

**STUDY OF GENETIC DIVERGENCE FOR
GRAIN YIELD AND YIELD COMPONENTS
IN FINGER MILLET**
[Eleusine coracana (L.) Gaertn.]

BY

JADHAV RANI ASARAM

B.Sc. (Ag.)

**THESIS SUBMITTED TO THE
ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF**

**MASTER OF SCIENCE IN AGRICULTURE
(GENETICS AND PLANT BREEDING)**

CHAIRPERSON: Dr. D. RATNA BABU



DEPARTMENT OF GENETICS AND PLANT BREEDING

**AGRICULTURAL COLLEGE, BAPATLA
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY**

2014

**STUDY OF GENETIC DIVERGENCE FOR
GRAIN YIELD AND YIELD
COMPONENTS IN FINGER MILLET
[*Eleusine coracana* (L.) Gaertn.]**

**JADHAV RANI ASARAM
B.Sc. (Ag)**

**MASTER OF SCIENCE IN AGRICULTURE
(GENETICS AND PLANT BREEDING)**



2014

CERTIFICATE

Ms. JADHAV RANI ASARAM has satisfactorily prosecuted the course of research and that thesis entitled “**STUDY OF GENETIC DIVERGENCE FOR GRAIN YIELD AND YIELD COMPONENTS IN FINGER MILLET [*Eleusine coracana* (L.) Gaertn.]**” submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date:

(D. RATNA BABU)

Chairperson

Assistant Professor

Department of Genetics and Plant Breeding
Agricultural College, Bapatla- 522101

CERTIFICATE

This is to certify that the thesis entitled “**STUDY OF GENETIC DIVERGENCE FOR GRAIN YIELD AND YIELD COMPONENTS IN FINGER MILLET [*Eleusine coracana* (L.) Gaertn.]**” submitted in partial fulfilment of the requirements for the degree of ‘**Master of Science in Agriculture**’ of the Acharya N. G. Ranga Agricultural University, Hyderabad is a record of the bonafide original research work carried out by **Ms. JADHAV RANI ASARAM** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

Thesis approved by the student’s advisory committee

Chairman : **Dr. D. RATNA BABU**

Assistant Professor
Department of Genetics and Plant Breeding
Agricultural College
Bapatla

Member : **Dr. LAL AHAMED M.**

Assistant Professor
Department of Genetics and Plant Breeding
Agricultural College
Bapatla

Member : **Dr. V. SRINIVASA RAO**

Professor & University Head
Department of Statistics and Mathematics
Agricultural College
Bapatla

Date of Final Viva-Voce:

DECLARATION

I, **JADHAV RANI ASARAM**, hereby declare that the thesis entitled “**STUDY OF GENETIC DIVERGENCE FOR GRAIN YIELD AND YIELD COMPONENTS IN FINGER MILLET [*Eleusine coracana* (L.) Gaertn.]**” submitted to the **Acharya N. G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: Bapatla

(JADHAV RANI ASARAM)
I.D. No. BAM-12-15

Date:

ACKNOWLEDGEMENTS

Accomplishment of this thesis is the result of blessings and love of my parents, benevolence of almighty, motivation and guidance of my teachers and help of my friends.

*First and foremost, I would like to put on record of my heartfelt gratitude to **Dr. D. Ratna Babu**, Assistant Professor, Department of Genetics and Plant Breeding, Agricultural College, Bapatla and the esteemed chairman of my Advisory Committee. I am profoundly thankful to him for his constant encouragement, keen interest, constructive suggestions, boundless help and indefatigable guidance which provided me commendable encouragement and shaped my efforts into a successful research work.*

*I sincerely extend my profound gratitude to **Dr. Lal Ahamed M.**, Assistant Professor, Department of Genetics and Plant Breeding, Agricultural College, Bapatla and member of my Advisory committee for his valuable suggestions, generous help and affectionate encouragement offered during my post graduation study and cooperation during submission of thesis.*

*I express my deep sense of gratitude to **Dr. V. Srinavasa Rao**, Professor & Head, Department of Statistics & Mathematics, Agricultural College, Bapatla member of my advisory committee for his timely and valuable help rendered during the course of investigation.*

*I deem it a great privilege to express my gratitude to **Dr. P. V. Rama Kumar**, Professor & Head, Department of Genetics and Plant Breeding, Agricultural College, Bapatla for his unstinted attention, constant encouragement, valuable suggestions and generous help during my post graduation study and research work.*

*I take this opportunity to acknowledge **Dr. P. R. K. Prasad**, Professor & Head, Department of Soil Science and Agricultural Chemistry for providing the lab facilities, cooperation and masterly suggestions during my chemical analysis.*

*I am very much thankful to **Dr. P. V. N. Prasad**, Principal Scientist & Head, Agricultural College Farm, Bapatla and **Smt. G. Kiranmai**, Block Manager for their help during my farm operations by providing sufficient labour.*

*I am in dearth of words to express my unboundful gratitude and love to my beloved parents, **Sri. Asaram Jadhav** and **Smt. Ganga Jadhav** and my beloved and dearest sisters **Sonu**, **Kalpna** and **Dnyaneshwari** & brother **Santosh** and **My Relatives** for their unbounding love, affection, guidance and dedicated efforts to educate me to this level.*

*I wish to express my unboundful love and fondness to my beloved everlasting friends, **Sandhya, Mrinali, Girriraj, Pallavi and Anil** whose encouragement is a constant inspiration to me during the course of my educational career.*

*It gives me immense pleasure to express my profound thanks to my seniors **Srilaxmi, Bhargavi, Anita, Rajitha, Anusha, Haritha, Nishit, Balakrishna, Ravikanth, Rajkumar** for the much needed moral support and help during the course of my study.*

*I place my sincere thanks to my colleagues **Vanaja, Jyothsna, Triveni, Revathi, Dikshita, Sujala, Patil, Prasanna, Vinay, Vijay, Eshwar, Neeraj, Praveen** for always being there besides me in difficult times during my course of study and giving constant motivation.*

*It gives me immense pleasure to express my profound thanks to the junior friends **Tejaswini, Ramadevi, Karunashri, Vijaydurga, Wani, Pawani** for their help and co-operation during the course of this work.*

*I am very much thankful to Record Assistants, **Sri Bhaskara Rao, Sri Srinivasa Reddy**, Office Subordinate **Shivaparvathi** and Casual Worker **Ramulamma and Chittamma** for their help during my PG programme in the department.*

I am thankful to Eswar Digitals and Computers for the neat typing and execution of my thesis.

Place:

Date:

(RANI A. JADHAV)

LIST OF CONTENTS

Chapter No	Title	Page No.
I	INTRODUCTION	
II	REVIEW OF LITERATURE	
III	MATERIAL AND METHODS	
IV	RESULTS AND DISCUSSION	
V	SUMMARY AND CONCLUSIONS	
	LITERATURE CITED	
	APPENDICES	

LIST OF TABLES

S. No.	Title	Page No.
2.1	Review of literature on genetic variability of yield and yield components in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
2.2	Review of literature on heritability of yield and yield components in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
2.3	Review of literature on genetic advance and genetic advance as per cent of mean of yield and yield components in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
2.4	Review of literature on association of component characters with seed yield per plant in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
2.5	Review of literature on association of yield components among themselves in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
2.6	Review of literature on direct effects of component characters on seed yield in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
2.7	Review of literature on indirect effects of component characters on seed yield in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
3.1	Name and origin of finger millet genotypes employed in the present study	
4.1	Mean Performance of 40 Genotypes in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] for all the characters under study.	
4.2	Analysis of variance for yield and yield component characters in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
4.3	Estimates of variability, heritability and genetic advance as per cent of mean for seed yield and yield components in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
4.4	Phenotypic and genotypic correlations among seed yield and yield contributing characters in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
4.5	Direct and indirect effects of different traits on seed yield per plant in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
4.6	Contribution of different characters towards genetic divergence in 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes	
4.7	Clustering pattern of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes by Tocher's method	
4.8	Average intra and inter-cluster D^2 values among seven clusters with 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes	

S. No.	Title	Page No.
4.9	The nearest and the farthest cluster from each cluster based on D^2 values using Tocher's method in 40 finger millet genotypes	
4.10	Mean values seven clusters estimated by Tocher's method from 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes	
4.11	Eigen values, proportion of the total variance represented by first four principal components, cumulative per cent variance and components loading of different characters in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.].	
4.12	PCA scores of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes.	
4.13	Clustering pattern of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes by Ward's minimum variance method	
4.14	Average intra and inter-cluster Euclidian ² values among seven clusters in 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes	
4.15	Mean values of seven clusters estimated by Ward's minimum variance method from 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes	

LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
ANOVA	:	Analysis of Variance
ARS	:	Agricultural Research Station
CD	:	Critical Difference
cm	:	Centimetre
CV	:	Coefficient of variation
d.f	:	Degrees of freedom
EDTA	:	Ethylene Diamine Tetra Aceticacid
<i>et al.</i>	:	and others people
g	:	Gram
GA	:	Genetic Advance
GAM	:	Genetic Advance as per cent of Mean
GCV	:	Genotypic Co-efficient of Variation
HClO ₄	:	Per Chloric acid
HNO ₃	:	Nitric acid
Kg	:	Kilogram
m	:	Metre
mg	:	Milligram
ml	:	Milli litre
Mha	:	Million hectares
MSL	:	Mean sea level
MSS	:	Mean sum of square
Mt	:	Million tonnes
N	:	Nitrogen
NaOH	:	Sodium hydroxide
NS	:	Non-significant
PCA	:	Principal Component Analysis
PCV	:	Phenotypic Co-efficient of Variation
S.E.	:	Standard error
S.Ed	:	Standard Error of difference
sq. m	:	Square metre
SS	:	Sum of square
t ha ⁻¹	:	Tonnes per hectare
via	:	Through
viz.,	:	Namely
2D	:	Two dimensional
3D	:	Three dimensional

LIST OF FIGURES

S. No.	Title	Page No.
4.1	Phenotypic path diagram showing direct and indirect effects of yield components on seed yield per plant in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
4.2	Genotypic path diagram showing direct and indirect effects of yield components on seed yield per plant in finger millet [<i>Eleusine coracana</i> (L.) Gaertn.]	
4.3	Intra and inter-cluster distance of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes in seven clusters based on Tocher's method	
4.4	Dendrogram showing relationship among 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes in seven clusters based on Mahalanobis' D^2 values	
4.5	Two dimensional graph showing relative position of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes based on PCA scores	
4.6	Three dimensional graph showing relative position of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes based on PCA scores	
4.7	Dendrogram showing relationship of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes in seven clusters based on Euclidean ² distance	
4.8	Intra and inter-cluster distance of 40 finger millet [<i>Eleusine coracana</i> (L.) Gaertn.] genotypes in seven clusters based on Euclidean ² values	

LIST OF APPENDIX

Appendix No.	TITLE	PAGE NO.
A.	Monthly meteorological data recorded at Agricultural College farm, Bapatla during the cropping period (26-08-2013 to 31-12-2013) – <i>kharif</i> , 2013.	

ABSTRACT

Name of the Author	: JADHAV RANI ASARAM
Title of the thesis	: STUDY OF GENETIC DIVERGENCE FOR GRAIN YIELD AND YIELD COMPONENTS IN FINGER MILLET [<i>Eleusine coracana</i> (L.) Gaertn.]
Degree to which it is submitted	: Master of Science in Agriculture
Faculty	: Agriculture
Department	: Genetics and Plant Breeding
Chairperson	: Dr. D. RATNA BABU
University	: Acharya N.G. Ranga Agricultural University
Year of Submission	: 2014

Present investigation was carried out during *kharif* 2013 at Agricultural College Farm, Bapatla with the prime objective of grouping the 40 genotypes of finger millet (*Eleusine coracana* (L.) Gaertn). into distinct classes based on their genetic diversity. Other parameters like mean, genetic variability, heritability, genetic advance as per cent of mean, character association and the magnitude of direct and indirect effects of yield component traits on grain yield were also studied.

Analysis of variance revealed significant differences among the 40 genotypes for all the eleven characters studied indicating a high degree of variability in the material. The genotypic coefficients of variation for all the characters studied were lesser than the phenotypic coefficients of variation indicating the influence of environment on expression of these traits.

The estimates of heritability and genetic advance as per cent of mean were high for all the 11 characters under study indicating the predominance of additive gene action and hence direct phenotypic selection is useful with respect to these traits.

Genotypic correlations in general were higher than phenotypic correlations indicating that the apparent associations are largely due to genetic reasons. The traits, 1000-seed weight, number of fingers per ear, ear weight per plant, finger length, days to maturity, productive tillers per plant, days to 50% flowering and plant height were found to possess significant positive association with seed yield per plant at both genotypic and phenotypic levels. Further, path analysis studies revealed that 1000-seed weight, number of fingers per ear, days to maturity, ear weight per plant, finger length and days to 50% flowering showed true relationship with seed yield per plant by establishing significant positive association and high positive direct effect.

Considering the nature and magnitude of character associations and their direct and indirect effects, it can be inferred that 1000-seed weight followed by number of fingers per ear, days to maturity, ear weight per plant, finger length and days to 50% flowering could serve as important traits in any selection programme for selecting high yielding genotypes in finger millet.

The results of multivariate analysis revealed considerable genetic divergence among the 40 genotypes studied. Both D^2 analysis and Ward's method grouped the 40 finger millet genotypes into seven clusters. However the clusters are different in different methods with respect to total number of genotypes included in each cluster.

By Mahalanobis' D^2 statistic, it could be inferred that seed protein content, seed calcium content, days to maturity and days to 50% flowering contributed maximum towards divergence. Based on inter-cluster distance among the groups, crosses may be effected between genotypes belonging to cluster V (Ratnagiri, Godavari, GE-1382) and cluster VII (GE-3434) followed by cluster IV (GE-3090,GE-1274, GE-3225, GE-4976, IE-2652, GE-145, GE-4707) and cluster VII (GE-3434).

In principal component analysis, first three principal components altogether explained 76.411% of the total variability. The significant factors loaded in PC_1 viz., number of productive tillers per plant, ear weight per plant, days to maturity, days to 50% flowering, number of fingers per ear, plant height, 1000-seed weight, seed yield per plant and finger length contributed maximum towards divergence. PCA analysis revealed that the genotypes GE-1382, GE-2723, GE-145, IE-2652 and GE-4976 showed maximum divergence.

Agglomerative cluster analysis revealed wide genetic distance between cluster IV (GE-3090, GE-1274, GE-3225, GE-4976) and cluster VII (TNAU-1214, OEB-532, IE-2323, GE-995, GE-3434).

It can be concluded that, the genotypes GE-3434, GE-1382 and GE-4976 had maximum divergence and are also better *per se* performers for the yield contributing characters. Hence, these genotypes may be utilized in hybridization programmes for obtaining productive recombinants.

Chapter - I

INTRODUCTION

Finger millet (*Eleusine coracana* Gaertn.) commonly known as African millet or ragi, is one of the important food crops and largely grown in southern states of India. It is the most important small millet cultivated in more than 25 countries in Africa and Asia. India is the major producer in Asia and in India, it is widely grown in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa, Gujarat, Jharkhand, Uttar Pradesh, Madhya Pradesh and Uttarakhand. In India, it is cultivated on 1.3 M ha, with a production of 1.59 Mt and a productivity of 1.7 t ha⁻¹ while in Andhra Pradesh it is grown in an area of 41,000 ha with a production of 45,000 t and a productivity of 1.19 t ha⁻¹ (Ministry of Agriculture, 2013).

