	100	100	100	Straight and semicurve
37	Shimoga-3	Plageotropic	5	2	3	5	100	40	60	100	75	Straight and semicurve
38	Shimoga-4	Orthotropic	5	5	5	5	100	100	100	100	100	Straight
39	Shimoga-7	Plageotropic	4	5	2	5	80	100	40	100	80	Straight
40	Shimoga-13	Orthotropic	5	4	3	5	100	80	60	100	85	Straight

The extent of flowering varied with the genotypes and the range was 20 to 100 per cent.

The genotypes viz., NTI-14, 19, 57, 78, 83, 85, and S-4 recorded 100 per cent flowering. These were closely followed by NTI-15, 16, 61, 62, 73, 77, 79 with the flowering per cent of 90 to 95. The genotypes viz., NTI-21, 56, 58 ranged between 20 to 25 per cent.

The flowering in tamarind is not a regular feature. However, in the present study cent per cent flowering was observed in all the four years in NTI-14, 19, 57, 78, 83, 85 and S-4.

4.1.4 Study of pod characters and its components

The data on pod characters for different genotypes are presented in Table-4 and 5.

4.1.4.1 Pod shape

Three types of pod shape were observed.

1. Straight
2. Semi curved
3. Straight and semi curved

1. Straight

In NTI-16, 62, 83, S-4, S-7 and S-13 the pod shape observed was straight type (Table-4).

Table 5 : Pod characteristics of tamarind genotypes (Fifth year of planting)

Sl. No.	Treatment (Genotypes)	Pod length (cm)	Pod width (cm)	Pod thickness (cm)	Pod weight (g)	No. of seeds/pod	Seed weight/ pod (g)	Pulp weight/ pod (g)	Shell weight/ pod (g)	Vein weight/ pod (g)
1	NTI- 1	6.50	1.77	1.28	6.09	4.38	1.67	1.98	2.18	0.33
2	NTI- 2	11.48	2.04	1.36	11.66	6.00	3.42	3.78	3.27	0.66
3	NTI- 5	10.07	2.07	1.43	12.11	4.17	2.47	3.96	3.07	0.57
4	NTI- 6	9.06	2.15	1.46	12.67	5.50	5.10	3.31	3.36	0.85
5	NTI- 7	9.47	2.02	1.49	11.50	4.83	3.78	3.67	3.37	0.65
6	NTI-14	8.46	1.76	1.36	9.34	5.20	3.90	3.85	2.66	0.73
7	NTI-15	9.19	2.39	1.60	10.64	4.10	2.77	4.01	2.90	0.44
8	NTI-17	7.03	1.56	1.27	5.09	3.83	1.59	1.65	1.74	0.18
9	NTI-19	11.17	2.60	1.56	14.32	5.90	3.68	4.98	5.04	0.98
10	NTI-31	8.90	2.36	1.52	9.42	2.67	2.12	2.80	2.07	0.90
11	NTI-54	8.04	1.65	1.17	7.05	5.00	2.54	2.24	3.17	0.18
12	NTI-55	8.74	1.81	1.47	9.77	6.63	3.45	2.66	2.40	0.34
13	NTI-57	7.94	1.67	1.70	7.35	4.13	2.09	2.22	1.79	0.19
14	NTI-59	6.62	1.44	1.17	4.20	4.00	1.86	0.92	1.21	0.27
15	NTI-60	8.99	1.62	1.15	7.18	6.25	3.17	2.31	2.83	0.41
16	NTI-61	8.31	2.12	1.34	8.22	5.38	2.86	2.90	2.38	0.38
17	NTI-62	8.81	1.83	1.38	8.36	7.30	3.56	2.11	3.39	0.40
18	NTI-70	8.25	1.72	1.31	6.29	4.38	1.86	1.51	2.27	0.11
19	NTI-71	7.83	1.86	1.35	6.98	4.83	2.31	1.91	1.91	0.35
20	NTI-73	9.03	1.79	1.18	6.45	5.90	2.48	1.87	2.00	0.29
21	NTI-75	9.23	2.14	1.64	12.04	5.67	5.33	3.07	3.81	0.64
22	NTI-77	9.32	2.04	1.59	5.93	5.60	2.18	1.47	1.78	0.24
23	NTI-78	8.44	1.84	1.38	8.87	6.00	3.47	2.67	2.67	0.70
24	NTI-79	8.38	2.03	1.33	8.00	3.80	2.53	2.69	2.40	0.37
25	NTI-80	10.55	1.80	0.88	8.10	2.50	1.60	2.99	2.67	0.47
26	NTI-82	8.21	1.54	1.13	6.07	5.33	2.99	2.06	2.06	0.40
27	NTI-83	8.96	1.85	1.46	9.52	7.10	4.51	2.49	3.68	0.38
28	NTI-84	8.61	1.88	1.29	7.97	5.30	3.46	2.53	2.85	0.51
29	NTI-85	8.23	2.28	1.35	8.73	6.40	3.84	2.00	3.28	0.33
30	Shimoga-3	8.05	1.78	1.25	6.21	7.00	3.09	1.88	2.98	0.63
31	Shimoga-4	6.61	1.82	1.41	5.73	3.00	2.29	2.14	2.42	0.38
32	Shimoga-7	8.14	1.64	1.42	12.15	3.50	1.55	0.67	2.18	0.14
33	Shimoga-13	9.40	2.25	1.55	5.24	6.00	5.52	1.98	3.65	0.39
	Mean	8.67	1.91	1.37	8.55	5.08	3.00	2.52	2.71	0.45
	S.Em	0.14	0.03	0.02	0.28	0.20	0.15	0.13	0.12	0.03
	C.D. (5%)	0.39	0.08	0.06	0.77	NS	NS	0.36	NS	NS

Note : Genotypes in which yield was not recorded and pods not well developed were not included.

2. Semi curved

In case of NTI-2, 6, 14, 15, and 79, semi curved type of podswere observed.

3. Straight and semi curved

NTI-1, 5, 7, 17, 19, 21, 31, 32, 54, 55, 57, 60, 61, 70, 71, 73, 74, 75, 76, 77, 78, 80, 82, 84, 85 and S-3 have produced pods with straight and semi curved shape.

4.1.4.2 Pod length, width and thickness

The data on quantitative characters of pods are presented in Table-5. Pod weight (g) and pulp weight (g) per pod are depicted in fig.1.

a. Pod length

Pod length varied from 6.5 cm (NTI-1) to 11.48 cm (NTI-2). There was significant difference among the *genotypes* in respect of pod length. Highest pod length was observed in NTI-2 (11.48 cm), followed by NTI-19 (11.17 cm), 80 (10.55 cm), 5 (10.07 cm), 7 (9.47 cm), S-13 (9.4 cm), among the different genotypes.

NTI-77 (9.32 cm), 75 (9.23 cm) and 15 (9.19 cm) were on par with each other in respect of pod length. Similarly there was no significant difference among the following

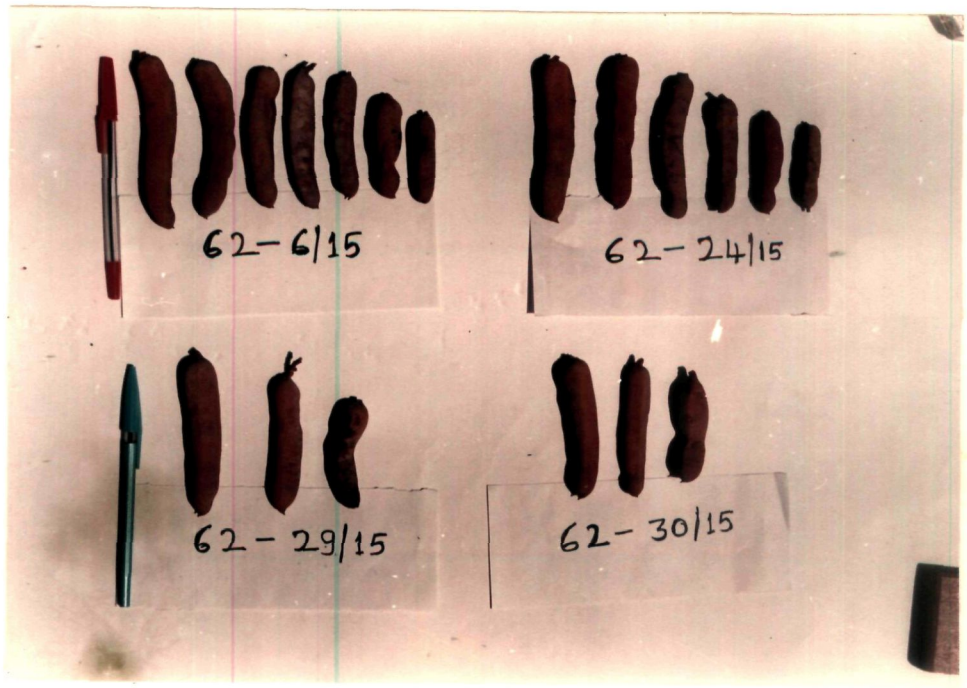


PLATE.5 POD SHAPE - STRAIGHT (NTI-62)

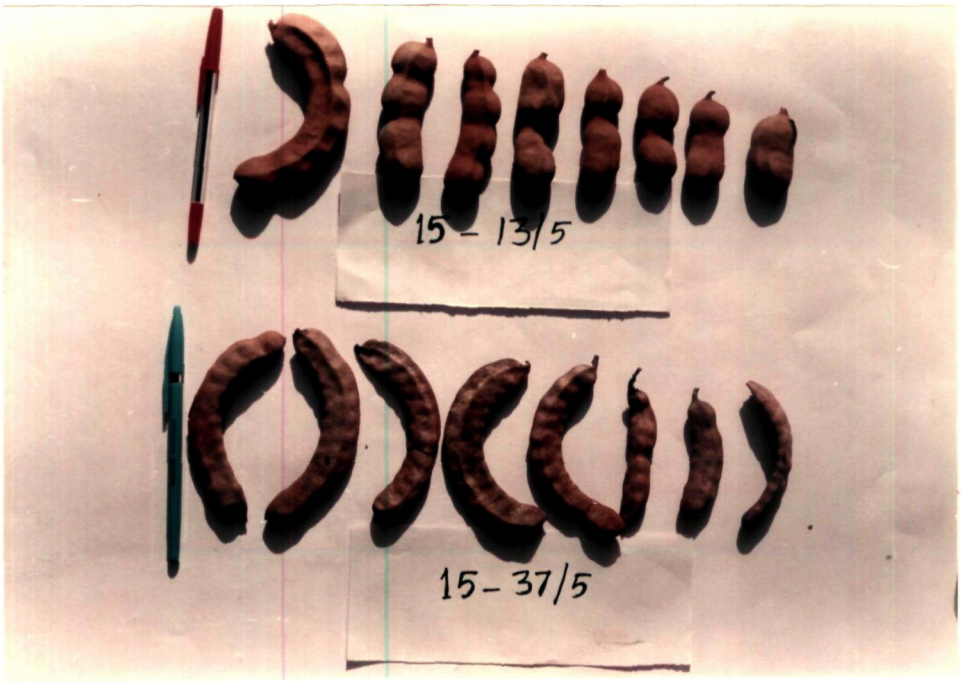


PLATE.6 POD SHAPE - SEMICURVED {NTI-15}

genotypes viz., NTI-60, 31 and 83 (8.99 cm, 8.96 cm, 8.90 cm respectively). Pod length was lowest in NTI-1 (6.50 cm).

b. Pod width

The range of variation for this character was from 1.44 cm (NTI-59) to 2.6 cm (NTI-19). There was significant difference among the genotype in respect of pod width.

Higher pod width was recorded in NTI-19 (2.60 cm), followed by 15 (2.39 cm), 31 (2.36 cm), 85 (2.28 cm) and S-13 (2.25 cm). Pod width was significantly higher in the above genotypes compared to others viz., NTI-19, 15, 31, 85, S-13. In respect of pod width, NTI-15, and 31, NTI-85 (2.28 cm), S-13 (2.25 cm) did not differ each other. Similarly there was no significant difference among the NTI-6 (2.15 cm), 61 (2.12 cm), 75 (2.14 cm). The pod width was lowest in NTI-59 (1.44 cm).

c. Pod thickness

The range of variation for this trait was from 0.88 cm (NTI-80) to 1.70 cm (NTI-57). There was significant difference among the genotypes. Highest pod thickness was observed in NTI-57 (1.70 cm), followed by 75 (1.64 cm), 77 (1.59 cm), 19 (1.56 cm), S-13 (1.55 cm) and NTI-31 (1.52 cm).

There was no significant difference in pod thickness in case of NTI-7 (1.49 cm), 55 (1.47 cm), 6 (1.46 cm) and 83 (1.46 cm). NTI-78 (1.38 cm), 62 (1.38 cm), 2 (1.36 cm), 14 (1.36 cm), 71 (1.35 cm), 85 (1.35 cm), 79 (1.33 cm), 61 (1.34 cm) and 70 (1.31 cm) were also found to be on par with one another. Lowest pod thickness was recorded in NTI-80 (0.88 cm).

4.1.4.3 Pod weight

The genotypes under study showed wide variability for this character with a range of 4.20 g (NTI-59) to 14.32 g (NTI-19) (Fig.1). There was significant difference among the genotypes.

Higher pod weight was recorded in NTI-19 (14.32 g), 6 (12.67 g), S-13 (12.15 g), 5 (12.11 g), 75 (12.04 g), 2 (11.66 g), 7 (11.50 g), 15 (10.64 g). In all 14 genotypes recorded higher pod weight than the general mean (8.55 g).

NTI-1, 70, 71, 73, 82, S-3 recorded 6.09 g, 6.29 g, 6.98 g, 6.45 g, 6.07 g, 6.21 g of pod weight respectively. They were on par with each other and categorized as third group. The minimum pod weight was observed in NTI-59 (4.20 g).

4.1.4.4 Number of seeds and seed weight per pod

Number of seeds per pod ranged from 2.5 (NTI-80) to 7.30 (NTI-62).

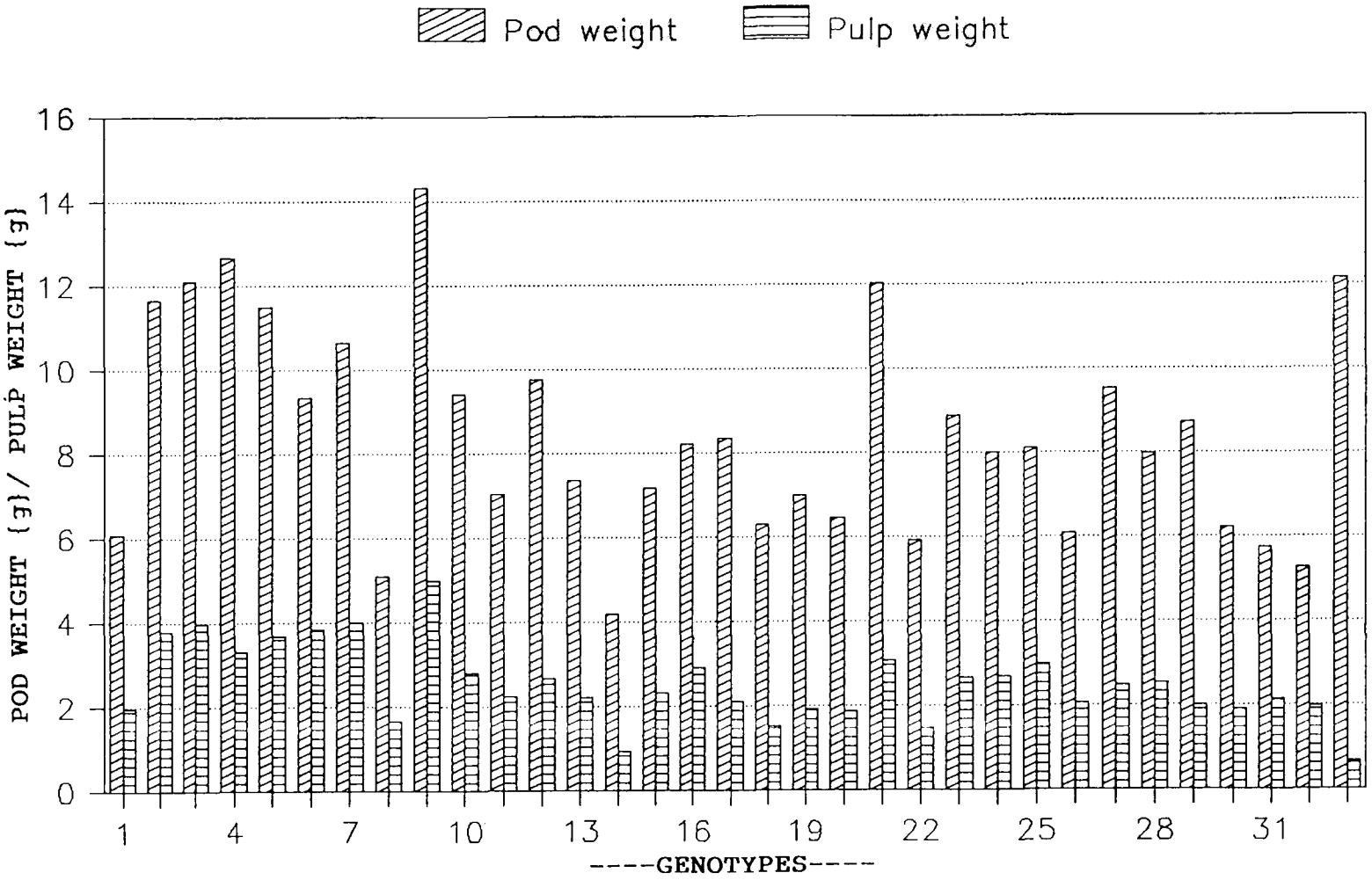


FIG.1 POD WEIGHT (g) AND PULP WEIGHT (g) PER POD IN DIFFERENT GENOTYPES.

7.30 (NTI-62).

There was no significant difference among the genotype in respect of number of seeds per pod. However, numerically higher number of seeds per pod was recorded in NTI-62 (7.3), 83 (7.1), S-3 (7.0), NTI-85 (6.4), 2 (6.0).

The lower number of seeds per pod was recorded in NTI-80, 31, S-4, S-13 and NTI-17 (2.50, 2.67, 3.00, 3.50, 3.83 respectively).

Seed weight per pod ranged from 1.55 g (S-13) to 5.5 g (S-7). There was no significant difference among the genotypes. However, higher seed weight per pod was recorded in S-7 (5.51 g), NTI-75 (5.33 g), 6 (5.10 g), 83 (4.51 g), 14 (3.90 g), 85 (3.84 g), 19 (3.68 g) and 62 (3.56 g).

The minimum seed weight per pod was recorded in S-13 (1.55 g) and this was followed by NTI-80 (1.60 g), 17 (1.60 g), 1 (1.67 g), 59 (1.86 g) and 70 (1.86 g).

4.1.4.5 Pulp, shell and vein weight per pod

a. Pulp weight

Pulp weight per pod varied from 0.67 g (S-7) to 4.98 g (NTI-19). Fifteen genotypes recorded pulp weight more than the general mean (2.52 g) (Fig.1).

There was significant difference among the genotypes in respect of pulp weight per pod (Table-5).NTI-19 was found to be

significantly superior over other genotypes in respect of pulp weight, which recorded to the extent of 4.98 g. Whereas NTI-2, 5, 6, 7, 14 and 15 were on par with each other.

The lowest pulp weight per pod was observed in S-7 (0.67 g).

b. Shell weight

Shell weight per pod ranged from 1.21 g (NTI-59) to 5.04 g (NTI-19). There was no significant difference among the genotypes in respect to shell weight per pod. However, numerically higher shell weight was observed in NTI-19 (5.04 g), 75 (3.81 g), 83 (3.68 g), S-7 (3.65 g), 62 (3.39 g), 7 (3.37 g), 6 (3.36 g), 2 (3.27 g), 5 (3.07 g) compared to others. The lowest shell weight was recorded in NTI-59 (1.21g).

c. Vein weight per pod

Vein weight per pod varied from 0.11 g (NTI-70) to 0.98 g (NTI-19). There was no significant difference among the genotypes in respect to vein weight per pod. However, numerically higher vein weight was recorded in NTI-19 (0.98 g), 31 (0.90 g), 6 (0.85 g), 14 (0.73 g), 78 (0.70 g). The lowest vein weight was found in NTI-70 (0.11 g).

4.1.4.6 Per cent of pulp, seed, shell, vein and hundred seed weight

The data on per cent of pulp, seed, shell, vein and hundred seed weight are given in Table-6 and depicted in Fig.2. The pod components were separated in 37 genotypes of tamarind during 1994 and 1995 and estimated the components of pod, expressed on per cent basis.

a. Pulp per cent

Pulp per cent ranged between 20.51 (S-7) and 43.57 (NTI-76). Higher per cent of pulp was observed in NTI-76 (43.57%), 32 (43.05%), 80 (39.18%), 31 (38.81%), 5 (35.06%) and 15 (35.03%).

Next best group of genotypes in respect of pulp percentage had NTI-19 (33.13 %), 14 (32.29%), 79 (30.85%), and S-4 (26.26%). Minimum pulp percentage was in S-7 (20.51%).

b. Per cent of seed

Per cent of seed ranged from 13.53 (NTI-76) to 40.67 (NTI-6). The lowest per cent of seed was observed in NTI-76 (13.53%) as against the highest in NTI-6 (40.67%). Other genotypes which had lower percentage of seed were NTI-80 (20.41%) and 19 (20.50%).

Table 6 : Per cent of pulp, seed, shell, vein and hundred seed weight of tamarind genotypes (1994 to 1995).