Ragi is commonly famous as “Nutritious millet” as the grains are nutritionally superior to many cereals. It contains protein (7-10%), calcium (344 mg/100 g), iron and other minerals. It is also rich in phosphorus (283 mg/100 g) and potassium (408 mg/100 g). The carbohydrates present in finger millet have the unique property of slower digestibility. The higher fibre content of finger millet helps in many ways as it prevents constipation, high cholesterol formation and intestinal cancer. Hence, people suffering from diabetics are advised to eat finger millet and other small millets instead of rice (Hadimani and Malleshi, 1993). It also contains amino acids lecithin and methionine, which help in bringing down cholesterol level.

The cultivated finger millet is a self pollinated tetraploid ($2n = 4x = 36$) and has morphological similarity to both *Eleusine indica* (L.) Gaertn. ($2n = 18$) and *Eleusine africana* ($2n = 36$). The cytological evidences indicate that *Eleusine indica* has contributed one of the genomes (AA) to the cultivated *Eleusine coracana* (AABB). Both tetraploids *Eleusine africana* and *Eleusine coracana* are closely related and gene flow occurring between them in nature suggests that *Eleusine coracana* possibly originated from *Eleusine africana* through selection (Hilu and Wet, 1976).

Heritability measures relative amount of the heritable portion of variation while the genetic advance helps to measure the amount of progress that could be expected with selection in a character.

Genotypic and phenotypic association reveals the degree of association between different characters and thus, aids in selection to improve the yield and yield attributing characters, simultaneously. Further, path coefficient analysis helps to determine direct and indirect relations among the traits as it is important in order to determine the plant selection criteria (Dewey and Lu, 1959).

Genetic diversity plays an important role in plant breeding either to exploit heterosis or to generate productive recombinants. The choice of parents is of greater importance in breeding programme. Assessment of a large number of germplasm for genetic diversity is of immense importance in selection of diverse genotypes for hybridization programme. Realising the importance of germplasm in the development of desirable varieties, breeders are now looking for more diverse forms from various sources to further augment the yield potential of the genotypes. Mahalanobis's D^2 statistic, Principal component analysis are few powerful tools for quantifying genetic divergence among germplasm collections with respect to characters considered together.

Keeping the above aspects in consideration the present investigation is proposed with the following objectives:

1. To estimate variability, heritability and genetic advance for yield and yield components.
2. To assess the character association among yield and yield components in finger millet genotypes.
3. To study the direct and indirect effects of yield components on grain yield in finger millet.
4. To study the genetic divergence among 40 genotypes of finger millet.

Chapter - II

REVIEW OF LITERATURE

The review of work done on finger millet [*Eleusine coracana* (L.) Gaertn.] relevant to the present investigation is furnished under the following headings.

2.1 Genetic variability

2.2 Heritability

2.3 Genetic advance and genetic advance as per cent of mean

2.4 Character association

2.5 Path co-efficient analysis

2.6 Genetic divergence

2.1 GENETIC VARIABILITY

An insight into the magnitude of variability present in a crop species is of utmost importance as it provides the basis for effective selection. The phenotype of a character is the resultant of interaction between genotype and environment. Partitioning of observed variability into heritable and non-heritable components is essential to get a true indication of the genetic variation of the trait.

The literature on genetic variability studies on finger millet is reviewed and presented in Table 2.1.

2.2 HERITABILITY

Heritability measures the relative amount of the heritable portion of variability. Consistency in the performance of selection in succeeding generations depends on the magnitude of heritable variation present in relation to observed variation. Basic information on heritability is a pre-requisite for planning any breeding programme.

A brief review of studies on heritability in finger millet was presented in Table 2.2.

2.3 GENETIC ADVANCE (GA) AND GENETIC ADVANCE AS PER CENT OF MEAN (GAM)

Genetic advance helps to measure the amount of progress that could be expected with selection for a particular character. Estimates of heritability along with estimates of genetic advance are more useful in choice of selection method rather than heritability or genetic advance alone (Johnson *et al.*, 1955).

The available literature on genetic advance and genetic advance as per cent of mean is reviewed and presented in Table 2.3.

2.4 CHARACTER ASSOCIATION

Plant yield is a complex and is a polygenically inherited trait. Therefore direct selection for yield is not much effective. But, it could be improved by selecting various component characters which are correlated to yield and are simple in inheritance with less environmental influence. Hence, correlation studies paved a path in order to find out the association between highly heritable independent character and most economic but dependent character like yield which would help the breeder in obtaining improved yields.

The available literature on the association of component characters with seed yield per plant and the associations among the yield component characters are presented in Tables 2.4 and 2.5, respectively.

2.5 PATH CO-EFFICIENT ANALYSIS

The estimation of path coefficients gives an exact picture of relative importance of the direct and indirect contribution of the component characters to yield. Path analysis proposed by Dewey and Lu (1959) facilitates the partitioning of the correlation coefficients into direct and indirect effects of various characters on seed yield. Thus path analysis would give a better insight into the cause and effect relationship between the pairs of characters.

The literature on direct and indirect effects of yield components on seed yield are reviewed and presented in Tables 2.6 and 2.7, respectively.

2.6 STUDIES ON GENETIC DIVERGENCE

The assessment of genetic diversity using quantitative traits has got prime importance in many contexts particularly in differentiating well defined population. The germplasm in a self-pollinated crop can be considered as a heterogeneous set of groups since each group being homozygous within it. Selecting parents for hybridization programme in these crops is difficult because, the success depends upon the segregates of hybrid derivatives between the parents, particularly when the aim is to improve the quantitative characters like yield.

To identify the parents that nick better, several methods of divergence analysis based on quantitative characters have been proposed to suit various objectives. Among them, Mahalanobis's generalized distance occupies a unique place and is an efficient method to measure the extent of diversity among genotypes, which quantify the differences among several quantitative traits.

Divergence analysis is performed to identify the diverse genotypes for hybridization purpose. Clustering by D^2 analysis is useful in this matter. The genotypes grouped together are less divergent than the ones, which fall into different clusters. Clusters separated by largest statistical distance (D^2) show maximum divergence (Singh and Chaudhary, 1977).

For the first time, Nair and Mukherjee (1960) used D^2 statistic as a measure of genetic divergence in the classification of natural and plantation Teak. The basic importance of genetic diversity in breeding for high yield has long been recognised and is evident from the results supported by several workers.

Suyambulingam and Jebarani (1977) studied 34 short duration finger millet varieties for their divergence and grouped them into six clusters using D^2 statistic. They reported that maximum diversity was contributed by number of tillers per plant, followed by plant height.

Jain *et al.* (1981) grouped 30 genetic stocks of finger millet from diverse geographical sources grouped into 13 clusters utilizing 12 characters by D^2 statistic and canonical analysis. Canonical analysis divergence pattern obtained by D^2 analysis. They reported that the clustering pattern did not follow geographical origin.

Jayaprakash Naik (1991) observed the formation of 13 clusters in Indian germplasm in a study of genetic diversity in Indian and African finger millet collections using D^2 analysis. The characters that contributed to divergence were days to flowering, days to maturity, tiller number, flag leaf length, finger number, spikelet number, glume length and harvest index.

Rao (1992) based on D^2 values, grouped 978 finger millet accessions into 38 clusters. The clustering pattern revealed that, there were 14 clusters predominantly occupied with Indian germplasm, two clusters with only African accessions, two clusters with unknown origin and remaining 20 clusters were having germplasm from different origins. Majority of accessions do not follow the pattern of geographic distinction. Hence, it is presumed that, there was no association of geographic diversity with the genetic diversity.

Sheriff (1992) studied 20 varieties of finger millet grown across two environments and assessed their genetic divergence using Mahalanobis' D^2 statistic. They were grouped into four clusters under rainfed and 11 under irrigated conditions. Characters like days to flowering, days to maturity, plant height, ear weight, ear length and grain weight contributed maximum to genetic diversity in both environments. They concluded that genetic diversity is not related to geographic diversity.

Jain *et al.* (2002) evaluated 40 genotypes in two consecutive years to assess the genetic divergence based on morphological characters related to grain yield and blast resistance in finger millet. The genetic diversity did not relate to geographic origin in same subcontinent, but it relates to some extent between the subcontinents.

Satish (2007) based on D^2 statistics, grouped 178 genotypes into 10 clusters. Clustering pattern revealed that there was no relationship between genetic divergence and geographical diversity. Highest contribution to genetic divergence of finger millet genotypes was contributed by floret number per spikelet followed by ear head length, flag leaf length, finger length and number of fingers per ear.

Kumar and Rai (2005) evaluated 30 genotypes of finger millet from diverse sources and grouped them into two clusters using D^2 analysis. The characters that contributed to divergence were days to 50% flowering, days to maturity and plant height.

Muduli and Misra (2012) studied 44 mutant lines of finger millet variety GPU 26. The result showed that, the traits such as days to 50% flowering and days to maturity contributed to the induced genetic divergence.

Jaya Lakshmi (2007) studied 30 genotypes of finger millet and grouped them into ten clusters. Total number of tillers per plant followed by test weight contributed more towards total diversity.

Anantharaju and Meenakshiganesan (2008) grouped 50 finger millet genotypes into 14 clusters. Among the characters studied, days to 50% flowering contributed more towards total diversity.

Arunprabhu *et al.* (2008) studied 150 finger millet germplasm lines for their variability and diversity. Based on Mahalanobis' D^2 analysis, genotypes were grouped into 18 clusters. Finger breadth, days to maturity and number of fingers per ear contributed maximum towards diversity.

Kadam (2008) assessed 70 genotypes of finger millet using Mahalanobis' D^2 analysis based on 15 characters and grouped them into eight clusters. Days to 50% flowering followed by flag leaf blade length contributed maximum towards total divergence and parallelism was observed between geographical diversity and geographical origin.

Kumar *et al.* (2010) studied 140 genotypes of finger millet for genetic divergence using D^2 analysis for ten quantitative traits. These genotypes were grouped into ten clusters. The inter-cluster distances between cluster X and I was highest and between clusters III & VIII was lowest. Genetic diversity was observed to be independent of the geographical origin of the genotypes.

Sahu and Pradhan (2012) grouped 30 finger millet genotypes into 12 cluster and observed that maximum contribution for the genetic divergence was by days to maturity followed by days to 50% flowering.

Karad and Patil (2013) grouped 65 finger millet genotypes into five clusters. They reported characters like days to 50% flowering, days to maturity and plant height contribute maximum to genetic divergence. The D^2 analysis showed that the most diverse parents could be utilized as parents in breeding programme to enhance the productivity of finger millet.

2.6.1 Principal component analysis and cluster analysis

Principal component analysis was carried out to perform the inter dependent traits into a set of independent traits as well as to reduce the dimensionality of the data structure (Banfield, 1978). It is defined as a method of data reduction to clarify the relationship between two or more characters into limited number of uncorrelated new variables. The reduction is achieved by linear transformation of the original characters into a new set of correlated variables known as principal components (PCs).

Suryakumar *et al.* (1998) used cluster analysis and principal component analysis in 99 finger millet genotypes and grouped into 10 clusters. They reported that clustering pattern did not follow geographical origin. The genotypes from the clusters II, X, V and VII having moderate to high genetic divergence coupled with high mean performance may be selected for yield and its important components viz., productive tillers and straw yield for better combination.

Vadivoo *et al.* (1998) grouped finger millet genotypes into eight clusters. Based on genetic diversity and performance, genotypes MS 1168, M174 and CO13 were found to be suitable parents for hybridization programme in yield improvement.

Bezaweletaw *et al.* (2007) studied 66 accessions of finger millet from five regions of Ethiopia and Eritrea to study genetic affinity within the germplasm. Cluster analysis grouped 66 accessions into five major clusters. Maximum inter-cluster divergence occurred between cluster I & cluster III. PCA identified five principal components which accounted for 80.7% of the total variation among the test genotypes. The principal component analysis indicated days to heading, culm thickness, leaf number per main tiller, leaf blade width and finger width contributed most towards the genetic divergence.

Reddy *et al.* (2009) studied more than 2000 accessions from five East African countries using PCA and cluster analysis. Cluster analysis using Ward's method was performed on first three PCs. Accessions from all the five countries were delineated into three clusters. PCA identified three principal components scored 95.1% of total variation. The important traits in the evaluation of germplasm are basal tillers, flag leaf sheath length, inflorescence length and width, longest finger length and width and panicles per plant, which explained the maximum variation in PC₁.

Dagnachew *et al.* (2012) studied 144 finger millet landraces and grouped into seven clusters which indicated that grain yield/plant, 1000-seed weight, days to 50% flowering, days to maturity were most important traits contributing for the overall variability. PCA identified five principal components that contributed 83.5% of total variation. First two principal components of grain yield per plant, 1000-seed weight, days to heading were the most important traits contributing the overall variability.

Wolie and Belete (2013) grouped 84 finger millet genotypes into eight clusters. PCA identified five principal components which explained 75.20% of the total variation. The highest average inter-cluster D^2 was recorded between cluster VII and cluster VIII followed by cluster III and VIII revealing maximum divergence for the characters considered.

Chapter - III

MATERIAL AND METHODS

The present investigation was carried out during *kharif* 2013 at Agricultural College Farm, Bapatla, Guntur District, Andhra Pradesh, which is located at an altitude of 5.4 m MSL, 15° 54' N latitude and 80°90' E longitude. The material used and the methods followed in the present investigation are described hereunder.

3.1 MATERIAL

The experimental material for this study consisted of forty genotypes of different maturity groups obtained from Agricultural Research Station (ARS), Vizianagaram, Andhra Pradesh and All India Coordinated Small Millets Improvement Project (AICSMIP), Bangalore. The information about the material used in this study is presented in Table 3.1.

Table 3.1 Name and origin of finger millet genotypes employed in the present study

Sr.No.	Genotype	Origin	Sr.No.	Genotype	Origin
1.	GE-2127	India	21.	GE-4976	Zambia
2.	GE-3090	Africa	22.	GE-4707	India
3.	GE-2078	India	23.	GE-2723	Africa
4.	GE-3225	India	24.	DHRS-1-1	India
5.	GE-4437	India	25.	GE-4736	India
6.	GE-995	India	26.	TNAU-1214	India
7.	GE-258	India	27.	IE-2323	India
8.	GE-1274	India	28.	GE-1382	Africa
9.	GPU-66	India	29.	GPU-67	India
10.	GE-1746	India	30.	Kalyani	India
11.	GE-666	India	31.	Srichaitanya	India
12.	GPU-48	India	32.	IE-2296	India
13.	GE-3138	India	33.	INDAF-9	India
14.	VL-149	India	34.	OEB-532	India
15.	GE-2941	Africa	35.	BR-10	India
16.	GE-3434	Africa	36.	IE-4795	Zimbabwe
17.	IE-501	India	37.	IE-2652	Malawi
18.	GE-3266	India	38.	Ratnagiri	India
19.	IE-3077	India	39.	GPU-82	India
20.	GE-145	India	40.	Godavari	India

3.2 METHODS

3.2.1 Experimental technique

The experimental techniques of the present investigation are detailed hereunder.