Sl. No.	Treatment (Genotypes)	Per cent				Hundred seed weight (g)
		Pulp	Seed	Shell	Vein	
1	NTI- 1	32.94	30.85	31.23	4.98	43.97
2	NTI- 2	30.74	35.35	29.06	4.85	62.33
3	NTI- 5	35.06	30.76	29.83	4.35	56.51
4	NTI- 6	25.84	40.67	28.27	5.23	78.82
5	NTI- 7	28.10	35.74	32.38	3.78	62.54
6	NTI-14	32.29	35.26	26.70	5.75	64.30
7	NTI-15	35.03	33.30	28.21	3.46	71.47
8	NTI-16	33.71	33.71	29.21	3.37	58.82
9	NTI-17	26.29	33.25	37.42	3.04	33.21
10	NTI-19	33.13	20.50	40.46	5.91	60.28
11	NTI-31	38.80	27.66	28.28	5.26	98.57
12	NTI-32	43.05	29.83	22.71	4.41	64.71
13	NTI-54	33.66	32.70	30.69	2.95	61.93
14	NTI-55	30.51	37.14	28.19	4.16	59.42
15	NTI-57	25.01	35.96	36.80	2.23	46.05
16	NTI-59	25.14	36.60	34.50	3.76	48.58
17	NTI-60	23.73	30.41	42.20	3.68	46.31
18	NTI-61	28.96	38.04	29.43	3.57	50.52
19	NTI-62	21.11	36.09	38.55	3.25	44.95
20	NTI-70	27.69	36.49	33.06	2.76	51.52
21	NTI-71	30.73	33.21	31.27	4.79	56.37
22	NTI-73	30.53	33.45	33.31	2.72	54.93
23	NTI-74	28.48	38.75	30.12	2.65	37.10
24	NTI-75	26.82	36.85	31.25	5.08	62.99
25	NTI-76	43.57	13.53	35.59	7.31	33.33
26	NTI-77	27.50	34.30	34.90	3.30	40.75
27	NTI-78	28.00	35.36	31.78	4.86	54.89
28	NTI-79	30.85	32.30	34.22	2.63	63.68
29	NTI-80	39.18	20.41	34.26	6.13	63.58
30	NTI-82	24.86	22.43	49.28	3.45	49.90
31	NTI-83	25.19	34.32	38.10	2.39	61.16
32	NTI-84	26.03	36.39	33.82	3.76	53.79
33	NTI-85	21.18	37.71	38.03	3.10	54.41
34	Shimoga-3	22.50	39.49	33.48	4.53	35.04
35	Shimoga-4	26.26	28.55	42.02	3.17	70.61
36	Shimoga-7	20.51	38.63	38.10	2.76	56.74
37	Shimoga-13	22.36	33.54	41.35	2.75	77.74

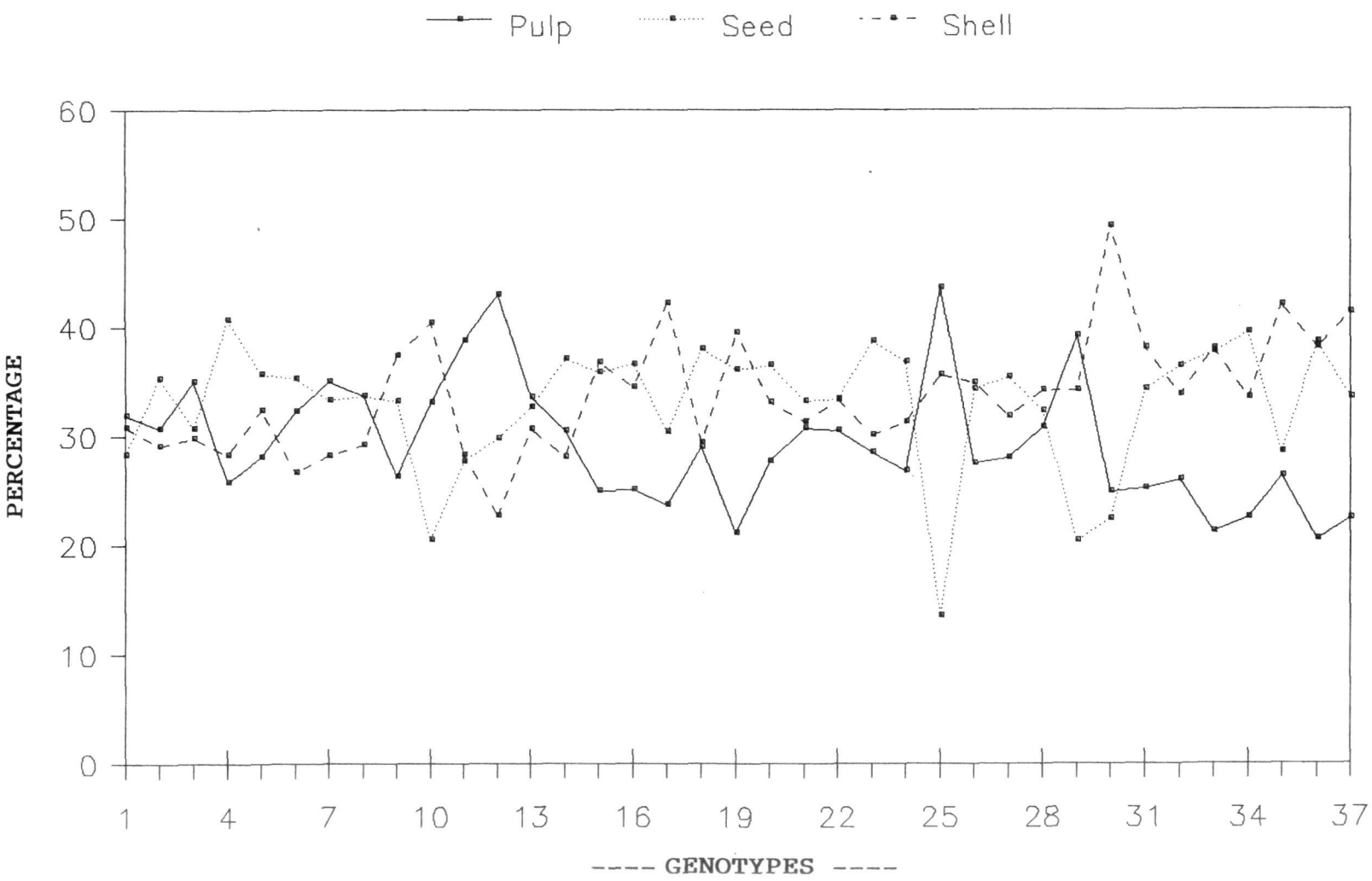


FIG.2 PERCENT OF PULP, SEED AND SHELL WEIGHT IN DIFFERENT GENOTYPES.

c. Shell per cent

Shell per cent ranged from 22.71 (NTI-32) to 49.28 (NTI-82). Other genotypes which had lower per cent of shell were NTI-14 (26.70%), 55 (28.19%) and 15 (28.21%).

d. Vein per cent

Per cent of vein ranged from 2.23 (NTI-57) to 7.31 (NTI-76).

The next lowest per cent of vein was observed in NTI-83 (2.39%), followed by NTI-79 (2.63%), 74 (2.65%), 73 (2.72%), S-7 (2.76%), NTI-54 (2.95%).

e. Hundred seed weight

Hundred seed weight ranged from 33.21 g (NTI-17) to 98.57 g (NTI-31). Highest seed weight was observed in NTI-31. This was followed by NTI-6 (78.82 g), S-13 (77.74 g), NTI-15 (71.47 g), S-4 (70.61 g).

4.1.4.7 Correlation coefficient of pod character

The data on character association on pod characters are presented in Table-7.

Table 7 : Correlation matrix of tamarind pod characters

Characters	Pod length	Pod width	Pod thickness	Pod weight	Seeds/ pod	Pulp weight	Shell weight	Vein weight
Pod width	0.558**	1.000						
Pod thickness	0.280	0.579**	1.000					
Pod weight	0.698**	0.768**	0.569**	1.000				
Seeds per pod	0.442*	0.250	0.476**	0.433*	1.000			
Pulp weight	0.605**	0.653**	0.279	0.827**	0.068	1.000		
Shell weight	0.723**	0.758**	0.550**	0.899**	0.473**	0.639**	1.000	
Vein weight	0.463**	0.584**	0.229	0.753**	0.127	0.750**	0.551**	1.000
Seed weight per pod	0.470**	0.543**	0.684**	0.812**	0.652**	0.402*	0.718**	0.477**

* - Singnificant at five per cent level
** - Significant at one per cent level

a. Pod length

Pod length was positively and significantly associated with pod width, pod weight, seeds per pod, pulp weight, shell weight, vein weight and seed weight per pod.

Pod length was positively and non significantly associated with pod thickness.

b. Pod width

Pod width was positively and significantly associated with pod thickness, pod weight, pulp weight, shell weight, vein weight and seed weight per pod. Pod width was positively associated with seeds per pod.

c. Pod thickness

Pod thickness was positively and significantly associated with pod weight, seeds per pod, shell weight, and seed weight per pod. Pod thickness was positively associated with pulp weight and vein weight.

d. Pod weight

Pod weight was positively and significantly associated with seeds per pod, pulp weight, shell weight, vein weight and seed weight per pod.

e. Seeds per pod

The number of seeds per pod was positively and significantly associated with shell weight, and seed weight per pod. Seeds per pod was positively and non significantly associated with pulp weight and vein weight.

f. Pulp weight

Pulp weight was positively and significantly associated with shell weight, vein weight and seed weight per pod.

g. Shell weight

Shell weight was positively and significantly associated with vein weight, and seed weight per pod.

h. Vein weight

Vein weight was positively and significantly associated with seed weight per pod.

4.1.5 Yield and yield components

The data on yield per tree and the mean number of pods over the years (last three years) and pod yield per tree in different years (1993, 1994 and 1995) (recorded at 4th, 5th and 6th year of age) are given in the Table-8.

Table 8 : Pod yield of tamarind genotypes (1993 to 1995)

Sl. No.	Treatment (Genotypes)	Number of pods per plant				Yield per plant (kg)			
		1993	1994	1995	Mean	1993	1994	1995	Mean
1	NTI- 1	26.80	89.60	5.60	40.67	0.15	0.46	0.04	0.22
2	NTI- 2	13.60	45.00	17.80	25.47	0.16	0.45	0.20	0.27
3	NTI- 5	11.60	50.60	74.20	45.47	0.10	0.45	0.74	0.43
4	NTI- 6	16.20	25.60	19.60	20.47	0.19	0.25	0.20	0.21
5	NTI- 7	22.80	32.00	40.00	31.60	0.24	0.21	0.37	0.27
6	NTI-14	15.80	56.40	64.80	45.67	0.10	0.36	0.76	0.41
7	NTI-15	12.80	91.00	32.80	45.53	0.07	0.77	0.29	0.38
8	NTI-16	7.20	59.60	23.60	30.13	0.07	0.20	0.15	0.14
9	NTI-17	2.60	15.40	5.60	7.87	0.02	0.07	0.03	0.04
10	NTI-19	5.60	157.00	33.20	65.27	0.14	1.45	0.60	0.73
11	NTI-21	2.40	0.00	0.00	0.80	0.01	0.00	0.00	0.00
12	NTI-31	53.80	24.80	0.60	26.40	0.47	0.19	0.01	0.23
13	NTI-32	0.00	13.40	8.80	7.40	0.00	0.13	0.13	0.09
14	NTI-54	5.40	10.60	3.20	6.40	0.04	0.06	0.02	0.04
15	NTI-55	2.20	27.60	15.60	15.13	0.02	0.13	0.15	0.10
16	NTI-56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	NTI-57	28.00	63.00	69.80	53.60	0.18	0.33	0.52	0.34
18	NTI-58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	NTI-59	0.00	23.40	11.20	11.53	0.00	0.08	0.04	0.04
20	NTI-60	16.60	15.20	16.40	16.07	0.04	0.12	0.15	0.11
21	NTI-61	43.00	46.00	28.60	35.20	0.26	0.28	0.29	0.28
22	NTI-62	43.40	91.00	24.00	52.93	0.25	0.51	0.20	0.32
23	NTI-70	7.60	32.00	16.00	18.53	0.04	0.19	0.13	0.12
24	NTI-71	57.20	133.20	11.80	67.40	0.40	0.09	0.14	0.21
25	NTI-73	18.20	38.80	12.20	23.07	0.08	0.24	0.07	0.13
26	NTI-74	0.00	20.20	23.80	14.67	0.00	0.06	0.07	0.05
27	NTI-75	20.00	68.40	20.00	36.13	0.19	0.58	0.27	0.35
28	NTI-76	2.20	1.60	0.40	1.40	0.02	0.01	0.002	0.01
29	NTI-77	54.40	67.00	15.60	45.67	0.14	0.29	0.14	0.19
30	NTI-78	11.60	52.80	20.00	28.13	0.09	0.36	0.19	0.22
31	NTI-79	3.80	76.40	18.00	32.13	0.02	0.53	0.15	0.23
32	NTI-80	7.80	3.40	0.00	3.73	0.08	0.02	0.00	0.03
33	NTI-82	12.20	46.40	2.80	20.47	0.06	0.27	0.03	0.12
34	NTI-83	28.00	46.00	22.60	32.20	0.27	0.38	0.21	0.29
35	NTI-84	1.40	36.60	2.00	13.33	0.01	0.23	0.02	0.09
36	NTI-85	27.00	62.40	17.60	35.67	0.16	0.47	0.23	0.29
37	Shimoga-3	4.00	4.60	2.80	3.80	0.07	0.02	0.01	0.04
38	Shimoga-4	4.40	150.40	39.80	64.87	0.02	0.80	0.44	0.42
39	Shimoga-7	2.20	19.80	11.60	11.20	0.01	0.12	0.11	0.08
40	Shimoga-13	4.80	42.40	3.60	16.93	0.06	0.48	0.05	0.20
	Mean				26.310				0.190
	S.Em±				19.530				0.130
	C.D. for Factor A (clones)				31.260				0.210
	C.D. for Factor B (Years)				8.560				0.057
	C.D. for Factor AB				54.130				0.360

4.1.5.1 Number of pods

The range of variation for the number of pods per plant for the last three years was from 0.8 (NTI-21) to 67.4 (NTI-71). In NTI-56 and 58, there was no bearing. There was significant difference among the genotypes in respect of number of pods per plant. Higher number of pods per plant per year was recorded in NTI-71 (67.4), 19 (65.27), S-4 (64.87), NTI-57 53.60), 62 (52.93), 14 (45.67), 77 (45.67), 15 (45.53), 5 (45.47) and 1 (40.67). Frequency distribution of genotypes based on the number of pods per plant is presented in Table-9.

There was no significant difference among the NTI-71, 19, S-4, NTI-57, 62, 14, 77, 15, 5 and 1 in respect of number of pods per plant.

Similarly, NTI-16, 7, 79, 83, 61 and 85 were on par with each other in respect to number of pods (30 to 40 pods per plant).

4.1.5.2 Pod yield in different years

The number of pods per plant obtained in different years (1993, 1994, 1995) in different genotypes is given in Table-8. The data indicated that there was significant difference within the genotype. In NTI-71, the pod number ranged from 11.80 (1995) to 133.20 (1994). Highest number of pods per plant was obtained during 1994, followed by 1993 (57.2). Similarly, alternate bearing tendency was

Table 9 : Frequency distribution of genotypes based on number of pods per plant

Sl. No.	Number of pods (Range)	Number of progenies	Clone number
1.	00-10	9	NTI-56, 58, 76, 21, 80, s-3, NTI-54, 32, 17
2.	11-20	8	S-7, NTI-59, 60, 80, 74, 55, S-13, NTI-70
3.	21-30	6	NTI-6, 82, 73, 2, 31, 78
4.	31-40	7	NTI-16, 7, 75, 79, 83, 61, 85
5.	41-50	5	NTI-1, 5, 14, 15, 77
6.	51-60	2	NTI-57, 62
7.	61-70	3	NTI-19, 71, S-4

observed in most of the genotypes, except NTI-57 and 14. In case of NTI-57 and 14 there was no significant difference in the yield between 1994 and 1995 (63.00 and 69.80 pods/plant respectively in NTI-57 and 56.40 and 64.80 pods/plant respectively in NTI-14).

In respect of NTI-62, there was significant difference in pod number among the years (43.40, 91.00 and 24.00 in 1993, 1994 and 1995 respectively).

4.1.5.3 Number of pods in different genotypes and different years

The interaction effect of genotypes and different years in respect of number of pods varied significantly. There was no significant difference in pod number of NTI-71 during 1993 (57.2/plant) and 1995 (11.8/plant). Whereas there was significant difference during 1994 (133.2) and 1995 (11.8). In case of NTI-19, which is next best progeny, there was no significant difference inrespect of pods in 1994 and 1995 yields (65.25 pods and 33.2 pods respectively). Whereas there was significant difference between 1993 and 1994. Similar was the trend with respect to S-4 genotype. The number of pods obtained was 4.4, 150.4, 39.4 per plant in 1993, 1994 and 1995, respectively and mean number of pods was 64.87 per plant, indicating variation in pod number from year to year within the genotype.

4.1.5.4 Yield per plant (kg)

The data on yield of different genotypes are presented in Table-8 and depicted in Fig.3. The average yield (kg/plant) and yield for the last three years in different years are given.

The mean yield varied from 0 kg to 0.73 kg per plant for the last three years, among the different genotypes. There was significant difference among the genotypes in respect to yield per plant. The highest yield was recorded with NTI-19, which was to the extent of 0.73 kg per plant (Fig.3).

Among the rest of the genotypes higher yield was recorded in NTI-5 (0.43 kg/plant), followed by S-4 (0.42 kg/plant), 14 (0.41 kg/plant), 15 (0.38 kg/plant), 57 (0.34 kg/plant), 62 (0.32 kg/plant), 75 (0.35 kg/plant), 85 (0.29 kg/plant), 83 (0.29 kg/plant), 61 (0.28 kg/plant), 7 (0.27 kg/plant). However, there was no significant difference among the genotypes mentioned above.

On the contrary NTI-31 (0.23 kg/plant), 2 (0.22 kg/plant), 78 (0.22 kg/plant), 6 (0.21 kg/plant), S-13 (0.20 kg/plant), NTI-77 (0.19 kg/plant), 16 (0.14 kg/plant), 70 (0.12 kg/plant), 60 (0.11 kg/plant), 82 (0.12 kg/plant), 55 (0.10 kg/plant) have found to be low yielder and they are on par with each other.

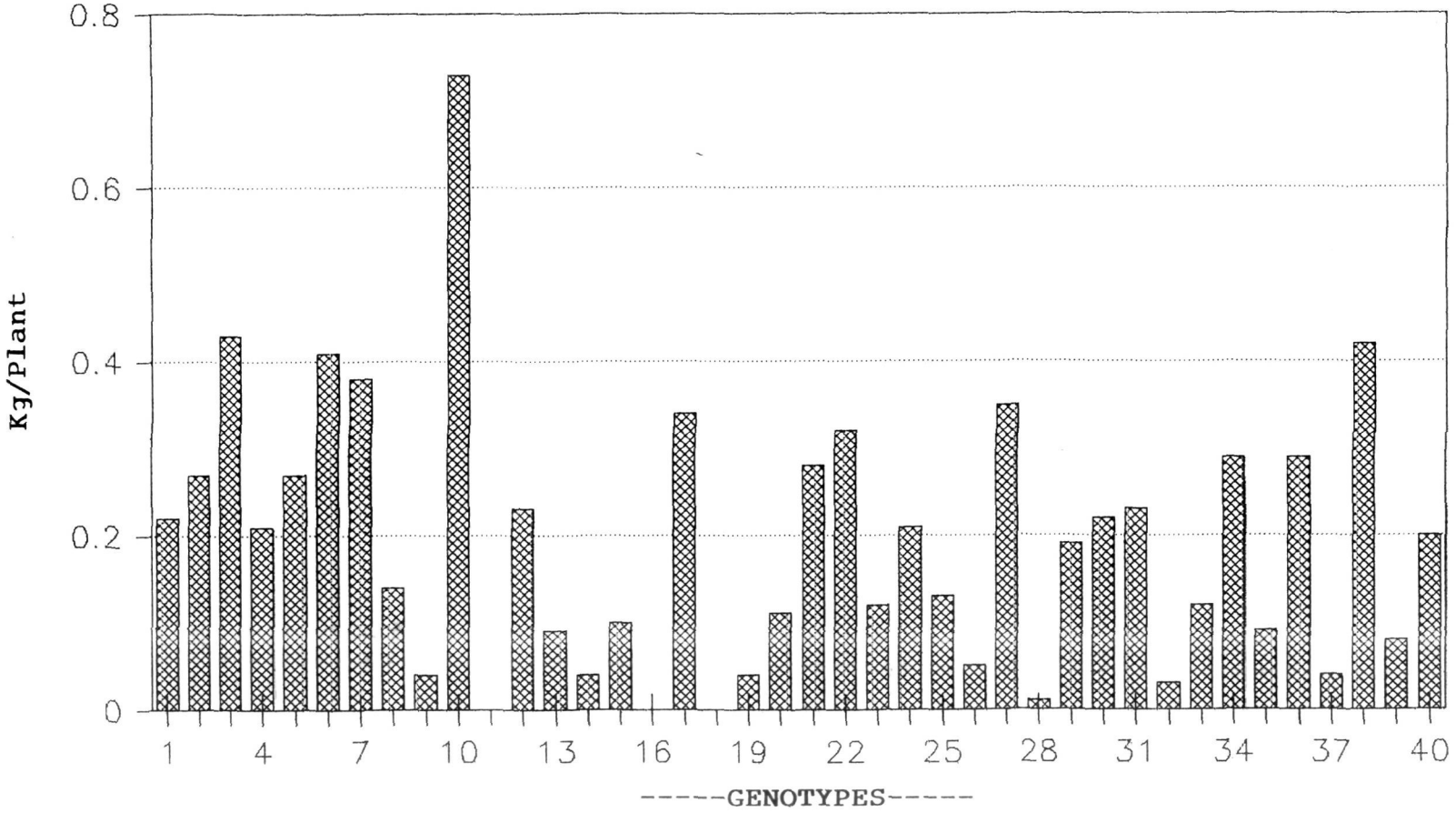


FIG.3 POD YIELD {Kg/Plant} IN DIFFERENT GENOTYPES

The data revealed that NTI-19 was found to be superior among the 40 genotypes and the yield was to the extent of 0.73 kg per plant, which was nearly three and a half times more than that of general mean (0.19 kg/plant). Twenty genotypes yielded higher than the plot average.

4.1.5.5 Yield in different years

The yield per plant obtained in different years (1993, 1994, 1995) in different genotypes is given in Table-8.

The results indicated that there was significant difference within the genotypes in respect of yield levels in all the years.

NTI-19, the yield ranged between 0.14 kg and 1.45 kg per plant, during 1993 and 1994 season respectively. Higher yield was obtained during 1994 (1.45 kg/plant), followed by 1995 (0.60 kg/plant), next was 0.14 kg per plant, during 1993. Similar trend was observed in NTI-5, where in yield ranged from 0.10 kg per plant to 0.74 kg per plant. There was significant difference in yield in different years within the genotype itself. Further, in NTI-14, 15 and S-4 trend remained same. S-4, yield ranged from 0.02 kg per plant to 0.44 kg per plant. In case of NTI-15, the yield ranged from 0.07 kg per plant to 0.29 kg per plant. Hence yield varied from year to year within the genotype.

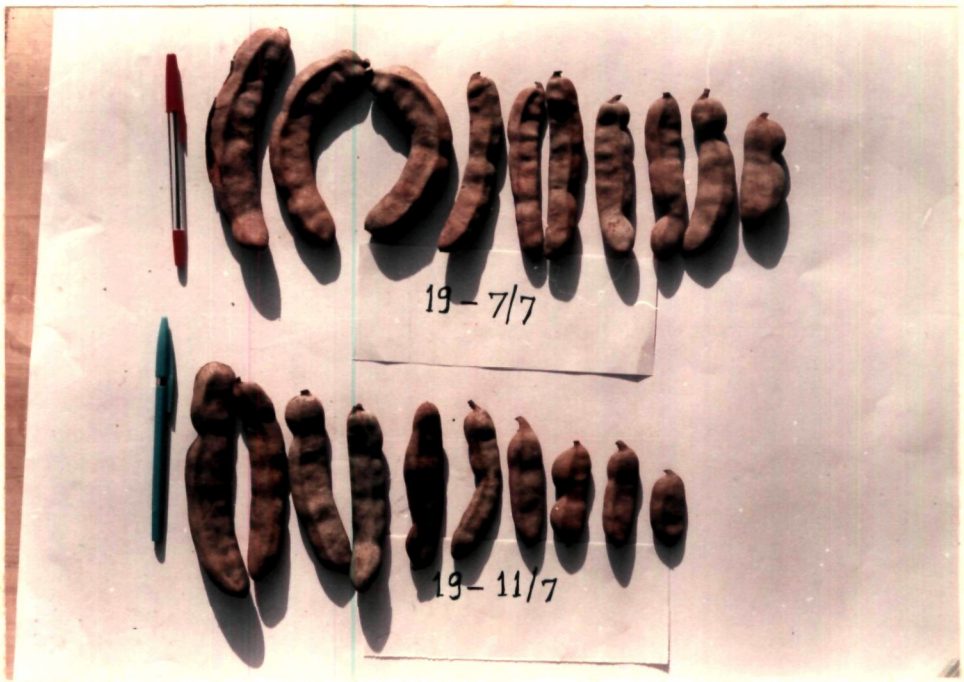


PLATE.7 HIGH YIELDING GENOTYPE OF TAMARIND (NTI-19)

There was no consistent yield in most of the genotypes. However, consistent yield was obtained in NTI-32 (0.13 kg per plant during 1994 and 1995). NTI-60 (0.12 kg/plant and 0.15 kg/plant), 61 (0.29 kg/plant and 0.28 kg/plant), 70 (0.19 kg/plant and 0.13 kg/plant), 77 (0.19 kg/plant and 0.14 kg/plant), S-7 (0.12 kg/plant and 0.11 kg/plant) recorded consistent yield during 1994 and 1995.