Location	:	Agricultural College Farm, Bapatla.
Season	:	<i>Kharif</i> , 2013
Design	:	Randomized Complete Block Design
Treatments	:	40 Finger millet genotypes
Replications	:	3
Spacing	:	20 cm × 10 cm
Number of rows	:	4 rows /genotype / replication
Row length	:	3m
Plot size	:	2.4 sq. m
Fertilizers	:	60kg: 30kg: 20kg NPK/ ha

3.2.2 Record of observations

Observations were recorded on ten randomly selected plants per treatment per replication and their means were used for statistical analysis. However, days to 50% flowering, days to maturity, 1000-seed weight and seed protein and seed calcium content were recorded on plot basis. The data on the following yield and yield component traits were recorded.

3.2.2.1 Plant height (cm)

The height of the fully matured plant from the base of the plant to the tip of the inflorescence (ear) was measured in centimeters.

3.2.2.2 Days to 50% flowering

The number of days taken from sowing to the opening of flowers in 50 per cent of population in each genotype were recorded.

3.2.2.3 Number of productive tillers per plant

Total number of ear bearing tillers in each randomly selected plant was counted at maturity.

3.2.2.4 Number of fingers per ear

Total number of fingers on the main ear were recorded.

3.2.2.5 Length of finger (cm)

The length from base to tip of longest finger on the main ear was recorded.

3.2.2.6 Ear weight per plant (g)

Total weight of the ears of a plant was recorded at harvest.

3.2.2.7 1000-seed weight (g)

The weight of 1000 randomly selected seeds was recorded in grams.

3.2.2.8 Days to maturity

The total number of days taken from date of sowing to complete maturity was taken as days to maturity.

3.2.2.9 Seed yield per plant (g)

Ten randomly selected plants were harvested and threshed. The cleaned seed was dried and weighed in grams and the mean yield of ten plants was taken as seed yield per plant.

3.2.2.10 Seed protein content (%)

The nitrogen content (%) in each sample was estimated by Microkjeldahl method and protein content (%) of each sample was estimated as described by Sadasivam and Manickam (1996). The protein % was calculated by using the following formula.

$$\text{Protein percentage} = \text{Nitrogen content (\%)} \times 6.25 \text{ (Factor)}$$

3.2.2.11 Seed calcium content (mg/100g)

The seed calcium content in the sample was estimated by Versenate titration method (Jackson, 1967). The seeds were ground into flour and calcium content was estimated as follows.

0.5g of sample was taken into a digestion tube and add 5 ml of diacid mixture of HNO_3 and HClO_4 in the ratio of (9:4) and allowed for overnight digestion. After that filter the sample and take 5 ml aliquot into a porcelain casserole. Add 4N NaOH and Ammonium purpurate indicator and then titrate the sample against 0.01N EDTA solution. Observe the end point by colour change from orange red to purple.

$$\text{Ca (mg / 100g)} = \frac{\text{ml of EDTA} \times \text{titre value} \times 1000 \times \text{equivalent}}{\text{Aliquot (ml) taken}}$$

3.3 STATISTICAL ANALYSIS

The data recorded on various characters were subjected to the following statistical analysis.

3.3.1 Analysis of variance

Analysis of variance of the characters was done as per standard statistical procedure for randomized complete block design as given by Panse and Sukhatme (1978).

$$Y_{ij} = \mu + t_i + r_j + e_{ij}$$

Where,

Y_{ij} = Performance of i^{th} genotype in j^{th} block

μ = General mean

t_i = i^{th} genotype effect

r_j = j^{th} block effect

e_{ij} = Random error

The structure of analysis of variance was as follows.

ANOVA Table for Randomized Block Design

Source of variation	Degrees of freedom	Mean sum of squares	Expected mean sum of squares	“F” calculated value
Replications	r-1	M_r	$\sigma_e^2 + t \sigma_r^2$	M_r / M_e
Treatments	t-1	M_t	$\sigma_e^2 + r \sigma_g^2$	M_t / M_e
Error	(r-1)(t-1)	M_e	σ_e^2	
Total	(rt-1)			

Where,

r = Number of replications

g = Number of genotypes

M_r = Mean sum of square of replication

M_t = Mean sum of square of treatment

M_e = Mean sum of square of error

σ_e^2 = Environmental variance

σ_r^2 = Variance due to replications

σ_g^2 = Variance due to genotypes

3.3.2 Estimation of genetic parameters

3.3.2.1 Estimation of variance components

Phenotypic and genotypic variances were estimated using the following formula,

$$\text{Genotypic variance } (\sigma_g^2) = \frac{M_t - M_e}{r}$$

$$\text{Phenotypic variance } (\sigma_p^2) = \sigma_g^2 + M_e = \frac{M_t - M_e}{r} + M_e$$

The test of significance was carried out using 'F' table value of Fisher and Yates (1963).

3.3.2.2 Coefficient of variation

The genotypic and phenotypic coefficients of variation were calculated using the formula by Burton (1952).

a) Genotypic coefficient of variation (GCV)

$$\text{GCV} = \frac{\text{Genotypic standard deviation } (\sigma_g)}{\text{General mean } (\bar{X})} \times 100$$

b) Phenotypic coefficient of variation (PCV)

$$\text{PCV} = \frac{\text{Phenotypic standard deviation } (\sigma_p)}{\text{General mean } (\bar{X})} \times 100$$

The GCV and PCV values were classified as described by Sivasubramanian and Menon (1973).

Classification	GCV/ PCV
Low	Less than 10%
Moderate	10 – 20%
High	More than 20%

3.3.2.3 Heritability

Heritability in broad sense was computed as the ratio of genetic variance to the total phenotypic variance and narrow sense heritability was the ratio of additive genetic variance to the total phenotypic variance as suggested by Hanson *et al.* (1956) and expressed as percentage.

$$\text{Heritability in broad sense } (h_{bs}^2) = \frac{\text{Genotypic variance } (\sigma_g^2)}{\text{Phenotypic variance } (\sigma_p^2)} \times 100$$

Heritability in broad sense was categorized as per the classification given by Johnson *et al.* (1955).

Classification	Heritability
Low	Less than 30%
Moderate	30 – 60%
High	More than 60%

3.3.2.4 Expected genetic advance

Genetic advance was calculated based on formula given by Johnson *et al.* (1955).

$$\text{Expected genetic advance (GA)} = K \times \sigma_p \times h^2$$

Where,

K = Selection differential at 5% selection intensity (2.06)

σ_p = Phenotypic standard deviation

h^2 = Heritability in broad sense

3.3.2.5 Genetic advance as per cent of mean (GAM)

$$\text{GAM} = \frac{\text{GA}}{\bar{X}} \times 100$$

Where,

GA = Genetic advance

$\bar{X}$ = Grand mean of the character

The range of genetic advance as per cent of mean was classified as suggested by Johnson *et al.* (1955).

Classification	GAM
Low	Less than 10%
Moderate	10 – 20%
High	More than 20%

3.3.5 Correlation studies

The phenotypic and genotypic correlation coefficients were worked out to determine the degree of association of a character with yield and also among the yield components by using covariance technique as per Falconer (1964).

$$\text{Phenotypic coefficients of correlation (r}_p\text{)} = r(x_i x_j)_p = \frac{\text{Cov}(x_i x_j)_p}{\left[V(x_i)_p \cdot V(x_j)_p \right]^{1/2}}$$

Where,

$r(x_i x_j)_p$ = Phenotypic correlation between i^{th} and j^{th} characters

$\text{Cov}(x_i x_j)_p$ = Phenotypic covariance between i^{th} and j^{th} characters

$V(x_i)_p$ and $V(x_j)_p$ = Phenotypic variance of i^{th} and j^{th} characters respectively

$$\text{Genotypic coefficients of correlation (r}_g\text{)} = r(x_i x_j)_g = \frac{\text{Cov}(x_i x_j)_g}{\left[V(x_i)_g \cdot V(x_j)_g \right]^{1/2}}$$

Where,

$r(x_i x_j)_g$ = Genotypic correlation between i^{th} and j^{th} characters

$\text{Cov}(x_i x_j)_g$ = Genotypic covariance between i^{th} and j^{th} characters

$V(x_i)_g$ and $V(x_j)_g$ = Genotypic variance of i^{th} and j^{th} characters respectively

3.3.5.1 Test of significance

Significance of correlation coefficients was tested by comparing phenotypic correlation coefficients with the table values (Fisher and Yates, 1963) at (n-2) degrees of freedom at 5% and 1% level where 'n' denotes the number of paired observations used in the calculation.

3.3.6 Path coefficient analysis

Path coefficient analysis was carried out by using the correlation coefficients to know the direct and indirect effects of the component characters on yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1959).

Path coefficients were obtained by solving the simultaneous equations which express the basic relationship between correlations and path coefficients.

The equations are as follows:

$$\begin{aligned}
 r_{1,y} &= P_{1,y} + r_{1,2} P_{2,y} + r_{1,3} P_{3,y} + \dots + r_{1,k} P_{k,y} \\
 r_{2,y} &= r_{2,1} P_{1,y} + P_{2,y} + r_{2,3} P_{3,y} + \dots + r_{2,k} P_{k,y} \\
 &\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
 &\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
 &\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
 r_{k,y} &= r_{k,1} P_{1,y} + r_{k,2} P_{2,y} + r_{k,3} P_{3,y} + \dots + r_{k,k} P_{k,y}
 \end{aligned}$$

Where,

$r_{1,y}$ to $r_{k,y}$ = Correlation coefficients between independent characters

$r_{1,2}$ to $r_{k-1,k}$ = Correlation coefficients between all possible combinations of independent characters

$P_{1,y}$ to $P_{k,y}$ = Direct effects of characters 1 to k on character y

The residual effect was computed by using the formula

$$R = \left[1 - (P_{1,y} r_{1,y} + P_{2,y} r_{2,y} + P_{3,y} r_{3,y} + \dots) \right]^{1/2}$$

Where,

R = Residual effect

$P_{1,y}$ = Direct effect of independent character '1' on dependent character 'y'

$r_{1,y}$ = Correlation coefficient of independent character '1' on dependent character 'y'

3.3.7 Genetic divergence

3.3.7.1 Mahalanobis' D^2 analysis

The data collected on different yield contributing characters was analysed using Mahalanobis' D^2 analysis to determine the genetic divergence among the genotypes in terms of 'generalised group distance' (Mahalanobis, 1928).

3.3.7.1.1 Test of significance

Variances were calculated for all the characters studied and test of significance was done. For the character pairs analysis of covariance was estimated on the basis of mean values (Panse & Sukhatme, 1978). After testing the difference between genotypes for each of the characters, a simultaneous test of significance for differences in the mean values of a number of correlated variables with regard to the pooled effect of characters was carried out using 'V' statistic, which in turn utilizes Wilk's criterion.

The sum of squares and sum of products of error and error + variety, variance-covariance matrix were used for this purpose. The estimation of Wilk's criterion was done using the following relationship.

$$\Lambda = \frac{|E|}{|E+V|}$$

Where,

Λ = Wilk's criterion

$|E|$ = Determinant of error matrix and

$|E+V|$ = Determinant of error + variety matrix

$$\log_e \hat{V}_{(stat)} = -m \log_e = -\left(n - \frac{p+q+1}{2}\right) \log_e \hat{V}_{(stat)} \dots\dots\dots (at pq \text{ df})$$

Where,

$$m = n - (p + q + 1)/2 = 2.3026 \log_{10} \hat{V}_{(stat)}$$

n = degree of freedom for error + varieties

p = number of variables /characters (11)

q = number of varieties –1 (or d.f.)

$V_{(stat)}$ is distributed as χ^2 with pq (429) degrees of freedom.

Transformation of correlated variables

In the present model, computation of D^2 values were reduced to simple summation of the differences in the mean values of various characters of the two genotypes *i.e.*, Σd_i^2 . Therefore transformation of the correlated variables into uncorrelated ones was done before working out the D^2 values. Transformation was done using pivotal condensation method.

3.3.7.1.2 Computation of D^2 values

For the given combination of i and j genotypes, the mean deviation *i.e.*, $Y_{it} - Y_{jt}$ for $t=1, 2 \dots p$ variables are computed and the D^2 values were calculated as,

$$D_{ij}^2 = \sum_{t=1}^p (y_i^t - y_j^t)^2$$

Where,

y_i^t is uncorrelated mean value of i^{th} genotype for character 't'

y_j^t is uncorrelated mean value of j^{th} genotype for character 't'

D_{ij}^2 is D^2 between i^{th} and j^{th} genotypes.

3.3.7.1.3 Testing the significance of D^2 values

The D^2 value obtained for a pair of population is taken as calculated value of χ^2 and is tested against the tabulated value of χ^2 for p degrees of freedom, where p is the number of characters considered i.e. 11 in the present study.

3.3.7.1.4 Contribution of individual characters towards divergence

In all combinations, each character was ranked on the basis of their contribution towards divergence between two entries ($d_i = Y_{it} - Y_{jt}$). Rank 1 is given to the highest mean difference and the rank p to the lowest difference, where p is the total number of characters. Percentage contribution towards genetic divergence was calculated using the following formula.

$$\text{Percentage contribution of the character (X)} = \frac{N \times 100}{M}$$

Where,

N = Number of genotype combinations where the character was ranked first.

M = All possible combinations of number of genotypes considered.

3.3.7.1.5 Grouping of genotypes into various clusters

The grouping of genotypes into different clusters was done using the Tocher's method as described by Rao (1952). The criterion was that the two varieties belonging to the same cluster at least on an average show a smaller D^2 value than those belonging to different clusters. For this purpose, D^2 values of all combinations of each genotype were arranged in ascending order of magnitude in a tabular form as described by Singh and Chaudhary (1977).

To start with, two populations having the closest distance from each other were considered, to which the third population having the smallest D^2 value from the first two populations was added. Similarly, the next nearest fourth population was

considered and this procedure was continued. At certain stage when it was felt that after adding a particular population there was an abrupt increase in the average D^2 , that population was not considered for including in that cluster.

The genotypes of the first cluster were then eliminated and the rest were treated in a similar way. This procedure was continued till all the genotypes were included into one or other cluster.

3.3.7.1.6 Average intra-cluster distance

For the measurement of intra-cluster distances, the formula used was $\Sigma D_i^2/n$ where, ΣD_i^2 was the sum of distances between all possible combinations (n) of the populations included in a cluster.

3.3.7.1.7 Average inter-cluster distance

Clusters were taken one by one and the distances from other clusters were calculated. The distance between two clusters was the sum of D^2 values between the members of one cluster to each of the members of the other clusters divided by the product of number of genotypes in both the clusters under consideration.

$$\text{Average inter-cluster distance} = \frac{D^2}{(n_1 \times n_2)}$$

Where,

D^2 = difference in the mean values between two populations when all the character are considered simultaneously.

n_1 & n_2 = number of genotypes of two clusters.

3.3.7.2 Principal component analysis and cluster analysis

Principal component analysis was carried according to procedure described by Banfield (1978). PCA can be performed on two types of data matrices viz., variance-covariance matrix and correlation matrix. With characters of different scale, a correlation matrix standardizing the original data set is preferred. If the characters are of same scale, a variance-covariance matrix can be used. In the present study, PCA was performed on the correlation matrix of traits, thereby removing the effects of scale (Jackson, 1991).