4.1.5.6 Yield in different genotypes and different years

The interaction effect of genotypes and different years in respect of yield varied significantly. Among the different genotypes the yield of NTI-19, differed significantly from year to year. This genotype recorded the highest yield to the extent of 1.45 kg per plant during 1994 and yield of the said genotype in other years was 0.14 and 0.60 kg per plant (1993 and 1995 respectively) indicating its tendency towards alternate bearing.

Similarly there was significant difference in yield in among years in NTI-5(0.10,0.45,0.74 kg/plant respectively), 14 (0.10, 0.36, 0.76 kg/plant respectively), S-4 (0.02, 0.80, 0.44 kg/plant respectively).There was no significant difference in the yield of NTI-5, between 1994 and 1995 (0.45 and 0.74 kg/plant respectively).

In NTI-15, there was no significant difference in yield in 1993 and 1995 (0.07, 0.29 kg/plant respectively).

Whereas, significant difference was observed in 1994 and 1993, 1995 yields within the genotype.

4.1.6 Tartaric acid content in different genotypes

The per cent of tartaric acid content among different genotypes was estimated during 1994 and 1995 and the results are presented in Table-10.

a. Tartaric acid content during 1994

Tartaric acid content ranged from 4.43 per cent (NTI-70) to 14.70 per cent (S-13). There was significant difference among the genotypes in respect of tartaric acid content. Highest per cent of tartaric acid was noticed in S-13 (14.7%) followed by NTI-57 (12.44%), S-7 (12.35%), S-3 (12.10%).

Significantly higher tartaric acid content was observed in S-13 (14.7%), over other genotypes. Whereas NTI-57 (12.44%), S-7 (12.35%), S-3 (12.10%), were on par in respect of per cent of tartaric acid content.

There was no significant difference among the NTI-7 (8.73%), 55 (8.52%), 80 (8.50%), 85 (8.93%), in respect of per cent of tartaric acid content.

The lower content of tartaric acid was noticed in NTI-70, 1, and 71 (4.43%, 4.58% and 4.65% respectively).

Table 10 : Tartaric acid content (per cent) in different genotypes of tamarind (1994 to 1995)

Sl. No.	Treatment (Genotypes)	% of tartaric acid (1994)	Treatment (Genotypes)	% of tartaric acid (1995)
1	NTI- 1	4.58	NTI- 1	6.97
2	NTI- 2	5.60	NTI- 2	7.75
3	NTI- 5	5.07	NTI- 5	6.53
4	NTI- 6	6.67	NTI- 6	6.00
5	NTI- 7	8.73	NTI- 7	9.00
6	NTI-14	6.20	NTI-14	12.23
7	NTI-15	6.55	NTI-15	6.30
8	NTI-17	6.93	NTI-16	9.90
9	NTI-19	6.54	NTI-17	14.22
10	NTI-31	6.40	NTI-19	13.63
11	NTI-54	6.70	NTI-31	15.20
12	NTI-55	8.52	NTI-32	16.70
13	NTI-57	12.44	NTI-54	10.00
14	NTI-58	6.55	NTI-55	5.50
15	NTI-59	7.93	NTI-57	4.50
16	NTI-60	8.13	NTI-59	4.78
17	NTI-61	5.59	NTI-60	4.00
18	NTI-62	5.64	NTI-61	6.17
19	NTI-70	4.43	NTI-62	5.43
20	NTI-71	4.65	NTI-70	5.43
21	NTI-73	5.69	NTI-71	6.47
22	NTI-75	6.17	NTI-73	6.70
23	NTI-76	6.00	NTI-74	4.73
24	NTI-77	6.43	NTI-75	6.23
25	NTI-78	6.46	NTI-76	7.20
26	NTI-79	7.62	NTI-77	7.05
27	NTI-80	8.50	NTI-78	6.20
28	NTI-82	6.83	NTI-79	7.68
29	NTI-83	8.33	NTI-82	10.10
30	NTI-84	9.64	NTI-83	9.35
31	NTI-85	8.93	NTI-84	11.75
32	Shimoga-3	12.10	NTI-85	7.32
33	Shimoga-4	8.02	Shimoga-3	9.20
34	Shimoga-7	12.35	Shimoga-4	8.15
35	Shimoga-13	14.70	Shimoga-7	10.20
36			Shimoga-13	8.80
	Mean	7.47		8.26
	S.Em±	0.20		0.31
	C.D. (5%)	0.55		0.86

b. Tartaric acid content during 1995

Tartaric acid content ranged from 4.00 per cent (NTI-60) to 16.7 per cent (NTI-32). There was significant difference among the genotypes in respect of percentage of tartaric acid content. Higher tartaric acid content was recorded in NTI-32 (16.7%), 31 (15.20%), 17 (14.22%), 19 (13.63%), 14 (12.23%), 84 (11.75%), S-7 (10.20%), 82 (10.10%) and 54 (10.0%).

Tartaric acid content was highest and significantly higher in NTI-32 (16.7%) over other genotypes.

The values for tartaric acid content were lower in NTI-60 (4.0%), 57 (4.5%), 74 (4.73%), 59 (4.78%), 62 (5.43%), 70(5.43%), 55 (5.5%). There was no significant difference in tartaric acid content in NTI-57 (4.50%), 59 (4.78%), and 74 (4.73%). Similarly NTI-55 (5.50%), 62 (5.43%), 70(5.43%) did not vary in tartaric acid content.

Most of the genotypes registered higher tartaric acid content during 1995 (8.26%) compared to 1994 season (7.47%).

4.1.7 Multivariate analysis, clustering pattern of tamarind genotypes

The data on canonical variate analysis clustering pattern and intra cluster distance are presented in Table-11, 12 and 13 respectively.

Table 11 : Elements of the first canonical vector in tamarind

Sl.No.	Characters	Vector-I
1.	Pulp weight (g)	1.000
2.	Shell weight (g)	0.007
3.	Pod width (cm)	0.007
4.	Seed weight (g)	0.004
5.	Number of seeds	0.004
6.	Pod weight (g)	0.004
7.	Pod length (cm)	0.003
8.	Pod thickness (cm)	0.002

Table 12 : Canonical roots and variability accounted by them in tamarind

Canonical roots	Variability accounted	Percentage variance	Cumulative variance
1.	14287.182	99.231	99.231
2.	62.036	0.431	99.661
3.	40.036	0.278	99.940
4.	6.400	0.044	99.984
5.	1.779	0.012	99.996
6.	0.316	0.002	99.999
7.	0.167	0.001	100.000
8.	0.044	0.000	100.000

Table 13 : Clustering pattern and intra cluster distance (D^2) among 40 genotypes of (*Tamarindus indica* L.) tamarind

Cluster	Number of genotypes	Genotypes (clone number) and sources	Intra cluster dist (D^2 value)
I	4	BGL1, BEL-61, 75, 85	14.27
II	4	BEL-2, UK-31, 73, 78	17.13
III	4	BEL-7, BEL-16, 79, 83	10.07
IV	4	BGL-5, BEL-14, BEL-15, 77	6.55
V	2	BEL-57, BEL-62	3.28
VI	3	DWD-19, DWD-71, S-4	8.97
VII	5	BEL-6, DWD-70, BEL-60, S-13, 82	15.63
VIII	5	DWD-55, BEL-59, S-7, 74, 84	11.47
IX	5	BEL-17, UK-32, S-54, S-3, NTI-80	12.47
X	4	BGL-21, BEL-56, BEL-58, 76	3.00

BGL - Bagalkot, BEL - Belgaum, DWD - Dharwad, S - Shimoga, UK - Uttar Kannada

4.1.7.1 Canonical variate analysis

The elements of first canonical vector are presented in Table-11. As revealed by the first vector, pulp weight alone contributed maximum in discriminating the genotypes. Shell weight and pod weight are the other two important characters which contributed to divergence. The first canonical vector accounted 99.231 per cent towards divergence (Table-12). The contribution of the remaining vectors, towards divergence was meagre (Table-12).

4.1.7.2 Clustering pattern, intra and inter cluster distance of 40 genotypes of tamarind

The horizontal line drawn at a dissimilar coefficient of 1.63 resulted into 10 clusters (Fig.4). Clusters-VII, VIII and IX were the largest with 5 genotypes each (Table-13) followed by clusters I, II, III, IV and X, with four genotypes in each case. Cluster VI had three genotypes, while Cluster-V was the smallest with two genotypes (Table-13 and Fig.5).

Cluster-II, recorded the highest intra cluster distance (17.13), followed by Cluster-VII (15.63), and Cluster-I (14.27), while Cluster-X recorded the lowest intra cluster distance (3.00) (Table-14).

1.63 {Dissimilarity Coefficient}

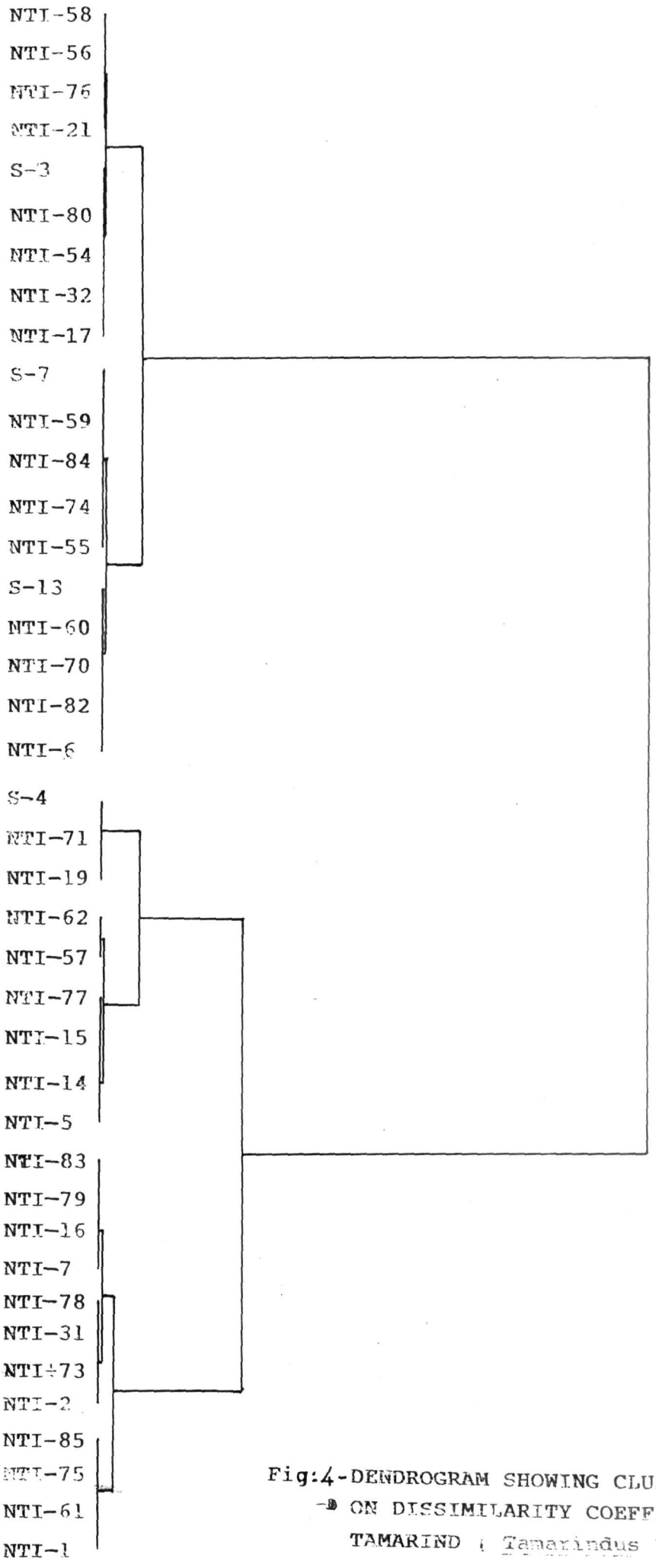


Fig:4-DENDROGRAM SHOWING CLUSTER FORMATION BASED ON DISSIMILARITY COEFFICIENT INDEX IN TAMARIND (Tamarindus Indica L)

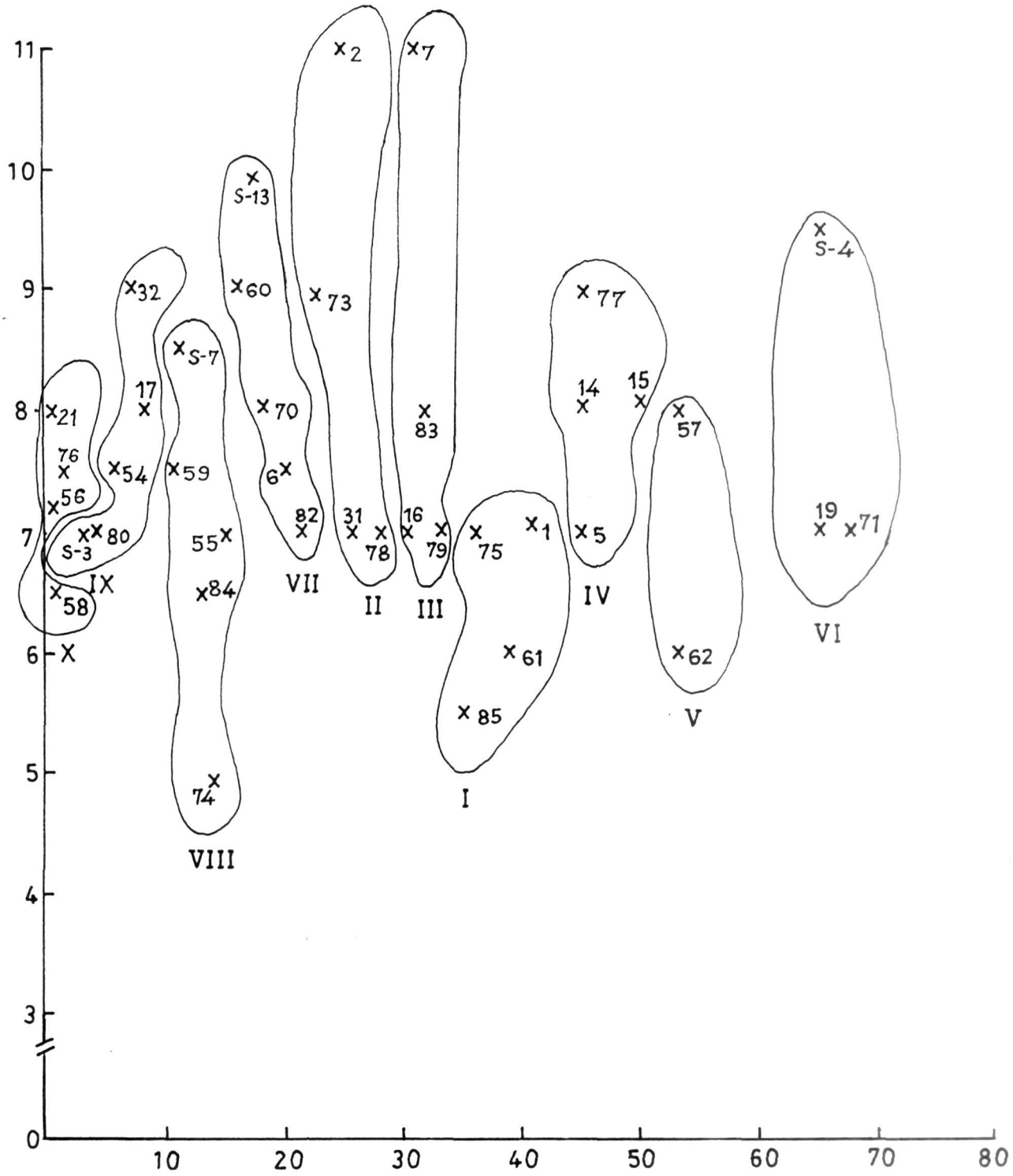


FIG: 5-CANONICAL GRAPH SHOWING THE CLUSTERING PATTERN IN 40 TAMARIND GENOTYPES.

Table 14 : Intra and inter cluster distance of 40 tamarind genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
I	14.27	162.91	50.55	69.97	242.61	792.76	391.86	623.63	1041.01	1403.42
II	-	17.13	45.01	401.73	765.75	1616.68	65.68	172.46	409.36	645.78
III	-	-	10.07	200.24	473.60	1166.03	183.61	353.27	676.68	975.31
IV	-	-	-	6.55	64.22	417.21	743.03	1060.70	1587.91	2034.26
V	-	-	-	-	3.28	166.60	1331.07	1615.75	2257.53	2774.91
VI	-	-	-	-	-	8.97	2252.90	2784.11	3609.50	4271.85
VII	-	-	-	-	-	-	15.63	41.95	149.26	331.08
VIII	-	-	-	-	-	-	-	11.47	64.04	143.15
IX	-	-	-	-	-	-	-	-	12.46	31.58
X	-	-	-	-	-	-	-	-	-	3.00

Table 15 : Cluster means for eight quantitative traits in tamarind.

Cluster	Pulp weight/ pod (g)	Shell weight/ pod (g)	Pod width (cm)	Seed weight/ pod (g)	No.of seeds per pod	Pod weight (g)	Pod length (cm)	Pod thickness
I	2.49	2.91	2.08	3.43	5.45	8.77	8.07	1.40
II	2.78	2.50	2.01	2.87	5.14	9.10	9.46	1.36
III	2.94	3.15	1.97	3.60	5.24	9.67	8.94	1.43
IV	3.32	2.60	2.07	2.83	4.49	9.51	9.26	1.50
V	2.17	2.59	1.75	2.82	5.71	7.86	8.38	1.54
VI	3.14	3.12	2.09	2.76	4.58	9.01	8.54	1.44
VII	1.97	2.54	1.86	2.93	4.99	12.67	8.93	1.37
VIII	2.02	2.53	1.69	3.57	5.48	6.80	8.03	1.34
IX	2.19	2.64	1.70	2.20	3.71	7.41	8.76	1.22
X	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cluster I was close to cluster III and IV, while it was moderately distant from clusters II, V, and VII. It however, showed high inter cluster D^2 value, with clusters VI, VIII, IX and X. Cluster II and III, were also nearer to each other, and both of them showed greater diversity, from cluster VI and cluster X, followed by cluster IX. Cluster IV was closer to cluster V. It showed greater diversity, with cluster VIII, IX and X, followed by cluster VII. Cluster V was also distant from cluster VII, VIII, IX and X. While it was nearer to cluster IV and moderately away from cluster I, II, III and VI. Cluster IV also appear to be placed further away from clusters VII, VIII, IX, X, II and III. Likewise cluster VIII showed greater diversity from cluster IV, V and VI. Cluster IX was very near to cluster X and cluster VIII. Both cluster IX and X showed greater diversity from cluster I, IV, V and VI. While they were moderately distant from cluster II, III and VII.

4.1.7.3 Cluster mean of 40 genotypes

Cluster means for eight quantitative traits are presented in Table-15. For pulp weight per pod Cluster-IV had the highest mean value (3.32) followed closely by Cluster-VI (3.14). For shell weight per pod, Cluster-III with mean value of 3.15 g was the highest, which was again followed by Cluster-

VI. Cluster-VI was again important for pod width, with the highest mean performance of 2.09 cm, followed closely by Cluster-I and IV. For seed weight per pod, Cluster-III had maximum mean value (3.60) followed closely by Cluster-VIII (3.57). Higher number of mean seeds per pod was found in Cluster-V (5.71). As regards pod weight, Cluster-VII was the best, since it had the highest mean (12.67 g) value for this character. And the next best was Cluster-III with 9.67 g. Cluster-II is characterized by lengthy pods, exhibiting the highest mean of 9.46 cm. However for pod thickness it was Cluster-V (1.54 cm).

4.1.8 Variability studies in half-sib families of tamarind

The data on progenies of 20 genotypes of tamarind in respect of germination per cent, height of the seedling and number of leaves at one month stage, and height of the seedling, number of leaves, leaf length, leaflet length amd diameter at six month stage are given in Table-16. The estimate of variance, GCV, PCV, heritability (b.s.) and genetic advance as per cent over mean are given in Table-17 and depicted in Fig.6 & 7.

4.1.8.1 Germination percentage

The general mean for germination per cent was 62.99. The range of germination per cent varied from 36.67 per cent

Table 16 : Performance of half sib families of tamarind in respect of germination and growth parameters

Sl. No.	Treatment (Genotypes)	Per cent germination	Ht. of the seedling at 1 month stage (cm)	No. of leaves at 1 month stage	Ht. at 6 month stage (cm)	No. of leaves at 6 month stage	Leaf length at 6 month stage (cm)	Leaf let length at 6 month stage (cm)	Diameter at 6 month stage (cm)
1	NTI- 6	76.66	14.26	3.59	28.27	10.87	5.93	2.39	0.33
2	NTI-15	50.00	10.53	2.91	25.83	12.37	5.07	1.78	0.26
3	NTI-19	36.67	9.99	2.53	24.43	8.53	5.04	2.01	0.28
4	NTI-57	53.33	10.34	2.82	23.87	10.57	5.02	1.99	0.26
5	NTI-60	73.33	10.17	3.19	18.93	11.37	4.64	1.91	0.25
6	NTI-61	60.00	9.61	2.95	24.17	13.77	4.74	1.88	0.28
7	NTI-62	56.67	10.93	3.33	25.47	12.20	5.36	1.90	0.29
8	NTI-70	50.00	7.00	2.48	16.67	8.47	3.98	1.57	0.20
9	NTI-71	40.00	10.61	3.26	20.70	10.27	4.65	1.83	0.30
10	NTI-73	53.33	9.09	2.90	19.93	11.40	4.54	1.80	0.24
11	NTI-74	76.67	8.88	3.33	16.10	8.87	4.20	1.70	0.20
12	NTI-75	60.00	10.43	3.47	24.23	16.27	5.00	2.08	0.27
13	NTI-77	56.67	10.12	3.00	23.57	15.77	4.46	1.89	0.23
14	NTI-78	73.33	9.98	2.69	19.07	9.57	4.61	2.02	0.23
15	NTI-79	76.67	12.63	3.25	24.30	10.10	5.66	2.50	0.27
16	NTI-82	73.33	11.18	3.15	19.73	8.73	4.97	1.82	0.23
17	NTI-83	93.33	10.41	3.22	19.20	9.73	5.06	1.89	0.26
18	NTI-84	80.00	9.40	3.03	19.70	7.17	5.15	2.04	0.22
19	NTI-85	63.33	10.55	3.05	20.30	9.47	4.77	1.93	0.22
20	Shimoga-4	56.67	12.45	3.31	23.70	12.10	5.24	2.08	0.30
	Mean	62.99	10.43	3.07	22.06	10.88	11.90	1.95	0.26
	S.Em±	2.43	0.22	0.05	0.05	0.37	0.07	0.03	0.01
	C.D. (5%)	6.72	0.61	0.14	1.38	1.02	0.19	0.08	0.03

Table 17 : Estimate of variance, genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability (Broad sense) and genetic advance (GA) as the percent of mean

Sl. No.	Character	Mean	Range	Genotypic variance	Phenotypic variance	Environmental variance	GCV %	PCV %	Heritability broad sense (%)	GA as % of mean
1.	Germination per cent	62.99	36.69 to 93.33	134.795	358.128	223.333	18.43	30.04	60.00	23.29
2.	Ht.at 1 month stage (cm)	10.43	7.14 to 14.26	1.85	3.05	1.194	13.04	16.73	61.00	20.93
3.	No.of leaves (1 month)	3.07	2.48 to 3.50	0.0693	0.1243	0.0555	8.56	11.47	56.00	8.85
4.	Ht.at six month stage (cm)	22.06	16.10 to 28.27	8.54	15.12	6.579	13.34	17.75	57.00	20.65
5.	No.of leaves (6 month)	10.88	7.17 to 16.27	4.22	8.465	4.245	18.88	26.75	50.00	27.47
6.	Leaf length (cm)	4.90	3.98 to 5.93	0.173	0.293	0.120	8.48	11.04	59.00	13.43
7.	Leaflet length (cm)	1.95	1.57 to 2.50	0.033	0.069	0.135	9.32	13.48	48.00	13.31
8.	Collar diameter (cm)	0.26	0.20 to 0.33	0.001	0.002	0.001	12.30	17.40	50.00	17.92

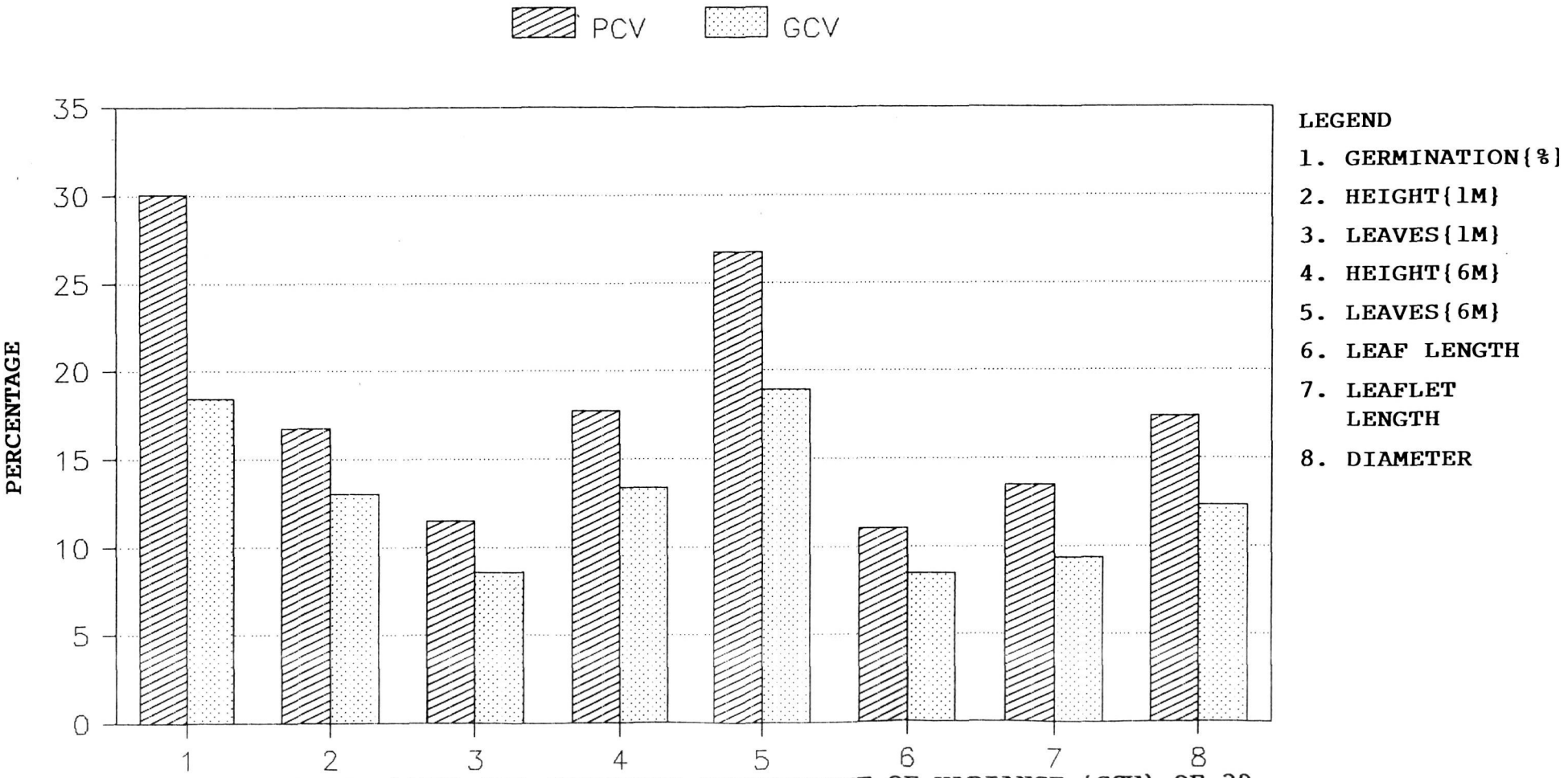


FIG.6 PHENOTYPIC {PCV} AND GENOTYPIC COEFFICIENT OF VARIANCE {GCV} OF 20 PROGENIES OF TAMARIND.

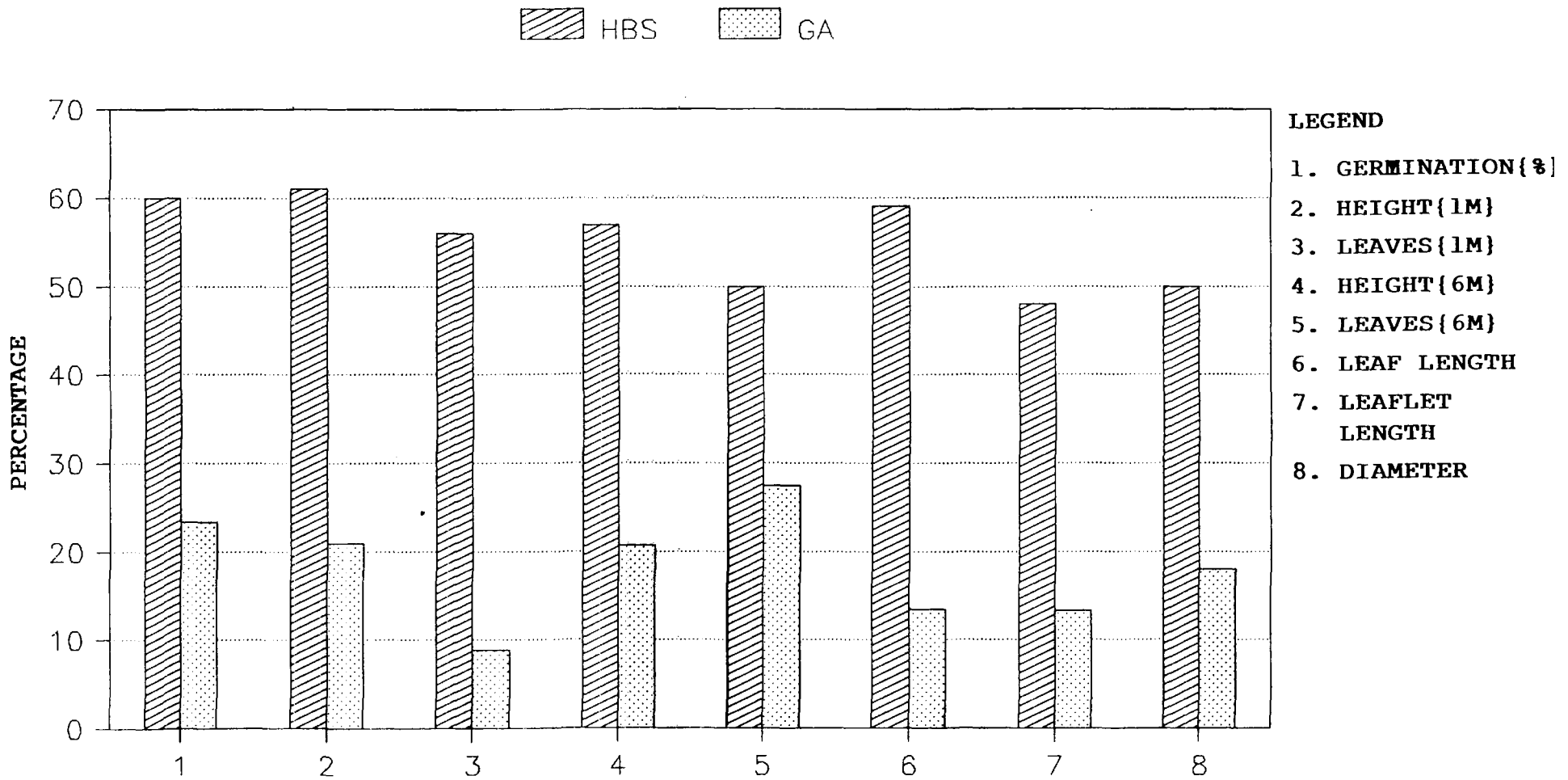


FIG.7 HERITABILITY {HBS} AND GENETIC ADVANCED {GA} AS PERCENTAGE OF MEAN IN 20 PROGENIES OF TAMARIND.

(NTI-19) to 93.33 per cent (NTI-83). There was significant difference among the families with respect to germination. NTI-83 recorded the highest per cent of germination (93.33%), followed by NTI-84 (80), 74 (76.67%), 79 (76.67%), 6 (76.66%), 60 (73.33%) and 82 (73.33%).

The per cent germination was lower in NTI-19, 71, 15, 57, 73 (36.67%, 40%, 50%, 53.33% and 53.33%, respectively).

Germination per cent did not differ significantly among the NTI-15 (50%), 57 (53.33%), 73 (53.33%), 62 (56.67%), 77 (56.67%) and S-4 (56.67%). But NTI-71 (40%) differed significantly from NTI-15, 57, 73, 62, 77 and S-4 inrespect of this character.

Heritability (broad sense) was 60 per cent which indicated that germination was a moderately heritable character. Genotypic coefficient of variation was 18.43, it means that the extent of variability due to genotypes was 18.43 per cent. Genetic advance as per cent over mean was high (23.29).

4.1.8.2 Height of seedling and number of leaves at one month stage

a. Height of seedling

The general mean for height of seedling was 10.43 cm. Height of the seedling varied from 7.00 cm (NTI-70) to 14.26 cm

(NTI-6). There was significant difference among the families with respect to height. NTI-6, recorded maximum height (14.26 cm) and it was followed by NTI-79 (12.63 cm), S-4 (12.45 cm), 82 (11.18 cm), 62 (10.93 cm), 71 (10.61 cm) and 15 (10.53 cm).

NTI-6 (14.26 cm) differed significantly in respect of height of seedling over NTI-79 (12.63 cm), S-4 (12.45 cm). NTI-79 and S-4 did not differ significantly. Lowest height of the seedling was noticed in NTI-70 (7.0 cm).

Heritability (broad sense) was 61 per cent. It indicated that height is moderately heritable character. Genotypic coefficient of variation was 13.04, it means that the extent of variability due to genotype was 13.04 per cent. Genetic advance as per cent over mean was high (20.93).

b. Number of leaves

The general mean for number of leaves was 3.07. The mean number of leaves varied from 2.48 (NTI-70) to 3.59 (NTI-6). There was significant difference among the families with respect to number of leaves per plant. Highest number of leaves was recorded in NTI-6 (3.59) followed by NTI-75 (3.47), 62 (3.33), 74 (3.33), S-4 (3.31), 71 (3.26), 79 (3.25), 83 (3.22) and 60 (3.19). Lowest number of leaves was observed in NTI-70 (2.48 cm).

The extent of variability due to genotype was 8.56 and heritability was 56. It showed that, number of leaves at seedling stage is a moderately heritable character. Genetic advance as per cent over mean was low (8.85).

4.1.8.3 Height of seedling and number of leaves at six month stage

a. Height of seedling

The general mean for seedling height was 22.06 cm. The range for height of seedling varied from 16.10 cm (NTI-74) to 28.27 cm (NTI-6). There was significant difference among the families with respect to height. NTI-6 recorded the highest height (28.27cm), followed by NTI-15 (25.83 cm), 62 (25.47 cm), 19 (24.43 cm), 79 (24.30 cm), 75 (24.23 cm), and 61 (24.17 cm). Lowest height was recorded in NTI-74 (16.10 cm).

The extent of variability due to genotype (GCV) was 13.34 and heritability was 57 per cent. It showed that seedling height is a moderately heritable character. Genetic advance as per cent over mean was high (20.65).

b. Number of leaves at six month stage

The general mean for number of leaves was 10.88. Number of leaves varied from 7.17 (NTI-84) to 16.27 (NTI-75). There was significant difference among the families with

respect to number of leaves produced per seedling. Highest number of leaves was recorded in NTI-75 (16.27), followed by NTI-77 (15.77), 61 (13.77), 62 (12.20), 15 (12.37), S-4 (12.10), 73 (11.40) and 60 (11.37). Lowest number of leaves was observed in NTI-84 (7.17).

Heritability (broad sense) was 50, it indicated that number of leaves at 6 month stage was a moderately heritable character. Genotypic coefficient of variation was 18.88. It means that the extent of variability due to genotype was 18.88 per cent. Genetic advance as per cent over mean was high (27.47).

4.1.8.4 Leaf and leaflet length

a. Leaf length

The general mean for leaf length was 4.90 cm Leaf length varied from 3.98 cm (NTI-70) to 5.93 cm (NTI-6). There was significant difference among the families with respect to leaf length. Higher leaf length was recorded in NTI-6 (5.93 cm), 79 (5.66 cm), 62 (5.36 cm), S-4 (5.24 cm), NTI-84 (5.15 cm), 15 (5.07 cm), 83 (5.06 cm), 19 (5.04 cm), 57 (5.02 cm) and 60 (5.00 cm).

There was no significant difference among NTI-15, 19, 57, 60, 83 and 84 in respect of leaf length. However, NTI-6,

recorded maximum leaf length (5.93 cm) and significantly differed from rest of the families. Leaf length was lowest in NTI-70 (3.98).

Heritability (broad sense) was 59 per cent, it indicates that leaf length was a moderately heritable character. Genotypic coefficient of variation was 8.48, it means that the extent of variability due to genotype was 8.48 per cent. Genetic advance as per cent over mean was moderate (13.43).

b. Leaflet length

The general mean for leaflet length was 1.95 cm. Mean Leaflet length ranged from 1.57 cm (NTI-70) to 2.50 cm (NTI-79). There was significant difference among the families in respect of leaflet length. Higher leaflet length was observed in NTI-79 (2.50 cm), 6 (2.39 cm), 75 (2.08 cm), S-4 (2.08 cm), NTI-84 (2.04 cm) and 19 (2.01 cm). There was significant difference between NTI-79 and 6 and NTI-6 and 75 inrespect of this character. Whereas there was no significant difference among NTI-19, 75, 78, 84 and S-4. Leaflet length was lowest in NTI-70 (1.57 cm).

Heritability (broad sense) was 48, which indicates that leaflet length is low heritable character. Genotypic

coefficient of variation was 9.32, which means that the extent of variability due to genotype was 9.32 per cent. Genetic advance as per cent over mean was moderate (13.31).

4.1.8.5 Diameter of the plant

The general mean for diameter of the plant was 0.26 cm. Diameter of the seedling ranged from 0.20 cm (NTI-62) to 0.33 cm (NTI-6). There was significant difference among the families in respect of diameter at collar region. Higher diameter was observed in NTI-6 (0.33 cm) followed by NTI-71 (0.30 cm), 62 (0.29 cm), S-4 (0.30 cm), NTI-19 (0.28 cm), 61 (0.28 cm), 15 (0.26 cm), 57 (0.26 cm), 75 (0.27 cm), 79 (0.27 cm). There was no significant difference among NTI-6, 71, and S-4, NTI-15, 19, 57, 61, 62, 75 and 79. Lowest diameter was observed in NTI-62 (0.20 cm).

Heritability (broad sense) was 50, which indicates that diameter is a moderately heritable character. Genotypic coefficient of variation was 12.30, indicating the extent of variability due to genotypes. Genetic advance as per cent over mean was moderate (17.92).

4.1.9 Correlation coefficient in half-sib families of tamarind

The expression of character is the consequence of a chain of interwoven events, each affecting the other, either

Table 18 : Correlation matrix (r) in respect of germination and growht parameters of seedlings in half sib families of tamarind

Characters	1	2	3	4	5	6	7	8
1. Per cent of germination	1.000							
2. Height at 1 month stage	0.191	1.000						
3. Number of leaves at 1 month stage	0.292	0.535*	1.000					
4. Height at 6 month stage	-0.184	0.538*	0.301	1.000				
5. Leaves at 6 month stage	-0.205	0.133	0.251	0.543*	1.000			
6. Leaf length at 6 month stage	0.095	0.660**	0.281	0.577**	0.109	1.000		
7. Leaflet length at 6 month stage	0.173	0.613**	0.342 *	0.460*	0.071	0.615**	1.000	
8. Diamter at 6 month stage	-0.152	0.604**	0.427 *	0.697**	0.323 *	0.561**	0.481*	1.000

* - Singnificant at five per cent level
** - Significant at one per cent level

directly or through other events. But generally, we can only observe the ultimate effect of association between the two events. The association can be measured as coefficient of correlation. This method removes the complex relationships between the characters into simple form of association. The method was applied in this study to understand the association of component traits with germination and growth parameters and among themselves. The results on character association of germination per cent and growth parameters are presented in Table-18.

a. Per cent of germination

Per cent germination was positively and non significantly associated with seedling height at one month.

b. Height and number of leaves at one month stage

Height of the seedling is positively and significantly associated with number of leaves at one month stage , height at six month stage, leaf length, leaflet length and diameter at six month stage. It was also positively associated with number of leaves at six month stage.

Number of leaves was positively but non significantly associated with height, leaf length, leaflet length and diameter at six month stage.

c. Height and number of leaves at six month stage

Height was positively and significantly associated with number of leaves, leaf length, leaflet length and diameter.

Number of leaves was positively but non significantly associated with leaf length, leaflet length and diameter.

d. Leaf and leaflet length

Leaf length was positively and significantly associated with leaflet length and diameter of the plant.

4.2 GENOTYPIC RESPONSE TO AIR LAYERING

The main objective of this experiment was to find out the genotypic response to rooting by air layering. To find out the rooting pattern and extent of rooting in different genotypes of tamarind, the following rooting characters were studied.

1. Number of layers rooted
2. Number of roots per layer
3. Length of longest root per layer

PLATE.8 SELECTION OF SHOOT FOR LAYERING

4. Dry weight of roots per layer

5. Post separation establishment of layer.

4.2.1 Number of layers rooted

The data on the number of layers rooted at the end of 90, 120 and 150 days in different genotypes are presented in Table-19.

a. Number of layers rooted at 90 days

Number of layers rooted in different genotypes varied from 0.2 (NTI-17, 80) to 4.2 (NTI-78). Sixteen progenies have recorded higher number of layers rooted over the general mean which was 1.61. There was significant difference among the genotype, in respect of rooting of layers. Higher rooting was observed in NTI-78, 84, 74, 77, 1 and 76 (4.2, 3.4, 3.2, 3.2, 3.0, 3.0, respectively). Number of layers rooted was significantly higher in NTI-78 (4.2), compared to NTI-84 (3.4), 77 (3.2), 1 (3.2), 76 (3.0). There was no significant difference among the NTI-1, 74, 76 and 77.

The genotypes NTI-70, 73 and S-4 were found to be on par with each other. Similarly the next group which included NTI-7, 14, 21, 58 and S-13 did not differ from each other. Number of layers rooted was lowest in genotypes NTI-17, 55, and

Table 19 : Response of different genotypes of tamarind to air layering

Sl. No.	Treatment (Genotypes)	No. of layers rooted at 90 days	No. of layers rooted at 120 days	No. of layers rooted at 150 days	Per cent of layers rooted		
					3rd month	4th month	5th month
1	NTI- 1	3.00	4.00	4.60	60	80	92
2	NTI- 2	0.60	3.40	4.00	12	68	80
3	NTI- 5	1.80	2.80	3.60	36	56	72
4	NTI- 6	0.80	1.80	2.80	16	36	56
5	NTI- 7	2.00	2.80	3.60	40	56	72
6	NTI-14	2.00	3.60	3.60	40	72	72
7	NTI-15	0.80	3.20	4.00	16	64	80
8	NTI-16	1.80	3.00	4.40	36	60	88
9	NTI-17	0.20	0.80	1.60	4	16	32
10	NTI-19	1.60	2.60	3.80	32	52	76
11	NTI-21	2.00	3.20	3.60	40	64	72
12	NTI-31	1.00	3.00	4.20	20	60	84
13	NTI-32	0.60	2.40	3.80	12	48	76
14	NTI-54	0.80	1.80	3.60	16	36	72
15	NTI-55	0.20	1.40	3.00	4	28	60
16	NTI-56	0.40	2.60	4.00	8	52	80
17	NTI-57	1.40	3.20	3.80	28	64	76
18	NTI-58	2.20	3.80	4.40	44	76	88
19	NTI-59	0.60	1.80	3.20	12	36	64
20	NTI-60	0.60	2.20	3.00	12	44	60
21	NTI-61	1.00	3.00	4.60	20	60	92
22	NTI-62	1.20	2.60	3.20	24	52	64
23	NTI-70	2.40	2.80	3.60	48	56	72
24	NTI-71	1.40	3.20	4.80	28	64	96
25	NTI-73	2.60	3.60	4.00	52	72	80
26	NTI-74	3.20	4.20	4.60	64	84	92
27	NTI-75	1.40	2.40	4.00	28	48	80
28	NTI-76	3.00	4.00	4.40	60	80	88
29	NTI-77	3.20	4.20	4.40	64	84	88
30	NTI-78	4.20	4.80	4.80	84	96	96
31	NTI-79	1.40	2.00	2.80	28	40	56
32	NTI-80	0.20	0.60	1.20	4	12	24
33	NTI-82	1.60	3.00	3.60	28	76	88
34	NTI-83	1.40	3.80	4.40	68	76	80
35	NTI-84	3.40	3.80	4.00	32	60	72
36	NTI-85	1.20	2.80	3.60	24	56	72
37	Shimoga-3	1.60	3.20	4.00	32	64	80
38	Shimoga-4	2.40	4.20	4.60	48	84	92
39	Shimoga-7	1.20	2.00	3.40	24	40	68
40	Shimoga-13	2.00	3.80	4.60	40	76	92
	Mean	1.61	2.94	3.78			
	S.Em±	0.10	0.10	0.09			
	C.D. (5%)	0.28	0.28	0.25			

80 (0.2 each). Other genotypes viz., NTI-2, 6, 32, 59, 60, 15 and 54 were on par with each other, but differed significantly from NTI-17, 55 and 80.

b. Number of layers rooted at 120 days

The number of layers rooted at 120 days after layering varied from 0.6 (NTI-80) to 4.8 (NTI-78) and twenty two genotypes recorded higher number of layers rooted over the plot mean (2.94). There was significant difference among the genotypes in respect of rooting of air layering.

Highest number of layers rooted was in NTI-78 (4.8) and this was closely followed by NTI-74, 77 and S-4 (4.2) and NTI-1 (4.0). In the next group of genotypes, number of layers rooted varied from 3.6 to 3.8 and they were on par with each other (NTI-14, 58, 73 and 83). The lowest number of layers rooted was with NTI-80 (0.60).

c. Number of layers rooted at 150 days

The number of layers rooted at 150 days varied from 1.2 (NTI-80) to 4.8 (NTI-78) and in 24 progenies, number of layers rooted was higher than the plot mean (3.78). There was significant difference among the genotypes in respect to number of layers rooted at the end of 150 days. Twenty genotypes which recorded the higher number of rooted layers at 120 days after layering continued to show their superiority at 150 days also.

There was no significant difference among the NTI-1, 61, 71, 74, 78, S-4 and S-13 in respect of number of layers rooted, which varied from 4.6 to 4.8. Similarly NTI-16, 58, 76, 77, 83 (4.4 each) did not differ in their rooting ability.

Next group comprised of genotypes (NTI-2, 15, 31, 56, 73, 75, 84 and S-3) in which number of layers rooted varied from 4.0 to 4.2 and they were on par with each other. The lowest value in respect of number of layers rooted was in NTI-80 (1.2).