3.3.7.2.1 Eigen values and eigen vectors

The eigen values and eigen vectors were computed from data matrix. Eigen values define the amount of total variation that is displayed on principal components. The proportion of variation accounted for each principal component (PC) is expressed as the eigen value divided by the sum of the eigen values.

$$\text{Per cent variance explained for PC}_1 = \frac{\text{eigen value (PC}_1\text{)}}{\text{Sum of eigen values}}$$

The eigen vector (loading) defines the correlation of each variable with the principal components. The principal components were identified by following procedure. The j^{th} principal component (Y_j) of the observations X is the linear combination given as follows:

$$Y_j = A_{1j}X_1 + \dots + A_{pj}X_p$$

Where,

A_{ij} are found such that Y_j is uncorrelated $Y_1, Y_2, \dots, Y_{j-1}$ the j^{th} largest variance. The A_{ij} are the elements of the normalized eigen vector associated with largest j^{th} eigen value. The variance of the j^{th} principal component of the λ_j and the total system variance trace (S) = $\lambda_1 + \lambda_2 + \dots + \lambda_p$.

The importance of the j^{th} principal component is given by,

$$\frac{\lambda_j}{\text{Trace (S)}}$$

This is informative about the proportion of total variation that can be accounted for the i^{th} principal component. The correlation between the i^{th} original variable X_i and the j^{th} principal component Y_j is given by,

$$\rho(X_i, Y_j) = \frac{A_{ij} \cdot \sqrt{\lambda_j}}{\sqrt{S_i}}$$

Where, S_i is the standard deviation of X_i .

Thus, a principal component is linear function of the test variables given as follows,

$$\text{Principal component} = ax_1 + bx_2 + \dots + hx_8$$

Where, a, b,.... are coefficients and $x_1, x_2 \dots$ etc., are the variables in such a way that the principal component has a unit variance as reported by Ehrenberg (1985).

PCA scores for each genotype under concerned PCs were computed and utilized to derive a 2D or 3D (dimensional) scatter plot of individuals.

3.3.7.2.2 Cluster analysis

Agglomerative hierarchical clustering technique was followed as given by Anderberg (1993).

3.3.7.2.2.1 Obtaining data matrix

PCA scores for 40 genotypes were used as input for clustering because principal component analysis provides variable independence and balanced weighting of traits, which leads to an effective contribution of different characters on the basis of respective variation.

3.3.7.2.2.2 Standardizing the data matrix

To compare the similarities among the genotypes, the data matrix was standardized with a column standardizing function *i.e.*, Q analysis. The data matrix is standardize in cluster analysis to make the characters contribute more equally to the similarities among genotypes and to nullify the arbitrarily affect the units chosen for measuring the attributes among the genotypes.

Column standardizing function CA-Q analysis was carried by the following formula.

$$Z_{ij} = \bar{X}_{ij} - X_j / S_{ij}$$

$$\text{Where, } \bar{X}_j = \sum_{i=1}^n X_{ij} / n$$

$$\text{Where, } S_{ij} = \frac{\sum_{i=1}^n X_{ij} - X_j \bar{n}}{n-1}$$

For, i = genotypes *i.e.*, 40

j = total variables *i.e.*, 11

The resulting data after standardization is unit less and have mean zero and variance one.

3.3.7.2.2.3 Computing the resemblance matrix

A resemblance coefficient, which measures the overall resemblance (the degree of similarity or distance) between a pair of genotypes, was computed. Here 40 genotypes were taken in data matrix therefore resemblance coefficient was computed.

The data matrix was transformed to distance matrix (resemblance matrix) based on the dissimilarity coefficients using squared Euclidean distance method.

$$\text{Squared Euclidean distance } [d_{ij}] = \sum_{k=1}^P (X_{ik} - X_{jk})^2$$

Where,

P = Number of genotypes *i.e.*, 40

X_{ik} = Value of i^{th} genotype for k PCA scores

X_{jk} = Value of j^{th} genotype for k PCA scores

3.3.7.2.2.4 Execution of the clustering method

Distance matrix was converted into dendrogram by using Ward's method where the distance between two clusters is the sum of squares between two clusters summed over all variables. At each stage in the clustering procedure within cluster sum of squares is minimized over all partitions obtained by combining two clusters from previous stage.

Chapter - IV

RESULTS AND DISCUSSION

Variability in a crop species is of utmost importance as it provides the basis for effective selection. The amount of variability present in a population is generally measured in terms of phenotypic and genotypic coefficients of variation. The information on the nature and magnitude of genetic variability present in a population is a prerequisite to start any crop improvement programme.

Yield is a complex character and dependent on many component traits. Hence it is necessary to have knowledge on the extent of association between yield and yield contributing characters. Expression of various traits often varies with breeding material and environment. Therefore, the information on character association between the traits themselves and with the yield for the specific breeding material being used at a particular location is important for breeding high yielding genotypes. Apart from the information on degree and direction of relationship between two or more traits it is very important to know the cause of association by knowing the direct and indirect effects of independent characters on dependent character.

Mahalanobis' D^2 statistic is an effective tool in quantifying the degree of genetic divergence at genotypic level and provides quantitative measure of association between geographic distribution and genetic diversity based on generalized distance (Mahalanobis, 1928). Principal component analysis was carried out to transform the inter dependent traits into a set of independent traits as well as to reduce the dimensionality of the data structure (Banfield, 1978). It is defined as a method of data reduction to clarify the relationship between two or more characters into limited number of uncorrelated new variables. The reduction is achieved by linear transformation of the original characters into a set of uncorrelated variables known as principal components (PCs).

The data collected on forty finger millet genotypes for eleven different traits was subjected to standard statistical analysis for drawing valid conclusions. The details of results obtained from the above investigation are discussed character-wise and presented under the following headings.

4.1 Mean, genetic variability, heritability and genetic advance

4.2 Character association

4.3 Path coefficient analysis

4.4 Genetic divergence

4.1 MEAN, GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE

The success of any breeding programme depends upon the quantum of genetic variability present in the population. Wider range of genetic variability helps in selecting desired genotypes. In addition to the genetic variability, knowledge on heritability and expected genetic advance helps the breeder to employ the suitable breeding strategy. Therefore, it is necessary to have knowledge of genetic variability, heritability and genetic advance present in the available genetic material.

Genetic variability together with the heritability estimates would give a better idea on the amount of genetic gain expected out of selection (Burton, 1952 and Swarup and Chaugle, 1962). Further, the magnitude of heritable variability is the most important aspect (Panse, 1957), which has close relationship with response to selection. Heritability estimates along with genetic advance are more helpful in predicting the gain under selection than heritability estimates alone. However, it is not necessary that a character showing high heritability will always exhibit high genetic advance (Johnson *et al.*, 1955).

The analysis of variance revealed significant differences among the genotypes for all characters under study, indicating a high degree of variability in the material. The details are presented in Table 4.2. and Table 4.3.

4.1.1 Plant height (cm)

The variation for plant height ranged from 78.90 cm (GPU-48) to 138.20 cm (GE-666) with a mean of 105.02 cm. The PCV (13.28) and GCV (11.93) estimates were moderate for both. These findings are in conformity with those of Prabhakar and Prasad (1984), Ramaswamy *et al.* (1994), Ravikumar and Seetharam (1994), Bendale *et al.* (2002), Bezawelelaw *et al.* (2006), Ganapathy *et al.* (2011), Priyadharshini *et al.* (2011) and Nishit (2013) and Ulaganathan and Nirmalakumari (2013).

High heritability (80.70%) coupled with high genetic advance as per cent of mean (28.30) was observed indicating the predominance of additive gene action in the inheritance of this trait and the desired results may be obtained by simple selection. The above findings are in agreement with Satish *et al.* (2007), Arunaprabhu *et al.* (2008), Kadam *et al.* (2009), Nandini *et al.* (2010), Ganapathy *et al.* (2011), Dagnachew *et al.* (2012), Haradari *et al.* (2012), Nishit (2013), Dhanalakshmi (2013) and Ulaganathan and Nirmalakumari (2013).

4.1.2 Days to 50 % flowering

The variation for number of days taken to 50% flowering ranged from 54 days (IE-501) to 84 days (GE-1382) with a mean of 70.03 days. The PCV (11.30) and GCV (11.12) estimates were moderate and difference between them is narrow indicating that the phenotypic variability is the direct measure of genetic variability. Similar results were reported by Ramaswamy *et al.* (1994), Bendale *et al.* (2002), Ganapathy *et al.* (2011), Dhamdhare *et al.* (2011) and Nishit (2013).

High heritability (96.80%) combined with high genetic advance as per cent of mean (28.91) was observed for this trait indicating the predominance of additive gene action and hence improvement in this trait can be anticipated by simple selection. These findings are in accordance with that of Priyadharshini *et al.* (2011), Ganapathy *et al.* (2011), Dhamdhare *et al.* (2011), Haradari *et al.* (2012), Wolie *et al.* (2013), Karad and Patil (2013), Nishit (2013) and Srilakshmi (2013).

4.1.3 Days to maturity

The number of days to maturity ranged from 88 days (GE-995, GE-2127, GE-4437 and IE-2323) to 122.33 days (GE-1382) with a mean of 103.05 days. The estimates of PCV (10.08) and GCV (10.02) were moderate and difference between them is narrow indicating that the phenotypic variability is the direct measure of genetic variability. Bandyopadhyay (1998), Dhamdhare *et al.* (2011) and Nishit (2013) also observed moderate variability for this trait.

High heritability (98.80%) accompanied with high genetic advance as per cent of mean (26.30) was observed indicating the predominance of additive gene action in the inheritance of this trait and the desired results may be obtained by simple selection. The above findings are in agreement with Abraham *et al.* (1989), Bandyopadhyay (1998), Sharathbabu *et al.* (2008), Dhamdhare *et al.* (2011), Wolie *et al.* (2013), Karad and Patil (2013), Nishit (2013) and Srilakshmi (2013).

4.1.4 Productive tillers per plant

This character possessed variability ranging from 2.20 (TNAU-1214) to 5.40 (GE-4976) with a mean of 3.65. The estimates of PCV (23.18) and GCV (20.10) were high. Higher PCV value than GCV revealed that variation is not only due to genotypes but also due to influence of environment and therefore selection will be misleading. Similar results were reported by Padamja (2006), Sarala (2007), Priyadharshini *et al.* (2011), Ganapathy *et al.* (2011), Wolie *et al.* (2013) and Karad and Patil (2013).

High heritability (75.20%) combined with high genetic advance as per cent of mean (46.03) was observed for this trait indicating the predominance of additive gene action and hence improving can be anticipated by simple selection. These findings are in accordance with that of Padmaja (2006), John (2007), Sarala (2007), Satish *et al.* (2007), Sharathbabu *et al.* (2008), Nandini *et al.* (2010), Ganapathy *et al.* (2011), Priyadharshini *et al.* (2011), Nishit (2013) and Srilakshmi (2013).

4.1.5 Fingers per ear

This character ranged from 3.73 (GE-995) to 7.60 (GE-2723) with a mean of 5.73. The PCV (15.27) and GCV (14.86) of this trait were moderate indicating the presence of considerable amount of variation for this character. Similar results were reported by Bezaweletaw *et al.* (2006), Padmaja (2006), Sarala (2007), Arunprabhu *et al.* (2008), Gowda *et al.* (2008), Nandini *et al.* (2010), Ganapathy *et al.* (2011), Priyadharshini *et al.* (2011), Srilakshmi (2013) and Nishit (2013).

High heritability (94.70%) in conjunction with high genetic advance as per cent of mean (38.20) was recorded indicating the predominance of additive gene action in the inheritance of this trait and the desired results may be obtained by simple selection. These results are in conformity with the observations of Satish *et al.* (2007), Sharathbabu *et al.* (2008), Nandini *et al.* (2010), Ganapathy *et al.* (2011), Priyadharshini *et al.* (2011), Reddy *et al.* (2012), Wolie *et al.* (2013), Karad and Patil (2013) and Dhanalakshmi *et al.* (2013).

4.1.6 Finger length (cm)

The variation for length of finger varied from 4.89 cm (GE-1274) to 9.44 cm (GE-2723 and GE-4976) with a mean of 6.87 cm. The PCV (20.72) and GCV (16.67) estimates were high & moderate respectively. Higher PCV value than GCV revealed that variation is not only due to genotypes but also due to environment and therefore selection will be misleading. Similar results were reported by Arunprabhu *et al.* (2008).

High heritability (64.70%) in conjunction with high genetic advance as per cent of mean (35.41) was recorded. This indicates that the heritability of finger length is due to additive gene effects and simple selection may be rewarding in improving this trait. The above findings are in agreement with Bezaweletaw *et al.* (2006), Ganapathy *et al.* (2007), John (2007), Sarala (2007), Arunprabhu *et al.* (2008), Gowda *et al.* (2008), Nandini *et al.* (2010), Shet *et al.* (2010), Ganapathy *et al.* (2011), Priyadharshini *et al.* (2011), Harti *et al.* (2013), Nishit (2013) and Srilakshmi (2013).

4.1.7 Ear Weight per plant (g)

Ear weight per plant showed variation from 10.52 g (GE-2078) to 27.71g (GE-2723) with a mean of 19.11g. The PCV (23.32) and GCV (21.43) estimates were high. Higher PCV value than GCV revealed that variation is not only due to genotypes but also due to influence of environment and therefore selection will be misleading. Similar results were reported by Bendale *et al.* (2002), Satish (2003), Sarala (2007), Nandini *et al.* (2010) and Dhamdhere *et al.* (2011).

High heritability (84.40%) in conjunction with high genetic advance as per cent of mean (52.02) was recorded. This indicates that the heritability of ear weight per plant is due to additive gene effects and simple selection methods may be effective in improving this trait. These results are in conformity with the observations of Padmaja (2006), Sarala (2007), Satish *et al.* (2007), Sharathbabu *et al.* (2008), Nandini *et al.* (2010), Dhamdhere *et al.* (2011), Dagnachew *et al.* (2012) and Srilakshmi (2013).

4.1.8 1000-Seed weight (g)

The variation for 1000 seed weight ranged from 3.24 g (GE-3266) to 4.80 g (GE-2723) with a mean of 3.91g. This character possessed low PCV (9.51) and GCV (9.24) indicating less variation for 1000-seed weight among the genotypes studied. Narrow difference between PCV and GCV value indicates that there is little role of environmental component in the observed variation. These findings are in tune with the results of Anuradha and Suryakumari (2005), Arunaprabhu *et al.* (2008) and Priyadharshini *et al.* (2011).

High heritability (94.40%) combined with high genetic advance as per cent of mean (23.73) was noted for this trait which revealed the importance of additive gene action. This indicates that this character can be improved through simple selection procedures. These findings are in agreement with the results of Satish *et al.* (2007), Sharathbabu *et al.* (2008), Shet *et al.* (2010), Dhamdhere *et al.* (2011), Dagnachew *et al.* (2012), Nishit (2013), Srilakshmi (2013) and Ulaganathan and Nirmalakumari (2013).

4.1.9 Seed protein content (%)

Seed protein content in the genotypes studied ranged from 5.70 percent (Ratnagiri) to 13.65 percent (GE-3434) with a mean value of 8.36 percent. The estimates of PCV (20.22) and GCV (20.20) were high and less difference between PCV and GCV indicate little role of environment. Similar results were reported by Maloo *et al.* (1998) and Srilakshmi (2013). High values of PCV and GCV indicates the presence of higher amount of variability for this character in the material studied.