4.2.2. Per cent of rooting in air layers of tamarind

The data on per cent of rooting of layers of tamarind at 90,120 and 150 days after layering are presented in Table-19.

a. Per cent of layers rooted at 90 days

The rooting varied from 4 per cent (NTI-17, 55 and 80) to 84 per cent (NTI-78) at the end of 90 days after layering. Higher per cent of rooting was recorded in NTI-78 (84%), 83 (68%), 74 (64%), 77 (64%) and 1 (60%).

The lowest value in respect of rooting of layers was observed in NTI-17, 55 and 80 followed by NTI-2, 32, 59, 60, 6 and 15.

b. Per cent of rooting at 120 days

Per cent of rooting ranged from 12 per cent (NTI-80) to 96 per cent (NTI-78) at the end of 120 days after layering. Higher per cent of rooting was observed in NTI-78 (96%), 74 (84%), 77 (84%), S-4 (84%), NTI-1 (80%). The lowest rooting was observed in NTI-80 (12%).

c. Per cent of rooting at 150 days

Per cent of rooting varied from 24 per cent (NTI-80) to 96 per cent (NTI-71, 78). The genotype NTI-78 topped the list at all the stages of observation. The higher per cent of rooting in layers was observed in NTI-1, 61, 71, 74, 78, S-4 and S-13 with a range from 92 to 96%, indicating their easy to root character. The lowest per cent was observed in NTI-80 (24%), followed by NTI-17 (32%), showing their difficult to root tendency.

4.2.3 Root characters

The data on number of roots, length of longest root, dry weight of roots per layer as observed in different genotypes is presented in Table-20.

a. Number of roots

The number of roots per layer varied from 1.60 (NTI-84) to 7.00 (NTI-62). There was significant difference among

Table 20 : Root characteristics and survival of different genotypes of tamarind air layers at the end of 6th month after potting

Sl. No.	Treatment (Genotypes)	No. of roots per layer	Root legth (cm)	Dry wt. of roots per layers (g)	Per cent survival of layers
1	NTI- 1	5.2	5.0	0.12	50.00
2	NTI- 2	4.0	5.5	0.27	20.00
3	NTI- 5	4.8	4.3	0.08	30.76
4	NTI- 6	3.6	4.7	0.09	50.00
5	NTI- 7	5.4	5.3	0.25	57.14
6	NTI-14	5.8	5.5	0.31	33.33
7	NTI-15	5.4	5.4	0.17	71.67
8	NTI-16	5.0	4.6	0.12	35.30
9	NTI-17	4.4	5.3	0.18	60.00
10	NTI-19	4.6	5.1	0.26	46.67
11	NTI-21	5.8	5.2	0.08	72.72
12	NTI-31	5.6	4.2	0.06	76.92
13	NTI-32	6.6	5.1	0.13	53.85
14	NTI-54	6.0	4.8	0.11	38.46
15	NTI-55	4.6	4.9	0.09	53.85
16	NTI-56	5.0	5.1	0.19	66.67
17	NTI-57	4.4	5.1	0.23	35.71
18	NTI-58	5.2	4.5	0.19	33.33
19	NTI-59	5.4	4.5	0.11	66.67
20	NTI-60	5.2	4.9	0.18	100.00
21	NTI-61	4.8	4.8	0.10	100.00
22	NTI-62	7.0	5.2	0.25	25.00
23	NTI-70	5.6	4.8	0.12	30.00
24	NTI-71	6.2	4.8	0.17	53.00
25	NTI-73	4.6	5.6	0.12	25.00
26	NTI-74	5.4	5.9	0.35	47.60
27	NTI-75	4.6	5.1	0.13	64.30
28	NTI-76	5.8	5.7	0.25	18.18
29	NTI-77	4.6	4.5	0.25	43.75
30	NTI-78	5.4	5.0	0.15	53.33
31	NTI-79	4.2	4.2	0.12	11.11
32	NTI-80	5.8	5.8	0.15	50.00
33	NTI-82	5.4	5.6	0.19	61.54
34	NTI-83	4.4	6.8	0.16	57.14
35	NTI-84	1.6	2.1	0.02	56.67
36	NTI-85	5.0	5.4	0.14	50.00
37	Shimoga-3	4.6	5.4	0.08	28.57
38	Shimoga-4	6.4	5.2	0.33	64.28
39	Shimoga-7	5.2	5.4	0.10	30.76
40	Shimoga-13	5.8	5.6	0.27	41.66
	Mean	5.11	5.05	0.17	
	S.Em±	0.11	0.07	0.01	2.57
	C.D. (5%)	0.30	0.19	0.03	7.10

the genotypes in respect of number of roots produced per layer. Significantly higher number of roots were observed in NTI-62 (7.00) followed by NTI-32 (6.6) and 54 (6.0).

The number of roots observed in case of NTI-14, 21, 76, 80, S-13 was 5.8 per layer. Similarly NTI-31 and 70 recorded the same value (5.6/layer). Further in NTI-7, 15, 59, 74, 78, 82, the number of roots per layer was 5.4. In case of NTI-1, 58, 60, S-7, the number of roots per layer was 5.2 and these were followed by NTI-16, 56 and 85 (5.0/layer). All the above genotypes were on par with each other.

The next group of genotypes included NTI-19, 55, 73, 75, 77 and S-3 where the number of root per layer varied from 4.6 to 4.8 which were on par with each other. Lowest number of roots were recorded with NTI-84 (1.6).

b. Length of roots

The length of longest root in each layer ranged between 2.10 cm (NTI-84) to 6.8 cm (NTI-83). There was significant difference among the genotypes. The highest and significantly higher length of root was observed in NTI-83 (6.8 cm) followed by NTI-74 and 80 (5.9 cm, 5.8 cm respectively). There was no significant difference in root length in case of NTI-76 (5.7 cm), 73 (5.6 cm), 82 (5.6 cm) and S-3 (5.6 cm).

Further NTI-2 (5.5 cm), 14 (5.5 cm), 15 (5.4 cm), 85 (5.4 cm), S-3 (5.4 cm) and S-7 (5.4 cm) were on par with each other with regard to length of root. The lowest length of root was observed with NTI-84 (2.10 cm only).

c. Dry weight of roots

Dry weight of roots per layer varied from 0.02 g (NTI-84) to 0.35 g (NTI-74). There was significant difference among the genotypes in respect of weight of roots per layer. Highest and significantly higher dry weight of roots was observed in NTI-74 (0.35 g), followed by S-4 (0.33 g) and 14 (0.31 g).

There was no significant difference in dry weight of the roots in case of NTI-2, 7, 19, 62, 76, 77 and S-3 where the dry weight ranged between 0.25 g and 0.27 g.

The next group of genotypes with regard to dry weight of roots included NTI-17, 58, 60 and 82 in which dry weight ranged between 0.18 g and 0.19 g.

The lowest value for dry weight of roots per layer was observed in NTI-84 (0.02 g only).

4.2.4 Post separation establishment of layers

The data on the post separation establishment of layers are presented in Table-20. The data on the survival of

air layers at the end of six month revealed significant difference among the different genotypes.

The survival per cent of layers varied from 11.11 per cent (NTI-79) to 100 per cent (NTI-60 and 61). NTI-60 and 61 recorded the highest per cent (100% in each) followed by NTI-31 (76.92%), 21 (72.72%), 15 (71.67%). There was no significant difference among NTI-31, 21, 15 in respect of survival per cent. The lowest per cent of survival of layer was observed in NTI-79 (11.11%).

In rest of the genotypes survival percentage ranged between 18.18 and 66.67 per cent.

4.2.5 Correlation coefficient of layers

The correlation coefficient among the different rooting characters of layers and survival per cent of layers after separation are presented in Table-21.

a. Number of layers rooted at 3^{rd} month

Number of layers rooted at 3^{rd} month was positively and significantly associated with number of layers rooted at 4^{th} and 5^{th} month and positively associated with root weight per layer. Whereas it was negatively associated with number of roots per layer, root length and per cent survival.

Table 21 : Correlation coefficient in respect of root parameters and per cent survival in tamarind layers

Characters	1	2	3	4	5	6	7
1. No.of layers rooted at 3rd month	1.000						
2. No.of layers rooted at 4th month	0.729**	1.000					
3. No.of layers rooted at 5th month	0.520**	0.785**	1.000				
4. No.of roots per layer	-0.032	0.042	0.067	1.000			
5. Root length	-0.003	0.064	0.029	0.255	1.000		
6. Root weight per layer	0.093	0.191	0.163	0.387**	0.398*	1.000	
7. Per cent of survival	-0.179	-0.056	0.060	0.138	-0.043	0.002	1.000

* - Singnificant at five per cent level
** - Significant at one per cent level

b. **Number of layers rooted at 4^{th} month**

Number of layers rooted at 4^{th} month was positively and significantly associated with number of layers rooted at 5^{th} month and positively associated with number of roots per layer, root length and root weight per layer and negatively associated with per cent survival.

c. **Number of layers rooted at 5^{th} month**

Number of layers rooted at 5^{th} month was positively but insignificantly associated with number of roots per layer, root length, root weight per layer and per cent survival

d. **Number of roots per layer**

Number of roots per layer was positively and significantly associated with root weight per layer and positively but insignificantly associated with root length and per cent survival.

e. **Root length**

Root length in each layer was positively and significantly associated with root weight per layer. It was negatively and nonsignificantly associated with per cent survival.

f. **Root weight**

Root weight per layer was positively but non significantly associated with per cent survival of layers.

Discussion

V. DISCUSSION

The department of forest, Government of Karnataka has surveyed the northern region of the state and selected the plus trees of tamarind (Anon., 1989). 'Plus tree' may be defined as outstanding individuals occurring in natural stands or in even aged plantations combining in themselves a number of desirable features (Zobel and Talbert, 1986). The plus trees, whose occurrence is low in frequency, perhaps hard to find, form the base material for tree improvement. Assembling of plus trees as clones in clonal orchards is done using ramets (grafts) in special designs to promote maximum cross pollination among the different clones and reduce inbreeding. Such clonal bank of *Tamarindus indica* L. has been established at Forest Research Centre, Gungargatti (Dharwad) using plus trees material from Belgaum, Bijapur, Dharwad, Shimoga and Uttar Kannada district of Karnataka state. The block consisting of 40 genotypes was taken for the present investigation on growth parameters, flowering pattern, pod characters and yield.

Variability, heritability, genetic divergence, and genotypic response to rooting through air layering were also studied. The results obtained from this investigation are discussed in this chapter.

5.1 MORPHOLOGICAL CHARACTER OF THE PLANT, FLOWERING BEHAVIOUR AND POD SHAPE

Out of 40 genotypes studied in 24 progenies viz., NTI-1, 2, 5, 6, 7, 15, 16, 17, 21, 31, 55, 56, 58, 59, 62, 71, 73, 74, 77, 79, 83, 84, S-3 and S-13, plant growth habit observed was orthotropic nature. This type of plant habit is useful for high density planting, because of its columnar growth habit, as against traditional wider planting, accommodating less number of plants per unit area. Whereas NTI- series viz., 14, 19, 32, 54, 57, 60, 61, 70, 75, 76, 78, 80, 82, 85, S-3 and S-7 were found to be plageotropic in growth habit.

The flowering pattern observed for the four years viz., 1992, 1993, 1994 and 1995 (Table-4) revealed that, the range of flowering varies from 20 to 100 per cent among the different genotypes. Hundred per cent flowering was observed in NTI-14, 19, 57, 78, 83, 85 and S-4.

The flowering and fruiting in tamarind is not a regular feature as in case of some of the mango and apple varieties. In apple biennial bearing varieties produce flowers on spurs, and the annual bearing varieties produce flowers mostly on the shoots. In apple spurs behave as independent units, whereas, no such individuality exists in mango shoots

(McCartney, 1925). Thus the growth pattern in these two types of fruit crops is different and bienniality in bearing is more a problem in mango than in apple. Singh (1959) reported that the age of the shoot does not govern fruit bud differentiation in mango. According to him, this may be due to the fact that the major role in the formation of fruit buds is played by some other factor or factors and not by the maturity or age of the shoot. Hence in tamarind also, the biennial bearing tendency is observed.

With regard to pod shape, three types were observed viz., straight, semi curved, and straight and semi curved. Among the 36 genotypes, 26 exhibited straight and semi curved pods. Five clones produced only straight pods and remaining five produced only semi curved pods.

Similar grouping of tamarind based on fruit shape was proposed by Bailey (1947), Cowen (1970), Paules (1975) and Shivanandam (1980). Cultivars were classified on shape, colour, and quality of fruit in oranges (Corbas and Moscosa, 1958), in mango (Singh, 1963), Jack (Guruprasad, 1981), Pumello (Naryanamurthy, 1982).

5.2 GROWTH, YIELD AND YIELD ATTRIBUTES

A wide range of variability was observed for all the quantitative characters studied. As presented under results, the range of variation noticed was appreciable for many characters.

The characters studied viz., plant height, diameter, number of shoots per 900 cm^2 canopy area, spread of plant in east to west and north to south direction and crown size differed significantly among the different genotypes (Table-2).

Plant height of genotypes varied from 1.47 m (NTI-74) to 2.99 m (NTI-2), diameter from 6.94 cm (NTI-74) to 11.58 cm (S-13), number of shoots per 900cm2 canopy area from 3.6 (NTI-60) to 7.6 (NTI-74), spread of plant, east to west from 1.34 m (NTI-74) to 3.10 m (NTI-7), north to south from 1.28 m (NTI-58) to 2.98 m (NTI-7) and crown size from 1.38 m (NTI-74) to 3.04 m (NTI-7) at the age of five years and significantly differed among the different genotypes.

Maximum height of plant was recorded in NTI-2 (2.99 m), followed by S-4 (2.90 m), 7 (2.82 m), S-7 (2.75 m), 15 (2.62 m), S-13 (2.06m). Highest diameter was noticed in S-13 (11.58 cm), followed by NTI-2 (11.40 cm), 7 (11.24 cm), S-4 (11.08 cm), NTI-32 (10.74 cm), 74, 84, S-13, NTI-19, 14.

Higher number of shoots per 900 cm^2 canopy area was recorded in NTI-14, 19, 74, 84 and S-3. This indicated the compact nature of canopy which provided more bearing area. Higher spread of plant from east to west was noticed in NTI-7 (3.10 m), 2 (2.99 m), 14 (2.82 m), S-4 (2.56 m) while for north to south direction in NTI-7, 2, 14, S-7 and S-4. As a result of this, higher crown size was noticed in NTI-7 (3.04 m), 2 (2.96 m), 14 (2.78 m), S-7 (2.50 m), S-4 (2.47 m) and were considered superior compared to other genotypes in respect of growth.

The data collected on number of pods per plant for three years varied significantly among the genotypes. NTI-71, 19, S-4, NTI-57, 62, 14, 77, 15 and 1 are found to be superior genotypes among the different genotypes.

Number of pods per plant varied significantly from year to year within the genotype. This revealed the alternate bearing tendency of the genotypes. However, in NTI-14 and 57 there was no significant difference in the number of pods per plant between 1994 and 1995 over the years. This indicated their tendency towards regular bearing in the initial stage itself.

Higher yield was obtained from NTI-19, 5, 14, S-4, NTI-15, 57, 62, 75, 83, 85, 79, 61, 7 and 2. NTI-19 was found to be superior among the 40 genotypes, and yield differed significantly from year to year.

NTI-56, 58, 21 and 76 did not produce the fruits and yield levels were low in NTI-80.

The research work done on cloning in tamarind is very meagre. Hence yield data of clonal progenies are not available. However, on well grownup trees the pod yield ranges from 180 kg to 225 kg (Rao, 1959, Lewis and Neelakantan, 1964) and 200 kg to 800 kg (Anon., 1989).

The highest and significantly higher yield was obtained in NTI-19 over all other genotypes. This has been found to be superior among the 40 genotypes. The next best genotypes in descending order were NTI-5, 14, S-4, NTI-15, S-7, NTI-62, 75, 83, 85, 79, 61, 78 and 2.

There was significant difference in length, width, thickness of pod and pod weight, pulp weight per pod, among the different genotypes. Whereas there was no significant difference on number of seeds, seed weight, shell weight and vein weight per pod (Table-5).

Pod length varied from 6.50 cm (NTI-1) to 11.48 cm (NTI-2), width from 1.44 cm (NTI-59) to 2.60 cm (NTI-19), thickness from 1.18 cm (NTI-73) to 1.70 cm (NTI-57), pod weight from 4.2 g (NTI-59) to 14.32 g (NTI-19), pulp weight from 0.92 g (NTI-59) to 4.98 g (NTI-19).

It is clear that a large variation for several quantitative characters are available for utilization in tamarind improvement programme. Such wide variation in other tree crops have been reported by several workers. Paules (1975), Thimmaraju *et al.* (1978) and Samiullah (1984) reported wide variation in tamarind for different characters studied and variations were significant for trunk length, seed yield per tree, pulp yield per tree, pod yield per tree. Keiding *et al.* (1986) and Magnussen and Yeatmen (1989) noticed wide variation for trunk diameter and height in Jack pine. Chaturvedi *et al.* (1989) also observed significant variation in eucalyptus for height and girth. Barner *et al.* (1992) observed appreciable variations for different characters studied in teak, spruce and eucalyptus. Environmental influence was more on characters like branching and growth compared to leaf form, stem straightness and wood density.

Pulp varied from 20.51 (NTI-7) to 43.57 per cent (NTI-76). Seed from 13.53 per cent (NTI-76) to 40.67 per cent (NTI-6), shell from 22.71 per cent (NTI-32) to 42.20 per cent (NTI-60), vein from 2.23 per cent (NTI-57) to 7.31 per cent (NTI-76) and hundred seed weight from 33.21 g (NTI-17) to 98.57 g (NTI-31) (Table-6).

The variation in pulp, seed, shell, vein and hundred seed weight was due to genotypic difference. According to

Hernandez-unzon and Lakshminarayan (1982), tamarind takes 245 days for fruit set to maturity.

The difference in the length of pod may be attributed to the difference in genotypes. Similar variation in fruit length in tamarind was reported by Hernandezunzon and Lakshminarayan (1982) and Kokate (1988). The variation in the width and thickness of pod was due to genetic differences among the genotypes. Similar variation in width and thickness of pod was reported elsewhere (Anon. 1972 and Shivanandam 1980).

The difference in pod weight in the present study may be attributed to number of seeds, seed weight, pulp content, shell weight among the different genotypes. Similar variation in fruit weight of trees of seedling origin was noticed in tamarind (Shivanandam, 1980) and in pumello (Celso,1964, Narayan murthy 1982).

Pulp weight is positively correlated to pod weight in tamarind (Shivanandam and Thimmaraju, 1988). Similar results of variation in pulp weight was recorded in jack fruit by Guruprasad (1981).

The difference in shell weight can be clearly attributed to the differences in size of the fruit. The difference in the fiber weight among the genotypes may be due

to the differences in the rate of development of vascular tissue in fruits.

The difference in seed weight may be attributed to the differences in the number and size of seeds among the clones studied. Similar differences in seed weight was recorded in tamarind by David [illegible] (1907) and Shivanandam (1980). Similarly Celso *et al.* (1954) and Narayanamurthy (1982) also recorded variation in seed weight in pumello.

The difference in seed number may be attributed to the differences in length of pod and ovule fertility. Bailey (1947) reported that in tamarind long pods contain seeds ranging from 6 to 12. Whereas short pods the number of seeds varies from 1 to 4. Cowen (1970) and Shivanandam (1980) recorded a wide variation in number of seeds per fruit in tamarind.

The data on degree of correlation among the different growth parameters in tamarind are given in Table-3 and 7. Plant height and diameter were positively and significantly correlated with plant spread,(east-west and north-south) and crown size. Number of pods and pod weight were positively associated with crown size.

Pod length was positively and significantly associated with pod width, pod weight, number of seeds per pod, seed weight, pulp weight, shell weight and vein weight per pod. Further pod weight was positively and significantly associated with seeds per pod, pulp, seed, shell, vein weight per pod.

The number of seeds per pod was positively and significantly associated with shell, and seed weight per pod. Pulp weight was positively and significantly associated with seed, shell and vein weight per pod.

Similar attempts have been made to assess the correlations among yield attributing traits in other perennial plant species. According to Sukumaran *et al.* (1982) important characters associated with coconut yield were average number of female flowers between 21 and 24 years, number of functional level at 19 years and internodal distance at a fixed mark. However, the association of coconut yield was positive and significant with stem height (Ramanathan, 1984).

5.3 QUALITY CHARACTER

Tartaric acid content ranged between 4.43 per cent (NTI-70) and 14.7 per cent (S-13) during 1994. There was significant difference among the different genotypes with respect to this trait. Similarly tartaric acid content ranged

between 4.00 per cent (NTI-60) and 16.7 per cent (NTI-32) during 1995.

The tamarind pulp contains 8 to 18 per cent tartaric acid (Lewis *et al.*, 1954; Anon., 1976 and Shivanandam, 1980). The differences in tartaric acid content are attributed to the differences in genotypes and varies from season to season.

5.4 MULTIVARIATE STUDIES

The studies carried out during the past have shown that better appreciation of genetic diversity and evolutionary history of crop plants is possible by employing complete statistical tool like multivariate technique. The usefulness of multivariate technique in quantification of genetic diversity has been demonstrated by Samiullah (1993) in tamarind Melendreas and Ortuno (1984) in lemon, Maluf *et al.* (1984) in leucaena, Butenko *et al.* (1987) in cherry.

Mahalanobis generalized distance estimated by D^2 statistic is a unique tool for discriminating the populations by considering a set of parameters together, rather than inferring indices concerning morphological similarity, eco-geographic diversity, and other similar criteria.

It is presumed that geographic diversity is positively related to genetic diversity (Thoday, 1953).

However, all the earlier workers do not hold the same opinion and in many studies it has been shown that no such parallelism exists between geographic and genetic diversity (Arunachalam and Jowahar Ram, 1967; Bhatt, 1970 and 1973; Sheriff, 1982; Kanwal *et al.*, 1983 and Nath *et al.*, 1985).

In the present study 40 genotypes of tamarind belonging to five districts were included to assess the nature of genetic diversity by multivariate analysis. In the canonical variate analysis, the number of variables were reduced to a linear expression called principal component and this accounts for most of the variation produced by these characters. Similarly a second succeeding principal component was also formed to account for the residual variability. The principal component which is a linear expression of the several variables assigns separate weights to each variable depending upon the ability of each character to discriminate the entries.

The first principal component was significant enough to use for the purpose of discriminating the genotypes and to cluster on the canonical configuration. The contribution of the remaining eight vectors was very low and hence, they were not considered.

Samiullah (1993) noticed that first principal components accounted for 96.93 per cent, out of which contribution of the first two components was only 42.37 per cent of the total divergence in tamarind. Butenko *et al.* (1987) observed in cherry, that 86.2 per cent of the total variation was accounted for by the first six principal components, while first component absorbed 35.9 per cent.

In tamarind, pod yield per tree, trunk length and number of primary branches were the most important characters that contributed towards divergence (Samiullah, 1984). However, in eucalyptus, contribution of number of branches, number of leaves, height, internodal length and leaf breadth and length ratio was more towards divergence (Surendram and Chandrasekharna, 1988). Illoh and Olorode (1990) reported that reproductive characters contributed more towards divergence in mango. It seems that growth parameters and reproductive characters in trees contributed more towards divergence.

According to Levin and Turner (1977), number of pods per plant is the one reproductive character that varies very much within a species of compositae family for the purpose of compensation of the deficit in the resource allocated for the reproductive process.

5.5 D^2 ANALYSIS AND CLUSTERING OF THE GENOTYPES BY USING DENDROGRAM TECHNIQUE

In the Mahalanobis D^2 analysis actual distance between the entries are obtained as these D^2 values represent the index of genetic diversity among clusters.