High heritability (99.80%) combined with high genetic advance as per cent of mean (53.29) was noted for this trait which revealed the importance of additive gene action. This indicates that this character can be improved through simple selection procedures. These findings are in agreement with the results of Maloo *et al.* (1998), Padmaja (2006), Sarala (2007), Priyadharshini *et al.* (2011), Karad and Patil (2013), Nishit (2013) and Srilakshmi (2013).

4.1.10 Seed calcium content (mg/100g)

The variation for this trait ranged from 234.00 mg/100g (GE-1382) to 478.66 mg/100g (GE-4976) with a mean of 331.31mg/100g. The PCV (17.39) and GCV (17.36) estimates are moderate and difference between them is narrow indicating that the phenotypic variability is the direct measure of genetic variability. Similar results were reported by Maloo *et al.* (1998), Padmaja (2006), Sarala (2007) and Srilakshmi (2013).

High heritability (99.60%) combined with high genetic advance as per cent of mean (45.75) was noted for this trait which revealed the importance of additive gene action. This indicates that this character can be improved through simple selection procedures. These findings are in agreement with the results of Maloo *et al.* (1998), Padmaja (2006), Sarala (2007) and Srilakshmi (2013).

4.1.11 Seed yield per plant (g)

The range of variation noted for this trait is from 7.30 g (GE-1274) to 22.75 g (GE-2723) with a mean of 14.15 g. The PCV (32.75) and GCV (27.21) estimates were high indicating the presence of high amount of variability in the material studied. These findings are in conformity with the results of Bendale *et al.* (2002), Satish (2003), Anand *et al.* (2005), Bezaweletaw *et al.* (2006), Arunaprabhau *et al.* (2008), Kadam *et al.*

(2009), Shet *et al.* (2009), Dhamdhare *et al.* (2011), Karad and Patil (2013) and Ulaganathan and Nirmalakumari (2013).

High heritability (69.00%) combined with high genetic advance as per cent of mean (59.72) was noted for this trait which revealed the importance of additive gene action. This indicates that this character can be improved through simple selection procedures. These findings are in agreement with the results of Padmaja (2006), John (2007), Sarala (2007), Satish *et al.* (2007), Gowda *et al.* (2008), Sharathbabu *et al.* (2008), Shet *et al.* (2010), Dhamdhare *et al.* (2011), Priyadharshini *et al.* (2011), Nishit (2013), Srilakshmi (2013) and Ulaganathan and Nirmalakumari (2013).

4.2 CHARACTER ASSOCIATION

Yield is a complex and polygenically inherited character resulting from multiplicative interaction of its component traits. The cumulative effect of such traits determines the yield. The change in one character brings about a series of changes in the other characters, since they are interrelated. Therefore, the correlation studies are of considerable importance in any selection programme as they provide degree and direction of relationship between two or more component traits.

The phenotypic and genotypic correlation coefficients between seed yield and yield component characters and among themselves were estimated and presented in Table 4.4. The results were discussed character wise hereunder. Genotypic correlations in general are higher than phenotypic correlations indicating that the apparent associations are largely due to genetic reasons.

4.2.1 Plant height

Plant height recorded highest significant positive association with days to maturity (0.7207^{**} and 0.6537^{**}) followed by days to 50% flowering (0.6730^{**} and 0.5896^{**}), fingers per ear (0.3965^{**} and 0.3366^{**}), seed yield per plant (0.2665^{**} and 0.2006^{**}) and ear weight per plant (0.2342^{**} and 0.1859^{*}) both at genotypic and phenotypic levels, respectively. Similar results were also observed by Bezaweletaw *et al.* (2006), Ganapathy *et al.* (2011), Muduli *et al.* (2012) and Nishit (2013) for days to maturity, Haider *et al.* (1995), Singh *et al.* (1995), Bedis *et al.* (2006), Ganapathy *et al.* (2011), Muduli *et al.* (2012) and Nishit (2013) for days to 50% flowering, Ravindran *et*

al. (1996), Bedis *et al.* (2006), Bezaweleaw *et al.* (2006), Sarala *et al.* (2007), Wolie and Dessalegn (2011), Nishit (2013) and Srilakshmi (2013) for number of fingers per ear, Harikrishna *et al.* (2005), Bedis *et al.* (2006), Shindey *et al.* (2010), Ganapathy *et al.* (2011) and Haradari *et al.* (2012) for seed yield per plant and Goud & Laxmi (1977) and Haider *et al.* (1995) for ear weight per plant.

This character also exhibited positive significant association with productive tillers per plant (0.2156^{*}), finger length (0.1898^{*}) and 1000-seed weight (0.1805^{*}) at genotypic level. These results are in agreement with the findings of Appudurai *et al.* (1977) and Priyadarshani *et al.* (2011) for productive tillers per plant, Priyadarshini *et al.* (2011) for finger length and Patnaik (1968) and Muduli *et al.* (2012) for 1000-seed weight. Further it also exhibited significant negative association with seed protein content (-0.3022^{**} and -0.2741^{**}) at both the levels. Similar results are also recorded by Srilakshmi (2013).

4.2.2 Days to 50 % flowering

This trait recorded highest significant positive association with days to maturity (0.8277^{**} and 0.8148^{**}) followed by seed yield per plant (0.5079^{**} and 0.4249^{**}), fingers per ear (0.5025^{**} and 0.4791^{**}), finger length (0.4485^{**} and 0.3714^{**}), ear weight per plant (0.3978^{**} and 0.3369^{**}), productive tillers per plant (0.3252^{**} and 0.2754^{**}) and 1000-seed weight (0.3238^{**} and 0.3170^{**}) both at genotypic and phenotypic levels, respectively. These results are in agreement with the findings of Mishra (1996), Bedis *et al.* (2006), Sumathi *et al.* (2006), Ganapathy *et al.* (2011), Muduli *et al.* (2012), Nishit (2013) and Srilakshmi (2013) for days to maturity, Harikrishna *et al.* (2005), Bedis *et al.* (2006), Kadam *et al.* (2009) and Nagaraja *et al.* (2010) for seed yield per plant, Bedis *et al.* (2006), Shindey *et al.* (2010) and Nishit (2013) for number of fingers per ear, Singh *et al.* (1995), Bedis *et al.* (2006), Sumathi *et al.* (2006), Ganapathy *et al.* (2011), Nishit (2013) and Srilakshmi (2013) for finger length, Haider *et al.* (1995), Haider & Mahto (1995) and Srilakshmi (2013) for ear weight per plant and Bedis *et al.* (2006), Haider *et al.* (1995), Nishit (2013) and Srilakshmi (2013) for productive tillers per plant.

At both genotypic and phenotypic levels, this character showed negative significant association with seed protein content (-0.2241^{**} and -0.2196^{*}). Similar findings were reported by Sarala *et al.* (2008).

4.2.3 Days to maturity

Days to maturity was found to have highest significant positive association with seed yield per plant (0.6245^{**} and 0.5137^{**}) followed by finger length (0.5375^{**} and 0.4271^{**}), ear weight per plant (0.5316^{**} and 0.4799^{**}), fingers per ear (0.4912^{**} and 0.4771^{**}), 1000-seed weight (0.4755^{**} and 0.4600^{**}) and productive tillers per plant (0.2883^{**} and 0.2458^{**}) both at genotypic and phenotypic levels, respectively. Similar results were also obtained by Bedis *et al.* (2006), Haradari *et al.* (2012) and Nishit (2013) for seed yield per plant, Bedis *et al.* (2006), Sumathi *et al.* (2006) and Ganapathy *et al.* (2011) for finger length, Srilakshmi (2013) for ear weight per plant, Srilakshmi (2013) for fingers per ear, Nishit (2013) for 1000-seed weight and Srilakshmi (2013) for productive tillers per plant. Further, it had negative significant association with seed protein content (0.2392^{**} and 0.2375^{**}) both at genotypic and phenotypic levels, respectively.

4.2.4 Productive tillers per plant

This trait possessed highest significant positive association with number of fingers per ear (0.7332^{**} and 0.6178^{**}) followed by seed yield per plant (0.5669^{**} and 0.4148^{**}), 1000-seed weight (0.5353^{**} and 0.4648^{**}), ear weight per plant (0.4388^{**} and 0.3236^{**}) and finger length (0.3625^{**} and 0.2211^{*}) at both genotypic and phenotypic levels, respectively.

Similar results were also reported by Ravindran *et al.* (2011) and Srilakshmi (2013) for number of fingers per ear, Harikrishna *et al.* (2005), Bezaweletaw *et al.* (2006), Ganapathy *et al.* (2011), Priyadharshini *et al.* (2011), Dagnachew *et al.* (2012) and Srilakshmi (2013) for seed yield per plant, Srilakshmi (2013) for 1000-seed weight, Haider *et al.* (1995), Haider and Mahto (1995) and Srilakshmi (2013) for ear weight per plant and Srilakshmi (2013) for finger length.

4.2.5 Fingers per ear

The trait, fingers per ear showed highest significant positive association with seed yield per plant (0.8534^{**} and 0.6838^{**}) followed by 1000-seed weight (0.7330^{**} and 0.6944^{**}), ear weight per plant (0.6516^{**} and 0.5911^{**}) and finger length (0.5211^{**} and 0.4068^{**}) both at genotypic and phenotypic levels, respectively.

These above results were in agreement with the findings of Bedis *et al.* (2006), Bezaweleaw *et al.* (2006), Shindey *et al.* (2010), Priyadharshini *et al.* (2011), Wolie and Dessalegn (2011), Muduli *et al.* (2012) and Srilakshmi (2013) for seed yield per plant, Srilakshmi (2013) for 1000-seed weight, Muduli *et al.* (2012) and Srilakshmi (2013) for ear weight per plant and Patnaik (1968), Bedis *et al.* (2006), Shindey *et al.* (2010), Nishit (2013) and Srilakshmi (2013) for finger length.

4.2.6 Finger length

This character exhibited highest significant positive association with seed yield per plant (0.7573^{**} and 0.5103^{**}) followed by 1000-seed weight (0.6233^{**} and 0.4950^{**}), ear weight per plant (0.6181^{**} and 0.4416^{**}) both at genotypic and phenotypic levels, respectively. Similar results were also reported by Bendale *et al.* (2002), Bedis *et al.* (2006), Ganapathy *et al.* (2011), Wolie and Dessalegn (2011) and Srilakshmi (2013) for seed yield per plant, Srilakshmi (2013) for 1000-seed weight and Bendale *et al.* (2002) for ear weight per plant. This character also exhibited non-significant negative association with seed protein content (-0.0711 and -0.0609) and seed calcium content (-0.0127 and -0.0098) at both genotypic and phenotypic level.

4.2.7 Ear weight per plant

The trait, ear weight per plant recorded highest significant positive association with seed yield per plant (0.7850^{**} and 0.6450^{**}) followed by 1000-seed weight (0.5671^{**} and 0.5130^{**}) at both genotypic and phenotypic levels, respectively. These results are in agreement with the findings of Bendale *et al.* (2002), Harikrishna *et al.* (2005), Padmaja (2006), Sarala *et al.* (2008), Haradari *et al.* (2012) and Muduli *et al.* (2012) for seed yield per plant and Harikrishna *et al.* (2005), Sarala *et al.* (2008) and Dagnachew *et al.* (2012) for 1000-seed weight. This character also exhibited positive non-significant association with seed protein content (0.0549 and 0.0531) both

genotypic and phenotypic levels, respectively and negative non-significant association with seed calcium content (-0.1252 and -0.1125) at both the levels.

4.2.8 1000-Seed weight

This trait recorded highest significant positive association with seed yield per plant (0.9021^{**} and 0.7640^{**}) at both genotypic and phenotypic levels. These results were in agreement with the findings of Harikrishna *et al.* (2005), Shet *et al.* (2010) and Srilakshmi (2013).

It also had non-significant positive association with seed calcium content (0.0101 and 0.0099) and seed protein content (0.0068 and 0.0075) at both genotypic and phenotypic levels, respectively. These results are in agreement with the findings of Srilakshmi (2013) for seed calcium content.

4.2.9 Seed Protein content

Seed protein content had negative non-significant association with seed calcium content (-0.1638 and -0.1634) and seed yield per plant (-0.0558 and -0.0467) at both genotypic and phenotypic levels, respectively. Similar results were reported by Sarala *et al.* (2008), Nagaraja *et al.* (2010) for seed calcium content at phenotypic level and Padmaja (2006) and Srilakshmi (2013) for seed yield per plant.

4.2.10 Seed calcium content

This character exhibited non-significant negative association with seed yield per plant (-0.1131 and -0.0891) at both genotypic and phenotypic levels. Similar association was reported by Padmaja (2006) and Sarala *et al.* (2008).

4.3 PATH COEFFICIENT ANALYSIS

Yield being a complex character, is composed of several components some of which affect yield directly while others contribute towards it indirectly. Correlation studies provide information only on the magnitude and direction of association of yield with its components and also among various components. But to know the direct effects of each independent variable on yield and indirect effects through other characters of each variable, path coefficient analysis has to be performed. In the present study, path analysis was used to work out the direct and indirect effects of yield contributing characters on yield using 40 genotypes of finger millet and the results are presented (Table 4.5.) character wise hereunder. The path diagrams were given in figures 4.1. and 4.2.

4.3.1 Plant height

At genotypic level, this trait had positive significant association (0.2665^{**}) and negative direct effect (-0.1676) on seed yield per plant. It also had positive indirect effects via days to maturity (0.1535), fingers per ear (0.1517), 1000-seed weight (0.0741), ear weight per plant (0.0398), finger length (0.0264) and days to 50% flowering (0.0112) and negative indirect effects via productive tillers per plant (-0.0193), seed calcium content (-0.0020) and seed protein content (-0.0013) at genotypic level.

This trait had significant positive correlation (0.2006^{**}) and negative direct effect (-0.0568) on seed yield per plant at phenotypic level. It also expressed positive indirect effects via 1000-seed weight (0.0732), days to 50% flowering (0.0624), ear weight per plant (0.0483), fingers per ear (0.0401), days to maturity (0.0218), seed protein content (0.0084), and finger length (0.0079) while it showed negative indirect effects via productive tillers per plant (-0.0027) and seed calcium content (-0.0020) at phenotypic level.

The direct effects of plant height are negative and the correlation coefficients are significantly positive at both phenotypic and genotypic level. Similar results were reported by Bendale *et al.* (2002). While it had positive indirect effects via days to maturity, fingers per ear, 1000-seed weight, ear weight per plant, finger length and days

to 50% flowering at both genotypic and phenotypic levels which seem to be the cause for positive correlation. Hence, these characters through which plant height is showing positive indirect effect are to be considered simultaneously during the selection process for the improvement of the dependent variable seed yield per plant.

4.3.2 Days to 50 % flowering

At genotypic level, this trait had a positive significant correlation (0.5079^{**}) and positive direct effect (0.0166) on seed yield per plant. It also exhibited positive indirect effects via fingers per ear (0.1923), days to maturity (0.1762), 1000-seed weight (0.1329), ear weight per plant (0.0675), finger length (0.0624) and seed calcium content (0.0027) and negative indirect effects via plant height (-0.1128), productive tillers per plant (-0.0291) and seed protein content (-0.0009).