Clustering was done by utilizing dendrogram technique as described by Sneath and Sokal (1973). Utilizing the D^2 values, the dissimilarity coefficients between the genotypes, were estimated and arranged into a reasonable hierarchial system and the diagrams called dendrograms representing the trees that connect the most similar entries were constructed.

Samiullah (1993) used non-hierarchial cluster analysis to group 300 tamarind genotypes into 16 clusters. Maluf *et al.* (1984) distinguished leucaena population into two groups based on hierarchial cluster analysis. Dendrogram technique was used by Melendreas and Ortuno (1984) to classify the lemon varieties in hierarchial order of similarity. Nema and Sharma (1986) used weighed pair group and similarity and distance coefficient to classify 42 cultivars of grape. Similarly D^2 technique has been used to group divergent population into different clusters by Singh *et al.* (1987) in sugarcane, Surendran and Chandrasekharna (1988) extended D^2 technique to group eucalyptus population into 11 clusters.

The D^2 statistic and principal component analysis in selecting divergent parents for successful hybridization have been adopted in many crops (Matzringer and Wensmen, 1967; Chandrasekaraiah *et al.*, 1969; Ram and Panwar, 1970; Bhatt, 1973; Maurya and Singh, 1977; Dremlyuk and Grigoryan, 1984).

The clustering pattern of different genotypes is presented in Table-13. The data clearly indicates that no parallelism can be drawn between geographic and genetic diversity. The genotypes collected from Bagalkot for instance, have got into Cluster-I, IV and X. Similarly, the genotypes from Belgaum, have found place in Cluster-II, III, IV, V, VII, VIII, IX and X. This particular aspects proves one more point, that is, the genotypes from Belgaum are relatively more diverse among themselves than the genotypes from any other region.

The intra cluster distance was relatively high in respect of Cluster number-I, II, VII, VIII and IX. Cluster-VII, VIII and IX are composed of clones from Belgaum, Dharwad and Shimoga. As already mentioned in the earlier paragraph, the genotypes of Belgaum region have been quite diverse, therefore, the inclusion of genotypes from Belgaum in these three groups in addition to the genotypes from two other zones, has probably contributed more towards intra cluster distance, by virtue of which, these three groups have shown high diversity. Same is the case with Cluster-II and III.

Cluster VI appearsto be relatively more diverse from all other clusters. Looking to the inter cluster distance values one can broadly categories, the clusters into five broad groups, the first group comprises clusters I, II and III. While second group comprising cluster IV, and V, third group comprises cluster VI, fourth group comprises cluster VII and VIII and finally fifth group comprising cluster IX and X.

Table-11 indicated that the first vector itself accounted for very large amount of total variance. It was to the extent of 99.231 per cent. Therefore, canonical root 1 only was considered for getting information on the relative contribution of different character towards divergence (Table-12). It is further interesting to note that of all the traits, pulp weight or pulp yield alone was responsible for the diversity observed in the material. It is often said that this kind of information provides a clue regarding the evolutionary history of the crop species.

The information obtained from the present study indicates that pulp weight was the most important factor, which was responsible for discrimination in the genotypes studied. It may be mentioned that the 40 genotypes which were ultimately selected for detailed investigation were chosen, on the basis of their yield potentiality. This being the fact, the pulp,

seed, shell content of these genotypes varied from 23.06 per cent to 32.91 per cent, 27.42 per cent to 36.03 per cent and 29.91 per cent to 38.86 per cent respectively as mentioned in Table-6.

It is also note worthy that the present findings are in agreement with those of earlier workers particularly, Illoh and Olorode (1990) Gangaprasad (1993) and Samiullah (1993).

As observed from Table-15, Cluster IV appears to be good source of a gene as for as pulp character is concerned. It was characterized by the highest mean weight for pulp weight and very high mean value for its associated characters like pod length, pod width and pod weight. But with lower mean value for the seed characters like seed weight and seeds per pod. To some extent Cluster-VI can also be regarded as important cluster as far as pulp weight is concerned. Genotype of this cluster may be used judiciously for further improvement of pulp character, by careful choice of other parental lines by thorough evaluation of other collections on similar basis.

5.6 VARIABILITY STUDIES IN HALF-SIB FAMILIES OF TAMARIND

The pattern of variability helps to design the testing procedure and identify the superior genotypes based on the desirable traits. The characters studied viz., germination

per cent, plant height, number of leaves at one month, further plant height, number of leaves, leaf length, leaflet length, diameter at six month stage differed significantly among the 20 genotypes (Table-16).

The germination per cent of 20 genotypes varied from 36.67 per cent (NTI-19) to 93.33 per cent (NTI-83), height of seedling from 7.00 cm (NTI-70) to 14.26 cm (NTI-6), number of leaves from 2.48 (NTI-70) to 3.59 (NTI-6) at one month. Height of seedlings ranged from 16.10 cm (NTI-74) to 28.27 cm (NTI-6), number of leaves from 7.17 (NTI-84) to 16.27 (NTI-75), leaf length from 3.98 cm(NTI-70) to 5.93 cm (NTI-6). Leaflet length from 1.57 cm (NTI-70) to 2.50 cm (NTI-79) and diameter of the plant from 0.20 cm (NTI-62) to 0.33 cm (NTI-6).

Among 20 genotypes NTI-6 recorded higher height and number of leaves at one month (14.26 and 3.50 respectively). Further higher leaf length, leaflet length and diameter were recorded in NTI-6, (5.93 cm), 2.39 cm and 0.33 cm respectively). Hence NTI-6, was found to have higher values for plant height, number of leaves, leaf length, leaflet length and diameter and significantly differed from other genotypes.

5.7 GENOTYPIC COEFFICIENT OF VARIATION (GCV), PHENOTYPIC COEFFICIENT OF VARIATION (PCV), HERITABILITY (h^2), GENETIC ADVANCE (GA) AND GENETIC ADVANCE AS PERCENTAGE OF MEAN

The genotypic coefficient of variation (GCV) was highest (Table-17) for number of leaves (18.88) followed by germination per cent (18.43), height (13.34), diameter (12.30), leaflet and leaf length (9.32 and 8.98% respectively).

PCV was the highest for germination per cent (30.04), followed by leaves (26.75), height (17.75), diameter (17.40), leaflet length (13.48) and number of leaves (11.47). In all the characters, PCV was higher than GCV indicating the role of environment. Similar results were reported by Srivastava *et al.* (1993) in *Terminalia arjuna* for the plant height and leaflet breadth and by Srivastava *et al.* (1993a) in the same species for leaf length, leaf breadth and seedling height. The variation was to the extent of 50 per cent and above for plant height, basal diameter, indicating the greater influence of environment in the expression of these characters.

Heritability (broad sense) was moderate in respect of germination (60%), height, number of leaves, leaf length, diameter of the plant, whereas it was low for leaflet length (Table-17) at six month stage. Srivastava *et al.* (1993a) reported high heritability for leaf length : leaf breadth and

low heritability for leaf length in *Terminalia arjuna*.

Genetic advance as percentage of mean was high in case of number of leaves (27.47) followed by per cent germination (23.29) and height at one month and 6 month (20.93 and 20.65 respectively). It was moderate in case of diameter (17.92), leaf length (13.43) and leaflet length (13.31).

Swarup and Chaugale (1962) opined that the GCV alone was not sufficient for the determination of the amount of heritable variation. Further, heritable variation may be efficiently used with greater degree of accuracy when studied in conjunction with genetic advance. Johnson *et al.* (1955a) suggested that heritability and genetic advance when considered together were more useful for predicting the resultant effect of selecting the best individuals than heritability or genetic advance alone. It was stated that high genetic gain along with high heritability shows the more effective conditions of selection.

With regard to correlation studies of half-sib families, it shows that plant height, number of leaves, leaflet length, which were positively correlated with each other can be considered as selection criteria to improve the productivity. Srivastav *et al.* (1993a) reported, positive

association between seedling height and leaf breadth in *Terminalia arjuna*.

5.8 GENOTYPIC RESPONSE TO AIR LAYERING

Vegetative propagation assumes greater importance in maintaining uniformity in the trees for achieving stability in quality and production. The results of the present study of genotypic response to rooting of air layers in different genotypes of tamarind are discussed here.

The extent of rooting varied from 4 (NTI-77, 55 and 80) to 84 per cent (NTI-78) at 90 days. 12 per cent (NTI-80) to 96 per cent (NTI-78) and 24 per cent (NTI-80) to 96 per cent (NTI-71, 78) at 120 days and 150 days respectively. This clearly indicates that there is lot of variation in rooting ability among different genotypes. Similar results were obtained in cashew. Aravindakshan *et al*. (1986) reported that in cashew variety NLR-2-1 the layers obtained by treating with IAA at 250 ppm and 100 ppm were superior compared to the other treatments including control. But in case of variety BLA-139-1, IBA at 250 and 500 ppm, IAA at 100 and 200 ppm were found to be superior.

Pre-girdling treatment of shoots improved the percentage of rooting and IBA treatment in Mussaenda as reported by Katagihallimath (1986).

It was observed that the ability of growth regulators to induce roots differed with the individual trees. These contradictory results of the growth regulators were probably because of the fact that they are specific in their action on particular plant species and genotype. This fact is in close agreement with tamarind as it is highly cross pollinated crop and large variation is observed in the seedling progenies. Hence in NTI-80 and 17, there was less rooting of layers compared to other genotypes of tamarind. This observation is in accordance with the observation made by Rameshnaik (1988) studied the propagation of 40 bougainvillea cultivars by cutting under Dharwad conditions. Among 40 cultivars, 13 cultivars were found difficult to root.

The number of roots per layer varied from 1.60 (NTI-84) to 7.00 (NTI-62), length of longest root varied from 2.10 cm (NTI-84) to 6.80 cm (NTI-83), dry weight of root varied from 0.02 g (NTI-84) to 0.35 g (NTI-74). There was significant difference among the different genotypes in respect of root characters.

In the present study, pre girdling 20 days before layering, use of IBA 500 ppm and layering in June month resulted in the higher rooting in tamarind layers except in NTI-80 and 17. Hence these two clones (NTI-80 and 17) appear to be difficult to root among the different genotypes.

The survival per cent of layers varied from 11.11 per cent (NTI-79) to 100 per cent (NTI-60, 61). Significantly higher survival of layer was observed in NTI-60, 61, 21 and 15. Lower per cent of survival was observed in NTI-79 and 76.

Several workers have observed that successful establishment of the plants depends upon the initial root characters like number of roots, and length of roots. It is evident from the present study that maximum per cent of survival (100%) at the end of 180 days was obtained with NTI-60 and 61. In these genotypes better rooting of air layers in terms of number, length and weight of roots, was observed, which further resulted in higher percentage of post separation establishment.

Lower survival value of layers was observed in NTI-79 and 76, although rooting was better. Lower survival value may be attributed to brittle nature of roots in the above said genotypes. Normally roots which are brittle in nature are likely to be damaged while uprooting and transplanting.

From the above results it may be concluded that the production of well developed flexible root system in air layers of tamarind has a direct influence on the establishment of layers in the field. These findings are in accordance with those of Bid and Mukherjee (1969) in mango.

Number of layers rooted at 90 days was positively but insignificantly associated with root weight (0.093), and negatively associated with number of roots (-0.032), root length (-0.003), and per cent of survival (-0.179) of layers (Table-21).

Number of layers rooted at 120 days was positively and nonsignificantly associated with number of roots (0.042), root length (0.064) and root weight (0.191) and negatively associated with per cent of survival (-0.056) of layers.

Number of layers rooted at 150 days was positively and nonsignificantly associated with per cent of survival (0.060). Therefore for better survival of layers, the layers can be separated 120 days after layering, so that the survival of layers would be better compared to 90 days after layering.

Number of roots per layer was positively and significantly associated with root weight per layer. Similarly root length was positively and significant associated with root weight per layer. Further, root weight per layer was positively and non significantly associated with survival of layers.

5.9 RESEARCH HIGHLIGHTS AND FUTURE LINE OF WORK

5.9.1 Research highlights

1. Based on the morphological character of the plant, the genotypes were grouped as vigorous, medium and low vigoured types, viz., NTI-2, 7, 15, 17, 19, S-4, S-7 and S-13 as vigorous type.
2. Two types of plant growth habit were observed viz., orthotropic and plageotropic.
3. Based on pod shape, the different genotypes were grouped into three as straight, semi curved, straight and semi curved type.
4. NTI-19, 5, S-4, NTI-14, 15, 71, 75, 57, 62, 83, 85, 61, 2 and 1 were found superior in respect of yield.
5. Multivariate analysis indicated that pulp weight alone contributed maximum in discriminating the genotypes. 40 genotypes were grouped into 10 clusters, Cluster-IV had the highest mean value (3.15) for pulp weight.
6. Variability studies in half-sib families indicated that NTI-6 was found to be superior among 20 progenies in respect of growth.
7. Among different genotypes, NTI-17 and 80 were found difficult to root and remaining genotypes were easy to root through air layering.

Description of eight promising genotypes of tamarind (*Tamarindus indica* L.)

I. Growth parameters of different genotypes at 5th year

Sl. No.	Genotype	Plant height (m)	Plant diameter (cm)	No.of sheets per 30cm² area	Canopy spread of plant (m)		Crown size (m)
					East to West	North to South	
1.	NTI-19	2.23	8.62	7.2	2.16	2.22	2.19
2.	NTI-5	2.21	7.80	4.2	2.14	2.18	2.16
3.	S-4	2.90	11.08	6.4	2.56	2.38	2.47
4.	NTI-14	2.26	9.26	7.0	2.82	2.74	2.78
5.	NTI-15	2.62	10.32	6.8	2.34	2.30	2.32
6.	NTI-75	1.86	8.60	5.2	1.90	1.96	1.93
7.	NTI-57	2.22	9.00	4.8	2.34	2.20	2.27
8.	NTI-62	2.15	7.46	5.2	2.00	1.92	1.96

NTI - Northern Zone *Tamarindus indica*; S - Shimoga

II. Growth habit, per cent of flowering and pod shape of promising tamarind genotypes

Sl. No.	Genotype	Growth habit	% of flowered trees	Pod shape
1.	NTI-19	Plageotropic	100	Straight and semi curved
2.	NTI-5	Orthotropic	80	Straight and semi curved
3.	S-4	Orthotropic	100	Straight
4.	NTI-14	Plageotropic	100	Semi curved
5.	NTI-15	Orthotropic	90	Semi curved
6.	NTI-75	Plageotropic	85	Straight and semi curved
7.	NTI-57	Plageotropic	100	Straight and semi curved
8.	NTI-62	Orthotropic	90	Straight

III. Pod characteristics of eight promising genotypes of tamarind

Sl. No.	Genotype	Pod length (cm)	Pod width (cm)	Pod thickness (cm)	Pod weight (g)	No.of seeds/ pod	Seed wt./pod (g)	Pulp wt./ pod (g)	Shell wt./ pod (g)	Vein wt./ pod (g)
1.	NTI-19	11.17	2.60	1.56	14.32	5.90	3.68	4.98	5.04	0.98
2.	NTI-5	10.07	2.07	1.43	12.11	4.17	2.47	3.96	3.07	0.57
3.	S-4	6.61	1.82	1.41	5.73	3.00	2.29	2.14	2.42	0.38
4.	NTI-14	8.46	1.76	1.36	9.36	5.20	3.90	3.85	2.66	0.73
5.	NTI-15	9.19	2.39	1.60	10.64	4.10	2.77	4.01	2.90	0.44
6.	NTI-75	9.23	2.14	1.64	12.04	5.67	5.33	3.07	3.81	0.64
7.	NTI-57	7.94	1.67	1.70	7.35	4.13	2.09	2.22	1.79	0.19
8.	NTI-62	8.81	1.83	1.38	8.36	7.30	3.56	2.11	3.39	0.40

IV. Pod yield of eight promising genotypes of tamarind

Sl. No.	Genotype	Number of pods per plant				Yield per plant (kg)			
		1993	1994	1995	Mean	1993	1994	1995	Mea
1.	NTI-19	5.60	157.00	33.20	65.27	0.14	1.45	0.60	0.7
2.	NTI-5	11.60	50.60	74.20	45.47	0.10	0.45	0.74	0.4
3.	S-4	4.40	150.40	39.80	64.87	0.02	0.80	0.40	0.4
4.	NTI-14	15.80	56.40	64.80	45.67	0.10	0.36	0.76	0.4
5.	NTI-15	12.80	91.00	32.80	45.53	0.07	0.77	0.29	0.3
6.	NTI-75	20.00	68.40	20.00	36.13	0.19	0.58	0.27	0.3
7.	NTI-57	28.00	63.00	69.80	53.60	0.18	0.38	0.52	0.3
8.	NTI-62	43.40	91.00	24.00	52.93	0.25	0.51	0.20	0.3

V. Tartaric acid content

Sl. No.	Genotype	Tartaric acid (%)
1.	NTI-19	13.63
2.	NTI-5	6.53
3.	S-4	8.15
4.	NTI-14	12.23
5.	NTI-15	6.30
6.	NTI-75	6.23
7.	NTI-57	4.50
8.	NTI-62	5.43

5.9.2 Future line of work

1. The present study was confined to only six years old trees, hence further observations are necessary on these genotypes.

2. Some of the desirable characters can be combined through breeding.

3. Duration of flowering, and pod maturity are to be studied.

4. Studies on flowering behaviour and yield are to be continued in order to identify the genotypes with tendency towards regular bearing.

5. Some anatomical studies are needed in difficult to root genotypes.

6. Post separation establishment of layers under open and glass house conditions needs to be studied.

7. Propagation studies by other vegetative means can be standardized.

8. Propagation by tissue culture technique is needed for mass multiplication of elite genotypes.

Summary

VI. SUMMARY

The present study was undertaken to evaluate 40 genotypes in the gene bank of tamarind (*Tamarindus indica* L.) established at Forest Research Centre (Gungargatti), Government of Karnataka, employing biometric analysis and to know the genotypic response to rooting through air layering. The study was conducted from 1992 to 1995 and the salient findings are summarised below.

1. Morphological characters and plant type

The growth parameter analysis for different characters viz. Plant height, diameter, number of shoots per 900 cm^2 area, spread of plant East-West, North-South and crown size showed significant variation among the 40 genotypes.

a. The height of the plant varied from 1.47 m (NTI 74) to 2.99m (NTI 2). Maximum height was recorded in NTI-2 (2.99 m), followed by S-4 (2.90 m), 7 (2.82 m) and and lowest height was recorded in NTI-61 (1.58 m).

b. Diameter ranged from 6.94 cm (NTI 74 to 11.58 cm (S-13). Higher diameter was recorded in S-13 (11.58 cm), NTI-2 (11.40 cm), 7(11.24 cm), S-4 (11.08 cm), lower diameter was observed in NTI 74 (6.94 cm).

c. The range of variation for number of shoots per 900 cm^2 area was between 3.6 (NTI-60) and 7.6 (NTI 74). NTI-74, 84, S-13, NTI - 19, 14, recorded higher number of shoots per 900cm^2 area (7.0 to 7.6), indicating the compact nature of canopy.

d. The range of variation for spread of plant in East-West direction was from 1.34 m (NTI-74) to 3.10 m (NTI-7), and North-South, the spread was from 1.28 m (NTI-58) to 2.98 m (NTI-7), crown size was from 1.38 m (NTI-74) to 3.04 m (NTI-7). Hence higher spread and crown size were noticed in NTI-7 compared to other genotypes of tamarind.

e. Based on the growth of plant the genotypes were grouped in three categories viz. vigorous, NTI-2, 7, 15, 17, 79, S-4, S-7 and S-13. Medium Viz., NTI-5, 14, 16, 19, 21, 54, 56, 57, 59, 60, 62, 71, 73, 76, 77, 78, 82 and 84, Low vigoured viz. NTI-1,6, 31, 32, 55, 58, 61, 70, 74, 75, 80, 83, 85, and S-3.

f. Plant height was positively and significantly correlated with plant diameter, plant spread and crown size. Plant diameter and spread (East-West) were positively and significantly correlated with plant spread North-South and crown size.

g. Two types of plant growth habit were observed viz. Orthotropic, and plageotropic.

i. NTI-1, 2, 5, 6, 7, 15, 16, 17, 21, 31, 55, 56, 58, 59, 62, 71, 73, 74, 77, 79, 83, 84 and S-4 exhibited orthotropic plant type.

ii. NTI-14, 19, 32, 54, 57, 60, 61, 70, 75, 76, 78, 80, 82, 85, S-3, S-7, S-13 exhibited plageotropic plant type.

2. Flowering behaviour in different genotypes of tamarind

The range of flowering varied from 20 to 100 per cent among the different genotypes. NTI-14, 19, 57, 78, 83, 85, and S-4 recorded 100 per cent flowering (1992 to 1995).

3. Pod characteristics and its components

a. Three types of pod shape were observed viz straight, semi curved, and semi curved and straight.

b. There was significant difference in length, width, thickness, weight, pulp weight per pod. Whereas, there was no significant difference in number of seeds per pod, seed weight per pod, shell weight and vein weight per pod.

c. Pod length varied from 6.50 cm to 11.48 cm, Width from 1.44 cm to 2.6 cm, thickness from 1.18 cm to 1.70 cm, pod

weight from 4.20 g to 14.32 g, Pulp weight from 0.67 g to 4.98 g, number of seeds per pod from 2.5 to 7.3, seed weight from 1.55 g to 5.50 g, shell weight from 1.21 g to 5.04 g, vein weight from 0.11 g to 0.98 g.

d. Per cent of pulp ranged from 20.51 to 43.57 seed from 13.53 to 40.67 per cent. Shell from 22.71 to 42.20 per cent, vein from 2.23 to 7.31 per cent. Hundred seed weight ranged from 33.21 g to 98.57 g.

e. Pod length was positively and significantly associated with pod width, weight, seeds, pulp weight, shell weight, vein weight, and seed weight per pod.

4. Number of pods and pod yield of tamarind

a. The range of variation for the number of pods per plant varied from 0.8 (NTI-21) to 67.4 (NTI-71). There was significant difference among the genotypes. Highest number of pods per plant was recorded in NTI 71 (67.4) and it was followed by 19 (65.27), S-4 (64.87), 57 (53.60), 62 (52.93), and these genotypes are superior compared to others.

b. There was no significant difference in the number of pods between year 1994 and 1995 in NTI-14 and 57 indicating their tendency towards regular bearing nature. Whereas

number of pods varied significantly among the genotypes NTI-62, 15, 5, and 1 for the year 1994 and 1995. Therefore it appears that these genotypes are having tendency towards biennial bearing.

c. The yield varied from 0 kg to 0.73 kg per plant. Highest yield was recorded in NTI-19 (0.73 kg/plant).

d. Yield per plant varied from year to year within the genotypes which was observed in NTI-19, 14, 5, and S-4.

5. Tartaric acid

Tartaric acid content ranged between 4.00 per cent to 16.7 per cent. Tartaric acid content in pulp was significantly higher in NTI-32 (16.70%).

6. Multivariate analysis, and clustering pattern of tamarind clones

a. As revealed by the first Vector, pulp weight alone contributed maximum (99.23%) in discriminating the genotype. Shell weight and pod weight are the other two important characters which contributed to divergence.

b. The horizontal line drawn at a dissimilar coefficient of 1.63, resulted into 10 clusters. Cluster II recorded

highest intra cluster distance (17.13), followed by Cluster-VII (15.63). While cluster X recorded lowest intra cluster distance (3.00).

c. For pulp weight per pod cluster IV had the highest mean value (3.15), pod weight cluster VII (12.67 g) was the best. cluster II is characterized by lengthy pods (9.46 cm).