At phenotypic level, days to 50% flowering exhibited positive significant correlation (0.4249^{**}) and positive direct effect (0.1059) on seed yield per plant. It also exhibited prominent positive indirect effects via 1000-seed weight (0.1550), ear weight per plant (0.0875), fingers per ear (0.0571), days to maturity (0.0271), finger length (0.0230), seed protein content (0.0068) and seed calcium content (0.0027) while it showed negative indirect effects via plant height (-0.0335) and productive tillers per plant (-0.0067).

This trait recorded positive direct effects as well as significant positive correlation coefficients with seed yield per plant both at genotypic and phenotypic level. Similar results were recorded by Reddy *et al.* (1994), Bendale *et al.* (2002) and Anuradha and Suryakumari (2005). Further, this trait also recorded positive indirect effects via fingers per ear, days to maturity, 1000-seed weight, ear weight per plant and finger length at both genotypic and phenotypic levels. Hence, for improvement of seed yield per plant simultaneous selection of these characters along with days to 50% flowering should be carried out.

4.3.3 Days to maturity

It showed significant positive correlation (0.6245^{**}) and positive direct effect (0.2129) on seed yield per plant at genotypic level. It also possessed positive indirect effects via 1000 seed weight (0.1952), fingers per ear (0.1879), ear weight per plant

(0.0902), finger length (0.0748) and days to 50% flowering (0.0138) and negative indirect effects via plant height (-0.1208), productive tillers per plant (-0.0258), seed calcium content (-0.0028) and seed protein content (-0.0010).

This trait showed significant positive association (0.5137^{**}) and positive direct effect (0.0333) on seed yield per plant at phenotypic level. It also displayed positive indirect effects via 1000-seed weight (0.2249), ear weight per plant (0.1246), days to 50% flowering (0.0863), finger per ear (0.0568), finger length (0.0264) and seed protein content (0.0073) and negative indirect effects via plant height (-0.0371), productive tillers per plant (-0.0060) and seed calcium content (-0.0029).

Thus this trait recorded positive direct effect coupled with positive correlation on seed yield per plant both at genotypic and phenotypic levels. These results are in accordance with Lal *et al.* (1996). The indirect effects via 1000-seed weight, fingers per ear, ear weight per plant, finger length and days to 50% flowering were also positive. Therefore along with days to maturity, the causal factors which had positive indirect effects on seed yield per plant may be considered simultaneously during the process of selection.

4.3.4 Productive tillers per plant

At genotypic level, this trait had a positive significant correlation (0.5669^{**}) and negative direct effect (-0.0894) on seed yield per plant. It also exhibited the positive indirect effects via fingers per ear (0.2805), 1000-seed weight (0.2197), ear weight per plant (0.0745), days to maturity (0.0614), finger length (0.0504), days to 50% flowering (0.0054) and seed calcium content (0.0017) and negative indirect effects via plant height (-0.0361) and seed protein content (-0.0012).

This character expressed significant positive association (0.4148^{**}) and negative direct effect (-0.0243) on seed yield per plant at phenotypic level. It also had positive indirect effects via 1000-seed weight (0.2273), ear weight per plant (0.0840), finger per ear (0.0736), days to 50% flowering (0.0292), finger length (0.0137), days to maturity (0.0082), seed protein content (0.0080) and seed calcium content (0.0015) and while it showed negative indirect effects via plant height (-0.0064).

Thus the trait showed negative direct effects coupled with highly significant positive association on seed yield per plant at both phenotypic and genotypic levels. These findings were in agreement with the results of Bendale *et al.* (2002) and Anuradha and Suryakumari (2005). This type of correlation does not explain the true relationship and direct selection through this trait will not be rewarding. In such situations the causal factors showing positive indirect effects on seed yield per plant viz., fingers per ear, 1000-seed weight, ear weight per plant, days to maturity and finger length which are responsible for positive correlation. Therefore these traits are to be considered simultaneously in selection process for improvement of the dependent variable.

4.3.5 Fingers per ear

At genotypic level, this character recorded significant positive association (0.8534^{**}) and positive direct effect (0.3826) on seed yield per plant. It also possessed positive indirect effects via 1000-seed weight (0.3009), ear weight per plant (0.1106), days to maturity (0.1046), finger length (0.0725), days to 50% flowering (0.0084) and seed calcium content (0.0068) and negative indirect effects via plant height (-0.0664), productive tillers per plant (-0.0655) and seed protein content (-0.0010).

This character expressed significant positive association (0.6838^{**}) and positive direct effect (0.1191) on seed yield per plant at phenotypic level. It also had positive indirect effects via 1000-seed weight (0.3396), ear weight per plant (0.1535), days to 50% flowering (0.0507), finger length (0.0252), days to maturity (0.0159), seed protein content (0.0072) and seed calcium content (0.0068) while it showed negative indirect effects via plant height (-0.0191) and productive tillers per plant (-0.0150).

Thus this trait showed positive direct effects coupled with highly significant positive association on seed yield per plant at both phenotypic and genotypic levels. These findings were in agreement with the results of Reddy *et al.* (1994), Lal *et al.* (1996), Anuradha and Suryakumari (2005), Nishit (2013) and Srilakshmi (2013) at phenotypic and genotypic levels.

The correlation coefficients are positive and highly significant and they are high particularly at genotypic level. This indicates direct effects of fingers per ear on yield at

both genotypic and phenotypic level accounted for the major portion in the total correlation between them, direct selection through fingers per ear will be effective.

4.3.6 Finger length

At genotypic level, this trait expressed significant positive association (0.7573^{**}) and direct positive effect (0.1391) on seed yield per plant. It also showed positive indirect effects via 1000-seed weight (0.2559), fingers per ear (0.1994), days to maturity (0.1144), ear weight per plant (0.1049), days to 50% flowering (0.0075) and seed calcium content (0.0006) while it showed negative indirect effects via productive tillers per plant (-0.0324), plant height (-0.0318) and seed protein content (-0.0003).

This trait exhibited significant positive association (0.5103^{**}) and positive direct effect (0.0619) on seed yield per plant at phenotypic level. It also showed positive indirect effects via 1000-seed weight (0.2421), ear weight per plant (0.1147), fingers per ear (0.0485), days to 50% flowering (0.0393), days to maturity (0.0142), seed calcium content (0.0051) and seed protein content (0.0019) while it showed negative indirect effects via plant height (-0.0073) and productive tillers per plant (-0.0054).

Thus the trait, finger length showed low positive direct effects coupled with significant positive association on seed yield per plant at both phenotypic and genotypic levels. Similar results were reported by Singh *et al.* (1995), Lal *et al.* (1996), Bendale *et al.* (2002) and Anuradha and Suryakumari (2005). These results indicate that there is considerable amount of contribution through the indirect effects via 1000-seed weight, fingers per ear, days to maturity, ear weight per plant and days to 50% flowering towards the positive correlation. In such situations, these indirect causal factors are to be considered along with finger length during selection.

4.3.7 Ear weight per plant

It showed positive significant correlation (0.7850^{**}) and positive direct effect (0.1698) on seed yield per plant at genotypic level. It also possessed positive indirect effects via fingers per ear (0.2493), 1000-seed weight (0.2398), days to maturity (0.1132), finger length (0.0860), days to 50% flowering (0.0066), seed calcium content (0.0056) and seed protein content (0.0002) and negative indirect effects via plant height (-0.0392) and productive tillers per plant (-0.0392).

At phenotypic level this trait exhibited significant positive association (0.6450^{**}) and positive direct effect (0.2597) on seed yield per plant. It also showed positive indirect effects via 1000-seed weight (0.2509), fingers per ear (0.0704), days to 50% flowering (0.0357), finger length (0.0273) and days to maturity (0.0160) while it showed negative indirect effects via plant height (-0.0106), productive tillers per plant (-0.0079), seed protein content (-0.0016) and seed calcium content (-0.0005).

Thus the trait, ear weight per plant showed positive direct effects coupled with significant positive correlation coefficients with seed yield per plant at both phenotypic and genotypic levels. These findings are in agreement with the results of Bendale *et al.* (2002) and Srilakshmi (2013). Further, this trait also recorded positive indirect effects via fingers per ear, 1000-seed weight, days to maturity, finger length and days to 50% flowering at both genotypic and phenotypic levels. Hence, for improvement of seed yield per plant simultaneous selection of these characters along with ear weight per plant should be carried out.

4.3.8 1000-Seed weight (g)

At genotypic level, this trait expressed significant positive association (0.9021^{**}) and positive direct effect (0.4105) on seed yield per plant. It also showed positive indirect effects via fingers per ear (0.2805), days to maturity (0.1012), ear weight per plant (0.0963), finger length (0.0867) and days to 50% flowering (0.0054) while it showed negative indirect effects via productive tillers per plant (-0.0478), plant height (-0.0302) and seed calcium content (-0.0004).

At phenotypic level, 1000-seed weight had significant positive association (0.7640^{**}) and positive direct effect (0.4890) on seed yield per plant. It also showed

positive indirect effect via ear weight per plant (0.1332), fingers per ear (0.0827), days to 50% flowering (0.0336), finger length (0.0306), days to maturity (0.0153) and seed calcium content (0.0075) and negative indirect effects via productive tillers per plant (-0.0113), plant height (-0.0085), and seed protein content (-0.0002).

Thus, 1000-seed weight had positive direct effect coupled with significant positive association on seed yield per plant at both phenotypic and genotypic levels. Similar results were reported by Reddy *et al.* (1994), Nishit (2013) and Srilakshmi (2013). As the direct effects of 1000-seed weight on yield at both genotypic and phenotypic level accounted for the major portion in the total correlation between them, direct selection through 1000 seed weight will be effective.

4.3.9 Seed protein content

At genotypic level, this trait exhibited non-significant negative association (-0.0558) and positive direct effect (0.0041) on seed yield per plant. While it expressed positive indirect effects via plant height (0.0506), productive tillers per plant (0.0267), ear weight per plant (0.0093), seed calcium content (0.0073) and 1000-seed weight (0.0028). It exhibited negative indirect effects via fingers per ear (-0.0921), days to maturity (-0.0509), finger length (-0.0099) and days to 50% flowering (-0.0037).

Direct effect of this trait was negative (-0.0308) and showed non-significant negative association (-0.0467) with seed yield per plant at phenotypic level. While it expressed positive indirect effects via plant height (0.0156), ear weight per plant (0.0138), productive tillers per plant (0.0064) and 1000-seed weight (0.0037) and negative indirect effects via seed calcium content (-0.0457), fingers per ear (-0.0279), days to 50% flowering (-0.0232), days to maturity (-0.0079) and finger length (-0.0038).

Thus seed protein content showed negative direct effect at phenotypic level and positive direct effect at genotypic level coupled with non-significant negative association at both phenotypic and genotypic levels. These results were in accordance with Harikrishna *et al.* (2005) for phenotypic level and Padmaja *et al.* (2006) and Sarala *et al.* (2008) for genotypic level. Negative direct effect at phenotypic level and low positive direct effect at genotypic level along with negative correlation at both the levels indicate that, the casual factors viz., plant height, productive tillers per plant, ear weight per plant

and 1000-seed weight which had positive indirect effects on seed yield per plant may be considered during the process of selection.

4.3.10 Seed calcium content

At genotypic level, this trait expressed non-significant negative association (-0.1139) and direct negative effect (-0.0444) on seed yield per plant. While it possessed positive indirect effects via days to maturity (0.0135), 1000-seed weight (0.0041) and productive tillers per plant (0.0035) and it showed negative indirect effects via fingers per ear (-0.0584), ear weight per plant (-0.0213), plant height (-0.0075), finger length (-0.0018), days to 50% flowering (-0.0010) and seed protein content (-0.0007).

At phenotypic level, seed calcium content had non-significant negative association (-0.0891) and negative direct effect (-0.0481) on seed yield per plant. But it had positive indirect effect via seed protein content (0.0050), 1000-seed weight (0.0048) and productive tillers per plant (0.0008) and negative indirect effects via ear weight per plant (-0.0292), fingers per ear (-0.0176), days to 50% flowering (-0.0063), plant height (-0.0025), days to maturity (-0.0021) and finger length (-0.0006).

Thus this trait recorded negative direct effects coupled with negative non-significant correlations on seed yield per plant at both phenotypic and genotypic levels. These results are in accordance with Srilakshmi (2013). As the correlation coefficients are non-significant and the direct effects are also negative at both phenotypic and genotypic levels the traits which had positive correlation with seed calcium content as well as with seed yield per plant may be considered during selection.

In plant breeding it is very difficult to have complete knowledge of all component traits of yield. The residual effect permits precise explanation about the pattern of interaction of other possible components of yield. In other words, residual effect measures the role of the possible independent variables which were not included in the study on the dependent variable. In the present study, the residual effect at genotypic level is 0.1166 indicating that the characters included in present investigation are contributing around 90 percent of variability pertaining to the dependent variable *i.e.*, yield. Only ten percent of contribution is from the few other characters which were not included in present study.

4.4 GENETIC DIVERGENCE

Conservation of germplasm resources is basic to crop improvement programmes. However, to understand the usable variability, grouping or classification of genetic stocks based on suitable scale is quite imperative. Similarly, choice of genetically divergent parents for hybridization under transgressive breeding programme is also dependent upon categorization of breeding materials on the basis of appropriate criteria. Systematic classification rests exclusively upon easily distinguishable qualitative attributes. This represents phylogenetic hierarchy or descriptive account of individuals or group of individuals. But it does not consider quantitative traits showing continuous variation which constitutes the backbone of plant breeding practices.

On the other hand, quantitative classification offers a quantified degree of divergence among genotypes or populations. This serves as a sound basis of grouping any two or more genotypes based on minimum divergence or resemblance between them. The models of multivariate analysis (i.e., simultaneous statistical treatment of a set of correlated metric traits in a group of populations) which satisfy this proposition are more than one; for instance Duncon's multiple range test, metroglyph and index score method, D^2 -statistic, Principal component analysis, factor analysis. However, out of all these, D^2 -statistic and Principal component analysis are now most frequently used for classificatory purposes. While the former gives a quantitative measurement of divergence among genotypes, the latter serves the same purpose in terms of spatial distance. Besides, both venture to define the relative contribution of different characters to differentiation among genotypes. This narrows down the problem of identifying the characters responsible for the discrimination between the populations.

The data collected on 11 yield and yield contributing characters from 40 genotypes of finger millet were subjected to genetic divergence analysis employing Mahalanobis' D^2 statistic, principal component and hierarchial cluster analysis. The magnitude of values suggested that there is considerable variability in the genotypes studied, which led to genetic diversity.

4.4.1 Mahalanobis' D^2 analysis

4.4.1.1 Test with Wilk's criterion ' Λ '

Univariate analysis of variance revealed the significant difference for all the eleven characters under study in the 40 finger millet genotypes. This significance of difference among 40 genotypes for all characters justify further calculation of D^2 values. However pooled differences are determined by Wilk's criterion. Wilk's statistic ' Λ ' which follows v-statistic representing χ^2 distribution at 429 df was calculated and found to be highly significant with a magnitude of 2698.25. Therefore, pooled differences (aggregate of all traits) among the 40 genotypes were significant justifying the need to calculate D^2 values.

4.4.1.2 Mahalanobis' D^2 values

To estimate the D^2 values, correlated means of characters were transformed into uncorrelated variables using Pivotal Condensation Method. It measures the degree of diversification and determines the relative contribution of each component character to total divergence. The D^2 values between any two genotypes was obtained as the sum of squares of the differences of their corresponding uncorrelated values. Thus D^2 values were obtained for all the possible 780 pairs of genotypes.

The percent contribution of all the 11 characters in the 40 genotypes towards genetic divergence is presented in Table 4.6. Among the characters studied protein content (57.56%) showed maximum contribution followed by calcium content (32.69%), days to maturity (6.92%), days to 50% flowering (1.28%), 1000-seed weight (0.77%), fingers per ear (0.64%), ear weight per plant (0.13%). While the contribution of other traits like plant height, productive tillers per plant, finger length and seed yield per plant was zero percent.

4.4.1.3 Grouping of genotypes into various clusters

The 40 genotypes were grouped into seven clusters using the Tocher's method (Table 4.7), with the criterion that the intra-cluster average D^2 values should be less than the inter-cluster D^2 values.

The distribution of 40 genotypes into seven clusters was at random with maximum number of genotypes in cluster II (16 genotypes). Cluster III and cluster IV were the second largest clusters having seven genotypes each followed by cluster I with five genotypes and cluster V with three genotypes. Clusters VI and VII were solitary clusters, hence no intra-cluster distances (D^2 values). The formation of distinct solitary clusters may be due to the fact that geographic barriers preventing gene flow or intensive natural and human selection for diverse and adaptable gene complexes must be responsible for this genetic diversity (Arunachalam and Ram, 1967).

4.4.1.4 Average intra and inter-cluster D^2 value

The average intra and inter-cluster D^2 values were estimated as per the procedure given by Singh and Chaudhary (1977) and are presented in the Table 4.8. The nearest and farthest cluster for each of the seven clusters are indicated in Table 4.9 and Fig 4.3.

Inter-cluster divergence expresses the diversification among clusters (group of genotypes resembling each other, hence with low intra-cluster divergence). Intra-cluster D^2 values ranged from 0.00 (cluster VI and VII) to 492.70 (cluster IV). The intra-cluster distance indicated the diversity among the genotypes grouped in that clusters. Genotypes grouped into the same cluster presumably differ little from one another as the aggregate of characters measured.

General notion exists that the larger is the divergence between the parental genotypes, the higher will be the heterosis in crosses (Falconer, 1964). Therefore, it would be desirable to attempt crosses between genotypes belonging to distant clusters for getting highly heterotic crosses which are likely to yield a wide range of segregants on which selection can be practiced. In the present study, inter-cluster distances were worked out considering 11 characters and these distances ranged from 280.93 (between cluster I and V) to 4451.42 (between cluster V and VII).

Cluster I comprising five genotypes was nearest to cluster V (280.93) followed by cluster II (343.39) and was farthest from cluster VII (2837.67) followed by cluster VI (1940.16).

Cluster II with 16 genotypes was the largest of all clusters. It was nearest to cluster I (343.39) followed by cluster III (580.87) and it was farthest from cluster VII (2206.00) followed by cluster VI (1518.31).

Seven genotypes were grouped into cluster III. It was nearest to cluster VI (468.68) followed by cluster II (580.87) and it was farthest from cluster V (1819.02) followed by cluster IV (1479.44).

Cluster IV also consisted seven genotypes as that of cluster III. It was nearest to the cluster II (586.45) followed by cluster I (852.15) and it was farthest from cluster VII (3589.81) followed by cluster VI (3015.21).

Cluster V comprised of three genotypes. It was nearest to the cluster I (280.93) followed by cluster II (755.34) and was farthest from cluster VII (4451.42) followed by cluster VI (3163.07).

Cluster VI was monogenotypic (GE-995). It was closest to the cluster III (468.68) followed by cluster VII (615.19) and was farthest from cluster V (3163.07) followed by cluster IV (3015.21).

Cluster VII was also monogenotypic (GE-3434). It was closest to the cluster VI (615.19) followed by cluster III (972.69) and was farthest from cluster V (4451.42) followed by cluster IV (3589.81).

The maximum inter-cluster distance was between cluster V and VII (4451.42), followed by cluster IV and VII (3589.81), cluster V and VI (3163.07), cluster IV and VI (3015.21), cluster I and VII (2837.67), cluster II and VII (2206.00) and cluster III and Cluster V (1819.02). This suggested that there is wide genetic diversity between these clusters. The genotypes GE-3434 and GE-1382 belonging to same geographical area i.e. Africa were grouped in two different farthest clusters, hence indicating geographical divergence and genetic diversity are not correlated. These results are in accordance with those of Jain *et al.* (1981, 2002), Rao (1992), Kadam (2008) and Kumar *et al.* (2010).

4.4.1.5 Cluster mean values

Cluster means indicate average performance of all genotypes present in a particular cluster. The cluster mean values for 11 characters are presented in Table 4.10. The data indicated a wide range of mean values between the clusters. Plant height had a range of 85.32 cm for cluster VI to 121.00 cm for cluster VII, days to 50% flowering had a range of 58.00 days for cluster VI to 77.22 days for cluster V, days to maturity had a

range of 88.00 days for cluster VI to 114.00 days for cluster VII, number of productive tillers ranged from 2.83 for cluster VI to 4.40 for cluster I, number of fingers per ear varied from 3.73 for cluster VI to 6.70 for cluster I, finger length varied from 5.86 cm for cluster VI to 8.08 cm for cluster VII, ear weight per plant ranged from 14.49 g for cluster VI to 25.97 g for cluster VII, 1000-seed weight varied from 3.36 g for cluster VI to 4.23 g for cluster I, seed protein content varied from 6.17 percent for cluster V to 13.66 percent for cluster VII, seed calcium content varied ranged from 253.00 mg/100g for cluster VI to 414.05 mg/100g for cluster IV and seed yield per plant varied from 9.51g for cluster VI to 18.73 g for cluster I.

The success and usefulness of Mahalanobis' D^2 analysis in quantifying genetic divergence in finger millet has been studied by Suyambulingam and Jebarani (1977), Jain *et al.* (1981), Shigeta (1985), Jayaprakash Naik (1991), Purushotham Rao (1992), Vadivoo *et al.* (1998), Surya Kumar *et al.* (1998), Jain *et al.* (2002), Satish (2003), Balwant Kumar *et al.* (2005), Jayalakshmi *et al.* (2007), Anantharaju and Meenakshiganesan (2008), Arun Prabhu *et al.* (2008), Kadam (2008), Dinesh Kumar *et al.* (2010) and Sahu and Pradhan (2012), Wolie and Belete (2013) and Karad and Patil (2013).

4.4.2 Principal component analysis

Principal component analysis or Canonical (vector) analysis is a sort of multivariate analysis where canonical vectors and roots representing different axis of differentiation and the amount of variation accounted for by each of such axis, respectively, are derived (Rao, 1952). It is called principal component analysis as it reflects the importance of the largest contributor to the total variation at each axis of differentiation. It measures divergence between varieties in terms of spatial distance rather than quantifying it as D^2 does. Thus, it confirms the group constellations obtained by D^2 analysis as varietal distribution in two-way pictorial graph fixing the relative position of each genotype.

In principal component analysis on correlation matrix, the standardization of columns (here characters) created 11 new variables for 40 genotypes without changing their relative positions. These 11 new variables are the principal components (PC_1 , PC_2

.....PC₁₁). Each principal component is a linear combination of the 11 attributes of data matrix. The loading values are scaled or standardized in such a manner that the sum of square of loadings within a principal component is equal to one. The loadings are viewed as weights defining the contribution of characters in respective principal component. Like regression coefficients, loadings sign (+ / -) are indicative of the direction of contribution. But unlike regression, only the relative contributions are important, so all signs can be changed without affecting the analysis (Jackson, 1991).

The loadings for first principal component were chosen so as to make its variance as large as possible. Loadings of second principal component were chosen such that the variance of PC₂ is as large as possible, subject to the constraint that PC₁ and PC₂ are uncorrelated. The process was continued to create 11 principal components, but PC's having eigen value less than one is not having any practical significance (Legendre and Legendre, 1984).

Results obtained from PCA on the correlation matrix of the traits reduce the dimensionality of the data set by creating several significant principal components having eigen value more than one. The PCA scores for individual genotypes were used for clustering the genotypes as suggested by Anderberg (1993). Results of PCA and cluster analysis are discussed here under.

Principal components (Eigen value greater than one), Eigen values (Latent Root), per cent variability, cumulative per cent variability and component loading of different characters are presented in Table 4.11.

In the present study, the first three principal components with eigen values more than one contributed 76.411 per cent towards the total variability. The principal component with eigen values less than one were considered as non- significant. It was therefore inferred that the essential features of data set had been represented in the first three principal components.

The first principal component contributed maximum towards variability (46.687%). The characters viz., number of productive tillers per plant (0.411), ear weight per plant (0.393), days to maturity (0.379), days to 50% flowering (0.374), fingers per ear (0.318), plant height (0.306), 1000-seed weight (0.305), seed yield per plant (0.223),

finger length (0.095) which were positively loaded. Seed protein content (-0.193) and seed calcium content (-0.084) were negatively loaded.

The second principal component (PC₂) described 16.081 per cent of total variance and it reflected significant positive loading of the characters viz., seed calcium content (0.689), plant height (0.220), days to maturity (0.184), days to 50% flowering (0.138), number of productive tillers per plant (0.098), ear weight per plant (0.021) and negative loading of seed yield per plant (-0.576), finger length (-0.191), fingers per ear (-0.169), seed protein content (-0.116) and 1000-seed weight (-0.005).

The third principal component (PC₃) was characterized by 13.643 per cent contribution towards the total variability. The characters viz., plant height (0.306), seed yield per plant (0.259), days to 50% flowering (0.201), days to maturity (0.092), finger length (-0.642), 1000-seed weight (-0.433), fingers per ear (-0.289), seed calcium content (-0.231), seed protein content (-0.208), ear weight per plant (-0.088) and number of productive tillers (-0.004). Plant height, seed yield per plant, days to 50% flowering and days to maturity loaded positively whereas, finger length, 1000-seed weight, fingers per ear, seed calcium content, ear weight per plant and number of productive tillers were negatively loaded.

Similarly, principal component fourth (PC₄) contributed 8.372 per cent towards total variability. In PC₄ finger length (-0.207) and finger per ear (-0.183) were negatively loaded and seed protein content (0.864) and ear weight per plant (0.216) were positively loaded.

The PCA scores for 40 finger millet genotypes in the first three principal components were computed. Principal component I, II and III were considered as three axis as X, Y and Z and squared distance of each genotype from these three axis were calculated and presented in Table 4.12. These PCA scores for 40 finger millet genotypes were plotted on graph to get two dimensional and three dimensional scattered diagrams (Fig.4.5 and Fig.4.6).

The analysis thus identified the maximum contributing variables *i.e.*, number of productive tillers, ear weight per plant, days to maturity, days to 50% flowering, fingers per ear, plant height, 1000-seed weight and seed yield per plant. It is important to study

the variance as the relative contribution than the signs (indicative of direction) in principal component analysis.

The PCA scores for 40 genotypes were plotted in graph to get two dimensional and three dimensional scatter diagrams (Fig.4.5 and Fig.4.6) and revealed diversity between the genotypes. The genotypes GE-3434, GE-1382 and GE-4976 showed maximum variance through PC₁ axis and these genotypes are considered to be highly divergent with required variability for further improvement in plant breeding programme. These genotypes may be used in crop improvement programmes for generating transgressive segregants. While the genotypes GE-995, IE-2323, GE-4437, GE-2127 and GE-3225 showed low variance on both sides of the axis so it may be considered that these genotypes are less efficient in breeding programme to improve yield unless they have special added advantage in them.

4.4.3 Hierarchical cluster analysis

The cluster analysis using Euclidean² distances provides a useful statistical tool for measuring the genetic diversity in germplasm collections with respect to characters considered together.

The principal component scores of genotypes were used as input for clustering procedures in order to group the genotypes into various clusters and to confirm the results of principal component analysis.

4.4.3.1 Grouping of genotypes into various clusters

Fourty genotypes were grouped into seven clusters using the Ward's minimum variance procedure (Anderberg, 1993) and the distributions of the genotypes into different clusters are presented in figure 4.7.

The 40 genotypes were grouped into seven clusters. The distribution of genotypes into seven clusters is presented in Table 4.13. Among all the clusters, cluster II was the largest containing twelve genotypes followed by cluster V containing seven genotypes, cluster VII with five genotypes, cluster I, III, IV and VI each containing four genotypes. The mutual relationship between clusters is represented diagrammatically (Fig.4.8) by taking average intra and inter-cluster Euclidean² distances.

4.4.3.2 Average intra and inter-cluster Euclidean² distance values

The average intra and inter-cluster Euclidean² distance were estimated based on Ward's minimum variance and are presented in the Table 4.14.

By Ward's method, the 40 genotypes were grouped into seven clusters. Of the seven clusters formed, cluster III has minimum intra-cluster Euclidean² distance value of 283.12 followed by cluster VI (452.46), cluster II (479.77), cluster I (490.25), cluster V (566.85), cluster IV (796.73) and cluster VII (991.64). The inter-cluster Euclidean² distances varied from 975.00 (between cluster II and cluster III) to 7648.89 (between clusters IV and VII). All the inter-cluster Euclidean² values were lying between these values.

Cluster I comprised of 4 genotypes. It was closest to cluster II (1041.53) followed by cluster III (1264.05) and farthest from cluster IV (3498.48) followed by cluster V (3214.63).

Cluster II comprised of 12 genotypes (the largest one). It was nearest to cluster III (975.00) followed by cluster I (1041.53) and farthest from cluster VII (3543.23) followed by cluster IV (2188.83).

Cluster III consisted of four genotypes. It was closest to cluster II (975.00) followed by cluster II (1264.05) and farthest from cluster VII (3318.13) followed by cluster V (2837.67).

Cluster IV was consisted of four genotypes. It was nearest to cluster VI (1418.75) followed by cluster III (1615.16) and farthest from cluster VII (7648.89) followed by cluster I (3498.48).

Cluster V was comprised of seven genotypes. It was closest to cluster VI (1118.85) followed by cluster II (1390.29) and farthest from cluster VII (6825.01) followed by cluster IV (3477.12).

Cluster VI was consisted of four genotypes. It was nearest to cluster V (1118.85) followed by cluster II (1234.63) and farthest from cluster VII (7242.93) followed by cluster I (3179.56).

Cluster VII was consisted five genotypes. It was nearest to cluster I (1608.58) followed by cluster III (3318.13) and farthest from cluster IV (7648.89) followed by cluster VI (7242.93).

Of the seven clusters formed, maximum intra-cluster distance Euclidean² distance was recorded by cluster VII (991.64) followed by cluster IV (796.73) and cluster V (566.85). The maximum inter-cluster distance was observed between cluster IV and cluster VII (7648.89) followed by cluster VI and VII (7242.93) and cluster V and cluster VII (6825.01). This suggested that there was wide genetic diversity between these clusters. The genotypes GE-3090, GE-3434 and GE-1382 belonging to Africa were distributed in cluster IV, VII and V respectively, which are having larger inter-cluster distances between them. Similarly genotypes belonging to India were also distributed in different clusters. This indicated that geographical diversity and genetic diversity are not related. Similar conclusion was drawn by Jain *et al.* (1981, 2002), Rao (1992), Kadam (2008) and Kumar *et al.* (2010).