7. Variability studies in half sib families of tamarind

The different characters studied viz, germination per cent, plant height, number of leaves, leaf length, leaflet length, diameter differed significantly among the 20 progenies studied.

a. NTI-6 was found to have higher values for plant height, number of leaves, leaf length, leaflet length, and diameter.

b. In all the characters, phenotypic coefficient of variance (PCV) was higher than genotypic coefficient of variance (GCV), indicating the influence of environment.

c. Heritability (broad sense) was medium in respect of all the characters except leaflet length, which was low.

d. Genetic advance as per cent over mean was high for germination per cent, height and number of leaves and was medium for leaf length, leaflet length and diameter.

e. Height at six month stage was positively and significantly associated with number of leaves, leaf length, leaflet length and diameter.

8. Genotypic response to air layering

a. The rooting varied from 4 per cent (NTI 77, 55, and 80) to 84 per cent (NTI-78) at 90 days, 12 per cent (NTI 80) to 96 per cent (NTI 78) and 24 per cent (NTI 80) to 96 per cent (NTI 71, 78) at 120 days and 150 days respectively.

b. The number of roots per layer varied from 1.60 to 7.00 length of longest root from 2.10 cm to 6.80 cm, dry weight of root from 0.02 g to 0.35 g. There was significant difference among the genotypes in respect of root parameters.

c. The survival per cent of layers varied from 11.11 per cent to 100 per cent, significantly higher survival of layers was observed in NTI 60, 61, 21, 31 and 15 over others.

d. Number of layers rooted at 120 days was positively and but non significantly associated with number of roots, root length, and root weight.

References

VII. REFERENCES

ANAND, I.J. AND MURTHY, B.R., 1968, Genetic divergence and hybrid performance in linseed. ***Indian Journal of Genetics***, 28 : 178-185.

ANDERSON, T.W., 1958, An introduction to Multivariate statistical Analysis. John Wiley and Sons Inc., New York, P.320

ANONYMOUS, 1972, *Tamarindus indica* L. In Wealth of India Council of Scientific and Industrial Research, New Delhi, Vol.X : pp.114-122.

ANONYMOUS, 1976, Tamarind, In ***Tropical legumes : Resources for the future***, National Academy of science, Washington, D.C.

ANONYMOUS, 1979, *Tropical legumes-Resources for the future*, National Academy of Science, Washington, D.C. p.122.

ANONYMOUS, 1989, Plus trees, Karnataka Forest Department, Silviculturist, Northern zone, Dharwad, Karnataka, pp.41-48.

A.O.A.C., 1975, ***Official and Tentative Methods of Analysis***. Association official Analytical Chemists, 12th Edn., Washington, P.401.

ARAVINDAKASHAN,K., GEORGE,T.K., BALAKRISHAN, S. AND VEERAGHAVAN, P.G., 1986, Studies on the effect of certain growth regulators on the rooting of cashew air layers. ***Cashew Causerie***, 8 : 14-15.

ARUNACHALAM, V. AND JAWAHAR RAM, 1967, Geographical diversity in relation to genetic divergence in cultivated sorghum. ***Indian Journal of Genetics***, 27 : 369-380.

BAGCHI, S.K., 1992, A Preliminary study on the genetic divergence of *Acacia nilotica* through seed parameters. ***Indian Forester***, 118(6) : 416-424.

BAGCHI, S.K., CHOUBEY, A.K. AND KULKARNI, H.D., 1987, Variability analysis among half-sib seedlings of *Santalum album* L. ***Indian Forester***, 113 (5) : 370-374.

BAGCHI, S.K. AND VEERENDRA, H.C.S., 1985, Study on intra-tree and inter-tree variations in leaves of *Santalum album*. ***My Forest***, 21 : 33-39.

BAGCHI, S.K. AND VEERENDRA, H.C.S., 1991, Variation and relationship in developmental growth phases of *Santalum album* after pruning ***Indian Forester***, 117(12) : 1053-1058.

BAILEY, 1947, Tamarind : ***The Standard Encyclopedia of Horticulture***, New York, M.C., 3 : 3306-3307.

* BARNER, H., DITLEISSEN, B. AND KRISTEN, 1992, ***Introduction to Tree Improvement*** DANIDA Forest seed centre, Humleback, Denmark, 81 pp.

BEARDMORE, J.A. AND SHAMI, S.A., 1976, Parentage genetic variation and selection. In : ***Population Genetics and Ecology***. Ed. Samuel Karlin and Eviator, Nero, Academic Press.

BHATT, G.M., 1970, Multivariate analysis approach to selection of parents for hybridization aiming yield improvement in self pollinated crops. ***Australian Journal of Agriculture Research***, 21 : 1-7.

BHATT, G.M., 1973, Comparison of various methods of selecting parents for hybridization aiming yield improvement in self-pollinated crops. ***Australian Journal of Agriculture Research***, 24 : 457-464.

BHUJBAL, G.G., 1972, Effective concentration of IBA in air layering of guava. ***Research Journal of Mahatma Phule Agriculture University***, 3 : 53-56.

BID, N.N. AND MUKHERJEE, S.K., 1969, Varietal response to etiolation and growth regulators treatment in air-layering of mango. ***Indian Journal of Agriculture Science***, 39 : 1073-1019.

BOSE, R. C., 1936, The exact distribution and movement of coefficient of the D^2 statistic, *Sankhya* 2 : 143-154.

BURLEY, J., WOOD, P.J. AND HANS, A.S. 1977, Variation in leaf characteristics among provenances of *Eucalyptus Camaldulensis* Dehn. growth in Zambia. ***Australian Journal of Botany***, 21 : 69-77.

BURNS AND PRAYAG, S.H., 1920, Book of Mango Bulletin. Department of Agricultural Bombay, 1 : 3-103.

* BUTENKO, A.I., KURSAKOVA, L.E., PERFLEV, C.E. AND LEBEDER, A.V., 1987, Determining the genotypic background of cherry varieties by the principal component method. ***Bulletine Nauchnoi Informatsai***, **45** : 52-57.

CARNAHAM, H.L. AND CARLSON, G.E., 1963, General and specific combining ability in relation to diallel crossing. ***Australian Journal of Biological Science***, **16**:463-493.

* CELSO, E., HERMOSA AND GANGULY, L.G., 1954, ***Philippines Agriculture***, 38 : 225-242.

CHALLAPILLI, A.P., 1992, Studies on evaluation of elite tamarind (*Tamarindus indica* L.) types for quality, yield and multiplication by air layering. ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Dharwad.

CHANDRASHEKHARAIAH, S.R., MURTHY, B.R., ARUNACHALAM, V., 1969, Multivariate analysis of divergence in Eu-Sorghums. In : *Proceedings of National Institute of Science*, 35 : 172-175.

CHATURVEDI, A.AN., SIVAJI, P. AND JAYARAM PRASAD, D.O., 1989, Eucalyptus provenances trials in Andhra Pradesh. *Indian Forester*, 115 : 145-154.

CORBOS, S. AND MOSCOSA, 1958, The puretorican chiranja-New all purpose citrus fruit. *Economic Botany*, 12 : 87.

COWEN, D.V., 1970, Tamarind In : *Flowering trees and Shrubs in India*. Thacker and Co. Ltd., Rampart Row Fort, Bombay, pp.51-52.

* DACUNCHA, A.B. AND DOBZHANSKY, T.,1954, *Evolution*, 8 : 119-134, as quoted by Beardmore and Shami, 1976.

DALJITH SINGH, 1963, Need for clonal selection and standardization in mango. *Punjab Journal of Horticulture*, 3 : 194-198.

DEVID, H.F.C.S., 1907, Tamarind, The uses and composition of tamarind seeds. *The Agricultural Ledger*, 2 : 13-16.

DHILLON, R.S., BISLA, S.S. AND BANGARWA, K.S., 1992, Correlation and path coefficient studies in morphological characters of Shisham (*Dalbergia sissoo* Roxb.). ***My Forest***, 28(4) : 349-353.

* DREMLYUK, G.K. AND GRIGORYAN, E.M., 1984, Methods of classifying inbred sorghum lines on the basis of genotypic values of characters using cluster analysis. ***Biologiya***, 6 : 119-124.

FALKENHAGES, E.R., 1991, Provenance variation in *Pinus radius* at six sites in South Africa. ***Silvae Genetica***, 40(2) : 41-56.

GALANG, F.C.AND LAZO, F.D., 1935, The relation of fruiting to vegetative growth characters in carbao mango (*Mangifera indica* L.). ***Philippine Journal of Agriculture***, 6 : 129-139.

GANESHAIAH, K.N., 1979, Multivariate analysis for yield and its contributing characters in horsegram *(Dolichos biflorus* L.). ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Bangalore.

GANGAPRASAD, S., 1993., Studies on genetic divergence in tamarind (*Tamarindus indica* L.) across provenances of southern Karnataka. *Ph.D. Thesis*, Submitted to University of Agricultural Sciences, Bangalore.

GRIFFING, B., 1956, Concept of general and specific combining ability in relation to diallel crossing system. ***Australian Journal of Biological Science***, 9:463-493.

GRUBB, N.H., 1955, Cherry varieties, nomenclature and identification. ***Scientiae Horticulture***, 11 : 46-56.

GUPTA, M.P. AND SINGH, R.B., 1970, Genetic divergence for yield and its components in greengram. ***Indian Journal of Genetics***, 29 : 212-221.

GURUPRASAD, T.R., 1981, Studies on systematic selection of jack fruit (*Artocarpus heterophyllus* L.) types. ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Bangalore.

HEGDE, N.K., 1987, Studies on the propagation of cashew (*Aracardium occidentale* L.) by air layering and epicotyl grafting. ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Dharwad.

HEGDE, S.S., 1988, Propagation studies in some important ornamental shrubs by cuttings. ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Dharwad.

HERNANDEZ-UNZON, H.Y. AND LAKSHMINARAYANA, S., 1982, Developmental physiology of tamarind fruit. ***Horticulture Science***, 17(6) : 938-940.

HERNANDEZ-UNZON, H.Y. AND LAKSHMINARAYAN, S., 1982a, Biochemical changes during development and ripening of tamarind fruit. ***Horticulture Science***, 17(6) : 940-942.

HILLING, K.W. AND FEZZONI, A.F., 1987, Multivariate analysis of sour cherry germplasm collection. ***Journal of American Society of Horticulture Science***, 113(6) : 928-934.

ILLOH, H.C. AND OLORODE, O., 1990, Numerical and taxonomic studies of mango (*Mangifera indica* L.) varieties in Nigeria. ***Euphytica***, 51(3) : 197-205.

* JAMBULINGAM, R., 1989, Growth and biomass of *Casuarina equisetifolia* Forest in different ecosystems. ***Ph.D. Thesis***, Submitted to Tamil Nadu of Agricultural University, Coimbatore.

JHA, K.K., GUPTA, C. AND VERMA, R.S., 1991, Field testing of few promising clones of poplar in Terai. ***Indian Journal of Forestry***, **14**(2) : 83-89.

JOHNSON, H.W.,ROBINSON, H.P. AND COMSTOCK, R.E., 1955, Estimates of genetic and environmental variability in soybean. ***Agronomy Journal***, **47** : 314-318.

* KANWAL, K.S., SINGH, R.M., SINGH, J. AND SINGH, R.B., 1983, Divergent gene pool in rice improvement. ***Theoretical and Applied Genetics***, **65**(3) : 263-267.

KAPUR,S.K. AND DOGRA, A.S.,1987, Provenance trial of *Eucalyptus tereticornis* in Punjab. ***Indian Forester***, **113**(1):2-5.

KAPUR, S.K. AND DOGRA, A.S., 1987a, Provenance trial of *Eucalyptus camaldulensis* in Punjab. ***Indian Forester***, **113**(2) : 471-475.

KATAGIHALLIMATH, SOMASEKHAR, 1986, Studies on the effect of pre-girdling and auxins on the rooting of air layers of *Mussaenda erythrophylla* Schum, and Thonn. Variety Rosea. ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Dharwad.

KEDHARNATH, S., 1982, Genetic variability and heritability of juvenile height growth in *Eucalyptus grandis*. ***Journal of Tree Science***, 1(1-2) : 46-49.

KEDHARANATH, S., 1986, Genetics and improvement of forest trees. ***Indian Journal of Genetics***, 46 : 172-180.

KEDHARNATH, S., CHETTY, C.K.R. AND RAWAT, M.S., 1969, Estimation of genetic parameters in Teak (*Tectona grandis*) without raising progeny. ***Indian Forester***, 95 : 238-245.

KEIDING, H., WELLENDORF, H. AND LAURIDSEN, E.B., 1986, Evaluation of an international series of teak provenance trials. ***DANIDA Forest Seed Centre***, Humleback, Denmark, P.81.

KHOSLA, P.K., DHALL, S.P. AND KHANNA, D.K., 1979, Studies in *Populus ciliata* Wall. Ex. Royle, I.Correlation of phenotypic observation with sex of trees. ***Silvae Genetica***, 28 : 21-23.

KHOSLA, P.K., KUSHAL, P.K. AND KHURANA, D.K., 1980, Studies in *Populus ciliata* Wall. Ex. Royle, II. Phenotypic variation in natural stands. ***Silvae Genetica***, 29 : 31-37.

KOKATE, A.S., 1988, Tamarind and Aonla, ***Summer Institute on Dryland Horticulture Advances in Arid Zone Fruits***, MPAU, Rahuri.

* KOVAS, S. AND BURGETIX, V., 1984, Chlorophyll and dry matter content of leaves and their correlation with yielding ability in some new selection of apple. ***Kereszeti Egytem Kazlemenye***, **48** : 41-47.

* KRISHNAMOORTHY, A.V.R.G., 1989, Provenance trials of Teak in Andhra Pradesh - A status paper in : Seminar on Provenance Research, Jan.18th and 19th Institute of Forest Genetics and Tree Breeding, Coimbatore.

KULKARNI, H.D. AND SRIMATHI, R.A., 1982, Variation in foliar characteristics in sandal. Biometric Analysis in Improvement of Forest Biomass (Ed.Khosla, P.K.). International Book Distributors, Dehra Dun, pp.63-69.

* KUMARAN, K., 1991, Genetic analysis of seed and juvenile seedling attributes in neem (*Azadirachta indica* A.Juss) and Pungam (*Pongamia pinnata* (Linn) Pierre). ***M.Sc. Thesis***, Submitted to Tamil Nadu Agricultural University, Coimbatore,

LAKSHMIKANTHAN, D., RAWAT, M.S. AND KEDHARNATH, S., 1974, Half-sib analysis of genetic variance in Teak. ***Indian Journal of Genetics***, **38A**: 423-428.

* LEBEDER, A.V. AND CHUCHA, V.S., 1984, Inter-relation of some quantitative characters in apple. ***Byul. Nauch. Inf.***, **41** : 20-24.

LEVIN, D.A. AND TURNER, B.L., 1977, Clutch size in compositae In : ***Evolutionary Ecology***, Ed. Bernardstone House and Christopher Perrina, University Park Press, London,

LEWIS, Y.S., DWARAKANATH, C.T. AND JOHAR, D.S., 1954, Utilization of tamarind pulp. ***Journal of Scientific and Industrial Research***, **13A** : 284.

LEWIS, Y.S., DWARAKANATH, C.T. AND JOHAR, D.S., 1957, Further studies on red tamarind. ***Current Science***, **26**:394-395.

LEWIS, Y.S. AND JOHAR, D.S., 1956, Characterization of the pigment in red tamarind. ***Current Science***, **25** : 325.

LEWIS, Y.S. AND NEELAKANTAN, S., 1964, The chemistry, biochemistry and technology of tamarind. ***Journal of Scientific Research***, **23** : 203-206.

MAGDALITA, P.M., ESPINO, R.B., ROSARIO, G.E. AND RIVERA, F.N., 1984, Phenotypic variability in some characters of papaya (*Carica papaya* L.). ***Philippine Agriculturist***, **67**(3) : 289-294.

* MAGNUSSEN, S. AND YEATMAN, C.W., 1989, Height and growth components in inter and intra provenance jack-pine families. ***Canadian Journal of Forestry Research***, **19** : 962-972.

MAHALANOBIS, P.C., 1928, A Statistical study at Chinese head measurement *Journal of Asiatic Society*, Bengal, **25** : 301-377.

MAHALANOBIS, P.C., 1936, The generalized distance in statistics. ***Proceedings of National Academy of Science***, India, **12** : 49-55.

MAHALANOBIS, P.C., MAJUMDAR, D.N. AND RAO, C.R., 1949, Anthropometric survey of the united provenance, A statistical study. ***Sankhya***, **9** : 90-324.

* MALUF, A.M., MARTINS, P.S., FERREIRA, P.E. AND MALUF, W.R., 1984, Cluster analysis and evaluation of leucaena populations for aluminium tolerance. ***Pesquisa Agropecuria Brasilaria***, **19**(8) : 999-1002.

MANATURAGIMATH, B.B., BULGANNAVAR, G.N., PARAMESWARAPPA, S. AND BURLEY, J., 1991, Provenance trial on *Eucalyptus cloeziana* in Western Ghats of Karnataka, India. ***Indian Forester***, **117** (12) : 1013-1020.

* MATZRINGER, D.F. AND WENSMEN, E.A., 1967, Genetic diversity and heterosis in *Nicotina* interspecific crosses. ***Zuchter***, 37(3) : 395-402.

MAURYA, D.M. AND SINGH, D.P., 1977, Genetic divergence in rice. ***Indian Journal of Genetics***, 37(3) : 395-402.

McCARTENY, J.L., 1925, Relatin of spur growth to blossom and fruit production in the wagener apple. ***Proceedings of American Society of Horticulture Science***, 22 :126-133.

MELENDREAS,F.A. AND ORTUNO,A.,1984,Statistical characterization of lemons. ***Agrologia***, 43 : 919-941.

MURTHY, B.R., ANAND, I.J. AND ARUNACHALAM, V., 1965, Sub species differentiation in *Nicotiana rustica* L. ***Indian Journal of Genetics***, 25 : 217-223.

NARAYAN, R.K.J. AND MACEFIELD, A.J., 1976, Adaptive response and genetic divergence in a world germplasm collection of chickpea (*Cicer arietinum*). ***Theoretical and Applied Genetics***, 47 : 179-187.

NARAYANAMURTHY, R., 1982, Studies on systematic evaluation of productive pumello of seedling type. ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Bangalore.

NATH, B., OMRAN, A.D. AND HOUSE, L.R., 1985, Genetic divergence among a non restorer collection of sorghum. ***Euphytica***, 34(2) : 441-447.

NELSON, C.D. AND TAUER, C.G., 1987, Genetic variation in juvenile characters of *Populus deltoides* Bartr. from the southern Great Plains. ***Silvae Genetica***, 36 (5-6) : 216-221.

NEMA, M.K. AND SHARMA, B.B., 1986, Numerical taxonomic studies in grape. ***Journal of Horticulture***, 43(3) : 194-202.

OTEGBEYE, G.O., 1991, Age trends in the genetic control of stem diameter of *Eucalyptus tereticornis* and the implication for selection. ***Silvae Genetica***, 40(2) : 85-87.

PANSE, V.G. AND SUKHATME, P.V., 1978, ***Statistical Methods for Agricultural Works***, Indian Council for AGricultural Research, New Delhi.

PAULES, D., 1975, Tamarind. ***Agricultural Agro Industry Journal***, 8 : 35-37.

PURI, D.N., GUPTA, R.K. AND DHYANI, S.K., 1989, Screening of promising Leucaena provenances for Doon valley. ***Indian Forester***, 115 : 900-904.

PURSEGLOVE, J.W., 1981, ***Tropical crops - Dicotyledons***, The English Language Book Society and Longman, Essen, U.K., pp.204-206.

* RAJARAM, S., 1990, Provenance studies in *Gliricidia sepium* (Jacq) Walp. ***M.Sc. (Agri) Thesis***, Submitted to Tamil Nadu Agricultural University, Coimbatore, P.118.

RAM, J. AND PANWAR, D.V.S., 1970, Interspecific divergence in rice. ***Indian Journal of Genetics***, **30** : 1-10.

RAMANATHAN, T., 1984, Characters association in coconut. ***Madras Agriculture Journal***, 71(3) : 52-57.

RAMESHNAIK, H.S., 1988, Studies on the propagation and flowering behaviour in Bougain villea cultivars under Dharwad condition. ***M.Sc. (Agri) Thesis***, Submitted to University of Agricultural Sciences, Dharwad.

RANDHAWA, M.D., 1965, Tamarind In : ***Flowering trees,*** National Book Trust, New Delhi, pp.104-106.

RAO, C.R., 1948, The utilization of multiple measurements in problems of biological classification. *Journal of Royal Statistics Society*, **10** : 159-203.

RAO, C.R., 1960, Multivariate analysis : An indispensable tool in statistical and applied research. ***Sankhya***, **20** : 317-338.

* RAO, M.G.V. AND BADAMI, K., 1930, A preliminary note on varieties of *Santalum album* L. Mysore Sandal Spike Investigation Committee Bulletin, No.3 : 5.

RAO, P.S., 1959, Tamarind In : Industrial gums, polysaccharide and their derivatives (Academic Press, New York) (ed.), Whistler and Be-Miller, pp.461-504.

RATHINAM, M., SURENDRAN, C. AND KNODUS, S., 1981, Inter-relationship of wood yield components in *Eucalyptus tereticornis* Sm. ***Indian Forester***, **108** : 465-470.

* ROBERTS, R.H., 1920, 'Off' year bearing and apple spur growth. ***Research Bulletin Agriculture Experiment Station***, University of Wisconsin.

* ROBERTS, R.H., 1925, Prune the bearing apple tree. ***Research Bulletin Wisconsin Agriculture Experiment Station***, P.378.

ROBINSON, H.F., COMSTOCK, R.E. AND HARVEY, P.H., 1957, Genotypic and phenotypic correlations in corn and their implications in selection. ***Agronomy Journal***, 43 : 282-287.

SAMIULLAH, R., 1984, Biometric studies in tamarind (*Tamarindus indica* L.). ***Ph.D. Thesis***, Submitted to University of Mysore, pp.1-154.

SAMIULLAH, R., 1993, Genetic diversity in tamarind, Abstracts of Golden Jubilee Symposium on Horticulture Research -Changing Scenario. Publication of Horticulture Society of India, New Delhi, P.473.

SAMIULLAH, R.,SHERIFF, R.A. AND CHICKADEVAIAH, 1993a, Character association and path analysis in Tamarind. Abstracts of Golden Jubilee Symposium on Horticulture Research -***Changing Scenario***. Publication by Horticulture Society of India, New Delhi, P.473.

SAVUR, G.R., 1956, Tamarind pectin industry in India. ***Chemistry and Industry***, 13 : 212-214.

SHERIFF, R.A., 1982, Genetic divergence studies in foxtail (*Setaria italica* B.). ***Ph.D. Thesis***, Submitted to the University of Agriculture Sciences, Bangalore.

SHIVANANDAM, V.N., 1980, Studies on systematic selection of productive types of tamarind (*Tamarindus indica* L.). ***M.Sc. (Agri) Thesis***, Submitted to UAS, Bangalore.

SHIVANANDAM, V.N. AND THIMMARAJU, K.R., 1988, Correlation between some fruit characters of four tamarind types. ***Mysore Journal of Agricultural Science***, 22 : 229-231.

SINGH, R.N., 1959, Studies in the differentiation and development of fruit-buds in mango (*Mangifera indica* L.) varieties. III.Mango shoots and fruit bud differentiation. ***Horticulture Advance***, 3 : 28-49.

SINGH, D., 1963, Need for clonal selection and standardization in mango. ***Punjab Journal of Horticulture***,3 : 194-198.

SINGH, N.B. AND BENIWAL, B.S., 1993, Variability, heritability and genetic gain of some growth characters in *Bambusa balcooa*. ***Indian Forester***, **119**(3) : 205-210.

SINGH, R.K. AND CHAUDHARY, B.D., 1985, ***Biometrical Methods in Quantitative Genetic Analysis***. A Kalyani Publishers, New Delhi, P.318.

SINGH, N.B. AND CHAUDHARY, V.K., 1992, Multivariate analysis of genetic divergence in wild apricot (*Prunus armeniaca* Linn). ***Indian Journal of Forestry***, **15**(3) : 211-216.

SINGH, H.N., RAI, J.N. AND VISHWAKARMA, R.S., 1987, Genetic divergence in sugarcane. ***Indian Sugar Crops Journal***, **13**(2-3) : 1-4.

SINGH, L.B. AND SINGH, R.N., 1958, Variability in mango and its significance to the production of new varieties. ***Indian Journal of Horticulture***, **16** : 168-172.

* SNEATH, P.H.A. AND SOKAL, R.R., 1973, ***Numerical Taxonomy***, W.H. Freeman and Co., San Francisco, P.573.

SNEDECOR, G., 1961, ***Statistical Methods***, Ed.S. IOWA State Uni. Press, Amer. IOWA, P.534.

SRIVASTAVA, D.P., SRIVASTAVA, P.K., GOEL, A.K. AND THANGAVELU, K., 1993, Genetic variability in *Terminalia arjuna* Beld. ***Indian Journal of Forestry***, **16**(3) : 223-225.

SRIVASTAVA, P.K., SIDDIQUI, A.A. AND GOEL, A.K., 1993a, Genetic variability in half-sib seedlings of *Terminalia arjuna* Bedd. ***Indian Forester***, **119**(1) : 53-58.

STEPHAN DURAIRAJ, M., 1981, Correlation studies between biomass yield and its correspond eye in *Casuarina equisetifolia*. Paper presented at National Seminar on Tree Improvement Thiruchipapalli, January 8, P.122.

* STEPHENSON, J. AND CHURCHILL, J.M., 1931, ***Medical Botany***, Vol.II, Academy Press, London, P.173.

SUKUMARAN, C.K., NARASIMHAYYA, C. AND VIJAYAKUMAR, G., 1982, Path coefficient analysis in coconut. In: ***IV Annual Symposium of Plantation Crops (PLACROSYM)***, Mysore, pp.191-199.

SUNDARAJAN, S. AND MADHAVA RAO, V.N., 1967, Studies on fruit development and fruit quality in some varieties of sapota. ***South Indian Horticulture***, **25** : 52-57.

* SURENDRAN, C., 1982, Evaluation of variability, phenotypic stability, genetic divergence and heterosis in *Eucalyptus tereticornis* Sm. ***Ph.D. Thesis***, Submitted to Tamil Nadu Agricultural University, Coimbatore.

SURENDRAN, C. AND CHANDRASEKARAN, P., 1988, Genetic divergence among half-sib progenies of *Eucalyptus tereticornis* Sm. In : Trends in Tree Sciences (Eds. Khosla, P.K. and Sehagal, R.N.)., ISTS, pp.218-224.

SURI, S.K., 1984, Analytical study of teak provenance tests in North Raipur division of Madhya Pradesh. ***Indian Forester***, **110** : 345-363.

SWARUP, V. AND CHAUGALE, D.S., 1962, Studies on genetic variability in sorghum : Phenotypic variation and its heritable components in some important quantitative characters contributing towards yield. ***Indian Journal of Genetics***, **22** : 31-36.

THIMMARAJU, K.R., NARAYAN REDDY, M.A., SWAMYRAO, N. AND SULLADMATH, U.V., 1978, Studies on the floral biology of tamarind (*Tamarindus indica* L.). ***Mysore Journal of Agricultural Sciences***, **11** : 293-298.

THODAY, J.M., 1953, Components of fitness. ***Symposium of Society on Experiment Biology***, 7 : 96-113.

* TRISDESLEY, M.L., 1921, A first study of the burmese Skull. ***Biometrika***, 13 : 247-257.

UPADHYA, M.K. AND MURTHY, B.R., 1971, Genetic diversity and combining ability in pearl millet. ***Indian Journal of Genetics***, 31 : 63-71.

VERMA, M.M., MURTHY, B.R. AND SINGH, H.B., 1973, Adaptation and genetic diversity in soybean. II.Genetic diversity and relationship with adaptation. ***Indian Journal of Genetics***, 33(3) : 326-333.

VOLKER, R.W., DEAN, C.A., TIBBITS, W.N. AND RAVENWOOD, I.C., 1990, Genetic parameters and gains expected from selection in *Eucalyptus globulus* in Tasmania. ***Silvae Genetica***, 39 : 18-21.

* WHITEMORE, R.N.H., THOMPSON, J.B. AND VALLE RIBERIO, M.A.M., 1958, Studies on breeding of self pollinated cereals. II. The use of diallel cross analysis in yield prediction. ***Euphytica***, 7 : 149-169.

WINTON, A.L, AND WINTON, K.B., 1935, The Structure and Composition of foods, John Wiley and Sons, Ltd., New York, 2 : 669.

* WRIGHT, S., 1921, Correlation and causation. *Journal of Agriculture Research*, 20 : 577-586.

YING, C.C. AND BAGLEY, W.T., 1976, Genetic variation of Eastern Cotton Wood in an eastern Nebraska Provenance Study. *Silvae Genetica*, 25 : 65-73.

ZOBLE, B. AND TALBERT, J.T., 1986, Applied Forest Tree Improvement, John Wiley and Sons, New York, P.505.

---

* - Original not seen.

Appendix

APPENDIX-I : PLUS TREES OF TAMARIND, THEIR LOCATION, DETAILS OF THE TREE AND CRITERIA FOR SELECTION

Species – Tamrindus indica

Hunse

Sl. No.	Tree No.	Forest Division	Range	Village or Beat	Location details & Name of Owner	Details of the tree			Yield in Kgs.	Fruit size		No. of fruits /Kgs.	Wt. of 100 seeds in gm.	Wt. of each fruit/ with seeds in gm.	Wt. of pulp/ fruit in gm.	Wt. of Seeds/ fruit in gm.	Criteria for selection
						Height in M	Grith in Cm	Crown width in M		Length in Cm	Breadth in Cm						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	NTI 1	Bagalkot	Badami	Bommasagar	Sri. Channayya Hiremath of Bommagagar.	40.00	505	22.00	800	25	3,5	19	140	50	26 52%	19 38%	Very high yield
2	NTI 2	Belgaum	Golehalli	Chinchwad	Sri. L. B. Patil of Chinchwad.	22.00	254	20.00	750	19	2.7	51	75	19.5	10.5 53%	7 35%	–do–
3	NTI 3	Bagalkot	Indi	Atharga	Sri. Channabasappa Ankalgi of Atharga.	42.00	305	25.00	675	23	2.5	30	110	35	19.00 54%	12 34%	–do–
4	NTI 4	—do—	—do—	—do—	—do—	40.00	420	20.00	650	22	3.0	35	115	30	16.00 53%	12 40%	–do–
5	NTI 5	—do—	Badami	Vasan	Sri. Ningappa Tegginmani of Vasan.	32.00	148	29.00	650	22	3.8	35	120	30	16 00 53%	11.5 38%	–do–
6	NTI 6	Belgaum	Golihalli	Chinchwad	Sri. K. H. Yallurkar of Chinchwad.	21.00	303	13.00	650	6.6	2.7	57	100	17.5	1000 57%	6.5 37%	–do–
7	NTI 7	—do—	—do—	Gudolli	Sri. P. K. Fernandis.	17.00	250	16.00	650	15.3	2.0	58	105	17.3	9.5 55%	6.5 37%	–do–
8	NTI 8	Dharwad	Dhundasi	Timmapur	Sri. M. S. Hutgar of Timmapur.	13.00	136	07.00	650	18.5	2.0	54	80	18.5	10 00 54%	7 38%	–do–
9	NTI 9	Bagalkot	Badami	Vasan	Sri. Rangappa Pagargowda of Vasan.	38.00	623	22 00	600	18.0	3.0	30	120	35	18.00 51%	12 34%	–do–
10	NTI 10	Bagalkot	Indi	Atharga	Sri. Shekharappa Pujari of Atharga.	35.00	580	20.00	600	24.0	3.0	33	115	30	16.00 53%	11 37%	–do–
11	NTI 11	—do—	—do—	—do—	Sri. Yerappa Kashbag of Atharga.	40.00	480	30.00	600	25.0	3.0	30	125	35	18 00 51%	14 40%	–do–
12	NTI 12	Gadag	Ron	Mensagi	Sri. Basappa Hebballi of Mensagi.	15.00	150	18.00	600	23.0	2.9	30	120	35	19.00 54%	12 34%	–do–
13	NTI 13	Belgaum	Golihalli	Chinchwad	Sri. A. B. Singapur.	18.00	250	16.00	600	18.5	2.4	50	85	19.5	10.5 54%	6.5% 33%	–do–
14	NTI 14	—do—	—do—	—do—	Sri. S. T. Golekar of Chinchwad.	17.00	252	15.00	600	17.00	2.6	55	90	18.0	9.5 53%	6.5 36%	–do–
15	NTI 15	Belgaum	Golihalli	Chinchwad	Sri. G. M. Kumbari of Chinchwad.	16.00	325	16,00	600	16.3	2.3	54	95	18.5	10.00 54%	6.5 35%	–do–
16	NTI 16	—do—	—do—	—do—	Sri. S. V. Patil of Chinchwad.	14.00	172	12 00	600	15 5	2.2	56	105	18.0	9.5 53%	6.5 36%	–do–
17	NTI 17	—do—	—do—	—do—	M. K. Urad of Chinchwad.	15.00	264	12.00	600	15.1	2.5	52	95	18.5	10·5 57%	6.5 35%	–do–
18	NTI 18	—do—	—do—	Gudolli	Sri, S. M. Basrikatti.	20.00	325	16.00	600	14.3	1.8	58	95	17,5	9.5 54%	6.5 37%	–do–

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
20	NTI 20	Dharwad	Dundashi	Ramankoppa	Sri. K. H. Thargatti of Ramankoppa.	18.00	265	11.00	600	16.0	1·9	50	95	19.5	10.0 51%	7.0 36%	Very high yield
21	NTI 21	Bagalkot	Badami	Badami (Bommasagar)	Sri. Mudiyappanavar of Badami.	20.00	150	16.00	560	25.0	3.0	30	130	35.0	19.0 54%	13.0 37%	Big size-fruits and high yield
22	NTI 22	—do—	Hungund	Gudur	Sri. B. K. Kulkarni of Gudur.	25.00	300	12.00	500	25.00	2.8	25	125	40.0	22.0 55%	14.0 35%	-do-
23	NTI 23	—do—	Badami	Vasan	Sri. Ningappa Teggimani of Vasan.	24.00	189	23.00	540	25.00	3.0	23	130	45.0	24.0 53%	15.0 33%	-do-
24	NTI 24	—do—	—do—	—do—	—do—	20 00	200	18 00	520	24.00	3.10	34	120	30.0	16 53%	11.5 38%	-do-
25	NTI 25	—do—	Indi	Atharga	Sri. Shekharappa Pujari.	30.00	450	25.00	550	23.00	2.8	35	115	30.0	16 53%	11.0 36%	-do-
26	NTI 26	Shimoga	Ayanur	Kunchenalli	Sri. Malleshi of Kunchenalli on the left side of Shimoga Devbal-Road, about 300 metres in side from the Road. Malki S. No. 75 of Kunchenalli.	18.00	190	11,00	450	23.00	2.75	45	68	21.0	12 3 58%	6.5 31.1%	-do-
27	NTI 27	—do—	—do—	Beerankeri	Sri. Basappagowda of Beerankeri. On the right side of Beeranakeri Kommanala colony road.	19.00	379	16.00	500	26.00	3.3	46	64	21.5	13.3 62%	7.0 32%	d-o-
28	NTI 28	Shimoga	Ayanur	Bikkenalli	Road side tree. On the right side of Shimoga Sawalnga road.	15.00	175	10 00	450	26.00	3.2	44	63	22.5	14.0 62%	7.5 33%	-do-
29	NTI 29	—do—	—do—	Abbalgeri	On the left side of Shimoga-Sawlanga road. Near Abbalgere bus-stop Road. side tree.	17.00	335	12.00	450	24.00	3.5	44	64	22.7	13.5 59%	7.5 33%	-do-
30	NTI 30	Gadag	Ron	Mensagi	Sri. Basappa Hebballi of Mensagi.	20.00	125	16.00	550	22.00	3.0	30	120	35.0	18.5 53%	12.00 34%	-do-
31	NTI 31	Yellapur	Mundgod	Arsingeri	Govt. primary school Arisinggeri.	18.00	420	10.00	450	24.00	2.5	35	95	30.0	18.5 62%	9.0 30%	-do-
32	NTI 32	—do—	—do—	—do—	Sri. Channappa Jigalur.	16.50	243	8.00	500	22.00	2.5	40	90	26.0	16.0 62%	8.5 32%	-do-
33	NTI 33	Dharwad	Dhundsi	Tadas	Sri. T. Y. Konnur	13.00	166	7.00	450	23.00	2.6	45	100	24.5	18.5 51%	8.00 7.5%	Medium size & good quality fruits
34	NTI 34	Bagalkot	Badami	Badami Banashankari	Sri Kadappa Rangappa Pujari of Badami.	10.00	280	10.00	500	16.0	2.5	40	95	25.5	15.5 61%	7 5 29%	-do-
35	NTI 35	—do—	—do—	—do—	-do-	12.00	380	12 00	550	15.00	2.8	35	105	30.0	18.0 60%	8.0 27%	-do-
36	NTI 36	—do—	—do—	—do—	Sri Ishwarappa Kallappa Pattanashetty.	20.00	400	19.00	530	18.00	2.5	42	110	26.0	14.0 54%	9.0 35%	-do-
37	NTI 37	—do—	—do—	—do—	Sri. Mallappa Hiremath ot Badami.	12.00	335	16.00	500	19.00	3.0	39	100	28.0	16.0 57%	8.5 30%	-do-
38	NTI 38	—do—	—do—	—do—	Sri. Shantappa Jigbaddi of Badami.	25.00	420	18.00	525	18.00	3.0	40	100	25.0	13.5 54%	9.0 36%	-do-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
39	NTI 39	Bagalkot	Badami	Badami (Banashankari)	Sri. Mallappa Holarkeri of Cholochagudda.	15.00	425	12.00	550	20.00	3.0	36	115	30.0	15.0 50%	11.0 37%	Midum size and good quality fruits.
40	NTI 40	—do—	—do—	Cholochagudda	Sri Shidhi master of Cholochagudda	12.00	390	11.00	510	20	3.0	38	110	29.0	14.0 48%	9.0 31%	–do–
41	NTI 41	Bagalkot	—do—	Nagral	Sri Challal patel modin of Cholochagudda.	15.00	275	9.00	525	18	3.0	45	100	25.0	13.5 54%	7.5 30%	–do–
42	NTI 42	—do—	—do—	Cholochagudda	Sri Sidhi master of Cholochagudda	10.00	140	9.00	550	16	2.8	39	110	28.0	15.5 55%	8.5 30%	–do–
43	NTI 43	—do—	—do—	—do—	Sri Beerankatti Ishwarppa of Cholochagudda.	12.00	215	9.00	500	20	2.7	36	110	29.5	16.0 54%	8.5 29%	–do–
44	NTI 44	—do—	—do—	Mallapur	Sri Adviyappa Mallayya of Mallapur	12.00	200	7.00	520	20	2.8	35	120	30.0	16.5 55%	10.0 33%	–do–
45	NTI 45	—do—	—do—	Vasan	Sri Bhimappa J. Nadvani of Vasan	33.00	300	20.00	500	20	3.0	32	115	33.0	19.0 57%	10.0 30%	–do–
46	NTI 46	—do—	—do—	—do—	Sri Ningappa Teggimani of Vasan.	25.00	195	20.00	500	20	2.8	36	115	30.0	16.5 55%	10.5 35%	–do–
47	NTI 47	—do—	—do—	—do—	Sri Basappa Ingaleshwar of Vasan.	35.00	400	30.00	500	20	2.4	41	115	26.0	11.0 43%	10.0 38%	–do–
48	NTI 48	Shimoga	Ayanur	Kollapur	Sri Papa Naik of Abbalgeri Near Devbal research nursery.	25.00	340	10.00	500	20	3.0	45	90	28.0	15.5 55%	8.5 30%	–do–
49	NTI 49	—do—	—do—	—do—	Sri Rama Naik of Sogolli Village.	24.00	200	7.00	500	18	2.7	40	80	27.0	14.0 52%	8.0 30%	–do–
50	NTI 50	—do—	—do—	—do—	Sri S. P. Ishwarappa of Savalanga,	19.00	290	10.00	550	17	2.7	43	85	26.5	13.5 51%	8.5 32%	
51	NTI 51	—do—	—do—	Old Kunchenahalli	Smt. Shitakai Bai. C/o Badiya of Kunchenahalli	22.00	334	13.00	550	19	3.0	45	65	26.0	14.0 54%	7.5 29%	
52	NTI 52	—do—	—do—	Kunchenahalli	Sri Malleshi of Kunchenahalli On the left side of Shimoga - Devbal road, about 300 mts. inside from the road.	17.00	127	12.00	450	19	3.0	43	60	25.0	13.5 54%	7.0 28%	–do–
53	NTI 53	—do—	—do—	Bikkenhalli	Sri Doddatammanappa of Bikkenhalli. On the left side of Shimoga Savlanga road, at a distance of 150 mts. from the road.	16.00	206	9.00	500	19	2.8	46	63	25.5	13.5 53%	7.0 25%	–do–
54	NTI 54	—do—	—do—	Hosalli	On the left side of shimoga Gajanur road, at a distance of 200 mts. from the road Near Bela tree	13.50	273	12.00	500	18	3.0	40	64	26.5	16.0 60%	7.5 28%	–do–
55	NTI 55	Dharwad	Kalghatagi	Dummwad	Sri Fakeerappa Basrikoppa of Dummwad.	14.00	440	16.00	450	11.5	1.7	43	90	22.5	11.5 51%	8.5 38%	–do–
56	NTI 56	Belgam	Golihalli	Chinchwad	Sri P. Y. Mandvi.	13.00	230	12.00	450	17.0	2.3	51	70	19.5	10.0 51%	6.5 33%	–do–
57	NTI 57	—do—	—do—	—do—	Sri Tukaram Patil of Chinchwad.	15.00	228	13.00	450	15.5	2.3	58	78	18.5	10.0 54%	7.0 38%	–do–

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
58	NTI 58	Belgaum	Golihalli	Chinchwad	Sri S. T. Takkar of Chinchwad.	15.00	272	12.0	550	15.5	2.2	55	69	18.5	10 0 54%	6.5 35%	—do—
59	NTI 59	—do—	—do—	—do—	Sri N. H. Patil of Chinchwad	16 00	240	15.0	500	16.4	2.4	51	80	20.5	11.0 54%	6.5 32%	—do—
60	NTI 60	—do—	—do—	—do—	Sri H. N. Patil of Chinchwad.	10.50	276	14.0	450	18.9	2.8	53	80	19.5	10.5 54%	6.5 33%	—do—
61	NTI 61	—do—	—do—	—do—	Sri D. B. Mandvi of Chinchwad.	17.00	224	15.0	500	17.8	2.6	54	75	18.5	10.0 54%	6.5 35%	—do—
62	NTI 62	—do—	—do—	Gudolli	Sri A. B. Wadkarof Gudolli	18.00	292	18.0	500	15.9	2.1	52	80	19.0	10.0 53%	7.0 37%	—do—
63	NTI 63	Dharwad	Dundsi	Tadas	Sri Maheboob Aralikatti of Tadas.	16,00	270	7.0	450	18.5	2.2	49	85	22.0	11.5 52%	8.0 36%	—do—
64	NTI 64	—do—	—do—	—do—	—do—	17.50	263	9.0	400	19.5	2.0	52	80	19,5	10.5 54%	7.0 36%	—do—
65	NTI 65	—do—	—do—	Kanankeri	Sri Bhimanna Siddappannavar of Konankeri.	18.00	360	8.0	500	15.2	3.00	54	75	19.0	9.5 50%	7.5 39%	—do—
66	NTI 66	—do—	—do—	Timmapur	Sri R. G. Pawar of Timmapur	16.00	290	8.0	450	15.5	2.2	58	75	18.5	9.5 51%	7.0 38%	—do—
67	NTI 67	—do—	—do—	—do—	Sri M. Y. Kammannanvar.	14.00	284	14.0	450	15.8	2.0	53	70	18.5	9.5 51%	6.5 35%	—do—
68	NTI 68	—do—	—do—	Ramankoppa	Sri. S. F. Kurodi of Ramankoppa.	14.00	179	7.0	400	7.7	2.0	58	65	18.0	9.5 52%	6.0 33%	—do—
69	NTI 69	—do—	—do—	Parasapur	Sri N. A. Yeligar of Parasapur	19.00	243	9.0	450	20.2	2.9	50	70	20.0	10.5 52%	6,5 32%	—do—
70	NTI 70	—do—	—do—	—do—	Sri R. M. Patil of Parasapur	16.00	222	10,0	450	20.0	2.0	53	70	19.5	10.0 51%	6.5 33%	—do—
71	NTI 71	—do—	—do—	—do—	Sri A. B. Harijan of Parasapur.	14.00	240	8.0	500	16.5	2.0	54	75	19.5	9,5 48%	7.0 36%	—do—
72	NTI 72	Haliyal	Dandeli	Alur	Sri Matur Kammar of Alur about 2 furlongs from Alur Bus-stop On the left side of Alur - Haliyal Road.	8.80	112	12.0	200	17.0	3.2	34	90	30	17.0 57%	9.5 32%	Early Bearer (Young tree)

Appendix-II: Meteorological data of Main Research Station, Dharwad for the years 1992 to 1995

Month	1992				1993			
	Temperature (°C)		RH (%)	RF (mm)	Temperature (°C)		RH (%)	RF (mm)
	Minimum	Maximum			Minimum	Maximum		
January	12.7	29.4	81	0.0	13.7	30.1	80	0.0
February	15.9	32.0	75	0.0	14.8	31.7	76	0.0
March	19.3	36.1	67	0.0	18.8	34.5	70	0.0
April	20.8	37.0	65	18.0	20.5	37.1	66	16.2
May	20.8	35.3	67	81.4	21.3	36.2	67	101.7
June	20.7	30.0	81	181.2	21.3	30.2	79	88.5
July	20.3	27.4	87	87.7	21.0	26.6	89	166.0
August	19.9	26.4	87	107.2	20.5	26.4	89	68.1
September	19.3	28.8	84	121.3	20.1	28.1	86	44.6
October	19.5	29.1	84	94.6	20.3	29.0	84	266.2
November	16.9	28.7	83	136.4	17.4	29.0	82	8.4
December	11.4	27.2	87	0.0	13.8	26.7	86	39.6
Total				827.8				799.3

Month	1994				1995			
	Temperature (°C)		RH (%)	RF (mm)	Temperature (°C)		RH (%)	RF (mm)
	Minimum	Maximum			Minimum	Maximum		
January	14.5	29.3	81	8.0	13.7	27.7	83	5.2
February	16.2	31.9	76	0.0	16.7	32.6	73	0.0
March	20.0	36.1	68	0.0	19.1	35.1	68	0.0
April	20.6	34.9	70	55.6	21.3	36.8	66	20.6
May	21.3	36.5	65	28.0	21.3	33.8	68	56.6
June	20.9	28.1	84	86.0	22.1	31.4	75	143.4
July	20.6	25.0	93	296.1	21.0	27.1	87	184.4
August	20.6	25.6	91	89.3	20.7	28.1	86	50.5
September	19.2	27.5	86	52.6	20.6	28.3	82	121.6
October	20.1	29.0	83	164.2	20.0	29.3	80	127.5
November	16.4	28.0	85	0.0	15.2	29.1	81	81.0
December	12.4	28.0	84	0.0	13.5	29.4	77	0.0
Total				779.8				790.8