Results of cluster analysis based on PCA scores were compared with the results of the principal component analysis on a visual aid in desecrating clusters in the two dimensional and three dimensional scattered diagrams. The genotypes falling in same cluster were present closer to each other in scattered diagram. Harikrishna *et al.* (2005) and Jayalakshmi (2007) studied the utilization of PCA combined with clustering of Ward's method in genetic divergence studies in finger millet.

4.4.3.3 Cluster means

Cluster means were computed for the 11 characters studied on pooled basis and are presented in Table 4.15.

Cluster I registered low mean value for plant height (92.296), days to 50% flowering (62.50), days to maturity (91.00), finger length (6.080) and seed yield per plant (11.876).

Cluster II recorded second lowest mean value for seed yield per plant (12.951), 1000-seed weight (3.797), finger length (6.417) and fingers per ear (5.411).

Cluster III recorded high mean value for plant height (117.083) and second high mean values for characters like days to 50% flowering (76.333), days to maturity (110.083), 1000-seed weight (3.966) and seed calcium content (394.417).

Cluster IV recorded high mean value for seed calcium content (442.167) and low mean value for ear weight per plant (15.614).

Cluster V registered high mean value for productive tillers per plant (4.457), fingers per ear (6.738), finger length (7.810), ear weight per plant (21.709), 1000-seed weight (4.161) and seed yield per plant (17.534).

Cluster VI recorded high mean value for days to maturity (76.667), days to maturity (111.667) and low mean values for 1000-seed weight (3.757) and seed protein content (6.737).

Cluster VII recorded high mean value for number of seed protein content (11.697) and low mean values for productive tillers per plant (3.107) and fingers per ear (5.373).

Thus, cluster V and VI showed high mean values for most of the yield contributing traits like productive tillers per plant, fingers per ear, finger length, ear weight per plant, 1000-seed weight and days to maturity. So the genotypes from cluster V (GE-3138, GE-2723, GE-1382, Kalyani, Ratnagiri, Godavari, INDAF-9) and cluster VI (GE-3266, GPU-67, GE-145, IE-2652) can be used for finger millet yield improvement programme.

4.4.4 Comparison of D^2 analysis, principal component analysis and cluster analysis

The grouping or clustering pattern using the D^2 analysis, principal component analysis and cluster analysis were compared and the implications are discussed here.

Mahalanobis' D^2 statistic and Jackson's principal component analysis are tools for analyzing multivariate data. PCA confirms the group constellations obtained by D^2 analysis. It determines the effective number of axis of differentiation primary and secondary or so based on number of canonical vectors. The advantage of PCA over D^2 analysis is that it reduces the dimensionality of the data set by creating significant

principal components which contributed towards maximum variability of the genotypes. The largest element (absolute value) in each vector constitutes the greatest contributor for divergence. In PCA, standardization of data made attributes to contribute equally towards the divergence studies irrespective of the units taken.

The principal component analysis sorted only significant principal components out of the total 11 attributes. The contribution of the main characters for variance easily identified by the characters loaded on the PC₁ with high loading values.

Both D² analysis and Ward's method grouped the 40 finger millet genotypes into seven clusters. However the clusters are different in different methods with respect to total number of genotypes included in each cluster. In D² analysis, cluster II is the largest with 16 genotypes followed by cluster III and IV (seven genotypes each), cluster I (five genotypes), cluster V (three genotypes) and cluster VI and VII (one genotype each), whereas in Ward's method, the cluster II is the largest comprising of 12 genotypes followed by cluster V (seven genotypes), cluster VII (five genotypes), cluster I, III, IV, VI (four genotypes each).

The pattern of distribution of genotypes into different clusters was at random. Furthermore, the two clustering methods grouped differently and clustering pattern for genotypes are not same. There was no solitary cluster formed in Ward's minimum variance method, where as in D² analysis cluster VI and VII represent solitary clusters due to absence of intra-cluster distance indicating that genetic diversity was the outcome of several factors along with geographic diversity. Hence, the selection for hybridization should be more based on genetic diversity.

In case of D² analysis, only the intra-cluster distance can be known but not the genotypes relative position in the respective cluster. Whereas in Ward's minimum variance dendrogram (cluster analysis) created sub-group within a cluster, so relative position of the genotypes within the clusters can be determined by seeing the dendrogram distance.

Two important points are to be considered while selecting genotypes for hybridization programmes: (i) Choice of the particular cluster from which genotypes are to be used as parents and (ii) selection of particular genotype from selected cluster. The clusters selected should be separated by largest statistical distance *i.e.*, maximum

divergence. Genotypes from these divergent clusters should be selected based on their *per se* performance for different yield contributing characters. However the selected genotype should be tested for their combining ability and the gene action using other biometrical techniques like Line $\times$ Tester or Diallel analysis.

Based on the results stated in Mahalanobis' D^2 , PCA, Agglomerative cluster methods out of 40 genotypes, GE-3434, GE-1382 and GE-4976 showed maximum divergence with good *per se* performance for seed yield contributing characters. Therefore these genotypes may be utilized properly by producing F_1 s. These F_1 s may express high heterosis in presence of dominance or may result in good transgressive segregants if additive component of gene action is predominant. So, these genotypes should be tested for their gene action and combining ability using suitable mating design before using them in hybridization programme.

Chapter - V

SUMMARY AND CONCLUSIONS

The present investigation was carried out during *kharif* 2013 at Agricultural College farm, Bapatla, Guntur, Andhra Pradesh with 40 genotypes of finger millet (*Eleusine coracana* (L.) Gaertn). with the prime objective of grouping the genotypes into distinct classes based on their genetic diversity.

Other parameters like mean, genetic variability, heritability, genetic advance as per cent of mean, character association and the magnitude of direct and indirect effects of yield component traits on finger millet grain yield were also studied for 11 characters viz., days to 50% flowering, days to maturity, plant height (cm), number of productive tillers per plant, number of fingers per ear, finger length (cm), ear weight per plant (g), 1000-seed weight (g), seed protein content (%), seed calcium content (mg/100gm) and seed yield per plant (g).

The analysis of variance indicated significant differences among 40 genotypes for all the characters studied. The genotypic coefficients of variation for all the characters studied were lesser than the phenotypic coefficients of variation indicating the influence of environment on expression of these traits. High PCV and GCV were recorded for seed yield per plant, ear weight per plant, productive tillers per plant and seed protein content while moderate PCV and GCV were recorded for seed calcium content, number of fingers per ear, plant height, days to 50% flowering and days to maturity. High PCV coupled with moderate GCV was observed for finger length. 1000-seed weight recorded low PCV and GCV. These results indicate that there is considerable amount of variability for majority of the characters studied.

The estimates of heritability and genetic advance as per cent of mean were high for all the 11 characters under study indicating the predominance of additive gene action and hence direct phenotypic selection is useful with respect to these traits.

Genotypic correlations in general were higher than phenotypic correlations indicating that the apparent associations are largely due to genetic reasons. The traits, 1000-seed weight, number of fingers per ear, ear weight per plant, finger length, days to maturity, productive tillers per plant, days to 50% flowering and plant height were found to possess significant positive association with seed yield per plant at both genotypic and phenotypic levels. Further, path analysis studies revealed that 1000-seed weight, number of fingers per ear, days to maturity, ear weight per plant, finger length and days to 50% flowering showed true relationship with seed yield per plant by establishing significant positive association and high positive direct effect.

Considering the nature and magnitude of character associations and their direct and indirect effects, it can be inferred that 1000-seed weight followed by number of fingers per ear, days to maturity, ear weight per plant, finger length and days to 50% flowering could serve as important traits in any selection programme for selecting high yielding genotypes in finger millet.

The results of multivariate analysis revealed considerable genetic divergence among the 40 genotypes studied. Both D^2 analysis and Ward's method grouped the 40 finger millet genotypes into seven clusters. However the clusters are different in different methods with respect to total number of genotypes included in each cluster.

By Mahalanobis' D^2 statistic, it could be inferred that seed protein content, seed calcium content, days to maturity and days to 50% flowering contributed maximum towards divergence. Based on inter-cluster distance among the groups, crosses may be between genotypes belonging to cluster V (Ratnagiri, Godavari, GE-1382) and cluster VII (GE-3434), cluster IV (GE-3090, GE-1274, GE-3225, GE-4976, IE-2652, GE-145, GE-4707) and cluster VII (GE-3434), cluster V (Ratnagiri, Godavari, GE-1382) and cluster VI (GE-995) and cluster IV (GE-3090, GE-1274, GE-3225, GE-4976, IE-2652, GE-145, GE-4707) and cluster VI (GE-995).

In principal component analysis, first three principal components altogether explained 76.411% of the total variability. The significant factors loaded in PC_1 viz., number of productive tillers per plant, ear weight per plant, days to maturity, days to 50% flowering,

number of fingers per ear, plant height, 1000-seed weight, seed yield per plant and finger length contributed maximum towards divergence. 2D and 3D graphs showed wide divergence between GE-3434, GE-1382 and GE-4976 signifying their usefulness in finger millet breeding to develop high heterotic hybrids.

Agglomerative cluster analysis revealed that wide genetic distance between cluster IV (GE-3090, GE-1274, GE-3225, GE-4976) and cluster VII (TNAU-1214, OEB-532, IE-2323, GE-995, GE-3434) followed by VI (GE-3266, GPU-67, GE-145, IE-2652) and cluster VII (TNAU-1214, OEB-532, IE-2323, GE-995, GE-3434) and cluster V (GE-3138, Kalyani, INDAF-9, GE-2723, Ratnagiri, Godavari, GE-1382) and cluster VII (TNAU-1214, OEB-532, IE-2323, GE-995, GE-3434). Therefore, in hybridization programmes selection of parents from these clusters may throw some superior segregants.

Based on the overall results obtained through Mahalanobis' D^2 , PCA, Agglomerative cluster methods, the genotypes GE-3434, GE-1382 and GE-4976 which are having better yield contributing characters are placed in clusters with maximum inter-cluster distance. Hence, these genotypes can be utilized in hybridization programmes to produce desirable recombinants.

LITERATURE CITED

- Abraham, M.J., Gupta, A.S and Sharma, B.K. 1989. Genetic variability and character association of yield and its components in finger millet (*Eleusine coracana* Gaertn.) in an acidic soil of Meghalaya. *Indian Journal of Agricultural Sciences*. 59: 579-581.
- Agalodia, A.V., Desai, K.B and Tikka, S.B.S. 1979. Analysis of the parameters of variability and interrelationship of yield attributes in finger millet. *Indian Journal of Agricultural Sciences*. 49: 924-928.
- AICSMIP. 2012. All India Coordinated Small Millet Improvement Project. *Annual Report*. ICAR, GKVK, Bangalore.
- Anand, M.M.P., Rao, M.R.G., Kulkarani, R.S and Ravishankar, C.R. 2005. An assessment of variability produced in F₂ generation of three crosses of finger millet (*Eleusine coracana* Gaertn.). *Mysore Journal of Agricultural Sciences*. 39 (4): 553-556.
- Anantharaju, P and Meenakshiganesan, N. 2005. Correlation and path coefficient analysis of yield and yield contributing characters in finger millet (*Eleusine coracana* (L.) Gaertn.). *Crop Research*. 30 (2): 227-230.
- Anantharaju, P and Meenakshiganesan, N. 2006. Genetic variability in finger millet (*Eleusine coracana* (L.) Gaertn.). *International Journal of Tropical Agriculture*. 24 (1-2): 269-274.
- Anantharaju, P and Meenakshiganesan, N. 2008. Genetic divergence studies in finger millet (*Eleusine coracana* (L.) Gaertn.). *Indian Journal of Agricultural Research*. 42 (2): 120-123.
- *Anderberg, M.R. 1993. *Cluster analysis for application*. Academic Press, New York.
- Anuradha, T and Suryakumari, S. 2005. Genetic parameters, correlations and path analysis in finger millet. *The Andhra Agricultural Journal*. 52 (3& 4): 575-576.
- Appadurai, R., Thangam, M.S., Ravindran, T.S and Natarajan, U.S. 1977. Genotypic association, heritability and path analysis in ragi (*Eleusine coracana* (L.) Gaertn.) *Madras Agricultural Journal*. 64: 15-21.

- Arunachalam, V and Ram, J. 1967. Geographical diversity in relation to genetic divergence in cultivated sorghum. *Indian Journal of Genetics and Plant Breeding*. 27: 369-380.
- Arunprabhu, D., Selvi, B and Govindaraj, M. 2008. Genetic variability and multivariate analysis in finger millet (*Eleusine coracana*) germplasm for yield characters. *Crop Research*. 36 (1,2 &3): 218-223.
- Bandyopadhyay, B.B. 1998. Variability, heritability and interrelationship of important quantitative characters in finger millet. *Annals of Agricultural Research*. 19: 173-176.
- *Banfield, C.F. 1978. Principal component analysis for genstat. *Journal of Statistics and Computer Simulation*. 6: 211-222.
- Basavaraja, G.T and Sheriff, R.A. 1991. Correlation and path analysis in F₂ and F₃ population of finger millet [*Eleusine coracana* (L.) Gaertn.]. *Indian Journal of Agricultural Sciences*. 64: 774-775.
- Bedis, M.R., Patil, H.S., Jangle, G.D and Patil, V.S. 2006. Correlation and path analysis in finger millet [*Eleusine coracana* (L.) Gaertn.]. *Crop Research*. 31 (2): 264-266.
- Bendale, W.W., Bhawe, S.G and Pethe, U.B. 2002. Genetic variability correlation and path analysis in finger millet (*Eleusine coracana* Gaertn.). *Journal of Soils and Crops*. 12 (2): 187-191.
- Bezaweleaw, K., Sripichitt, P., Wongyai, W and Hongtrakul, V. 2006. Genetic variation, heritability and path-analysis in Ethiopian finger millet [*Eleusine coracana* (L.) Gaertn.] Landraces. *Kasetsart Journal of National Sciences*. 40: 322-334.
- Bezaweleaw, K., Sripichitt, P., Wongyal, W and Hongtrakul, V. 2007. Cluster and component analyses of finger millet landraces from Ethiopia and Eritrea. *Kamphaengsean Academic Journal*. 5 (1): 40-52.
- Burton, G.W. 1952. Quantitative inheritance in grasses. *Proceedings of the 6th International Grassland Congress*, Pennsylvania State College, USA. 277-283.
- Chaudhary, S.K. 1989. Correlation and Path analysis in finger millet under mid altitude conditions. *International Journal of Tropical Agriculture*. 7: 45-49.
- Chaudhari, L.B and Acharya, R.C. 1969. Genetic variability and path coefficient analysis of components of ragi (*Eleusine coracana*). *Experimental Agriculture*. 5: 295-300.

- Dabholkar, A.R. 1999. *Elements of Biometrical Genetics*. 2nd ed. Concept Publishing Company, New Delhi. 467-476.
- Dagnachew, L., Kassahun, T., Masresha, F and Santie De Villiers. 2012. Inheritance and association of quantitative traits in finger millet (*Eleusine coracana* subsp. *coracana*) landraces collected from Eastern and South Eastern Africa. *International Journal of Genetics*. 2 (2): 12-21.
- Dagnachew, L. Kassahun, T., Masresha, F and Santie De Villiers. 2012. Multivariate analysis for quantitative traits in finger millet (*Eleusine coracana* subsp. *coracana*) population collected from eastern and south eastern Africa: detection for patterns of genetic diversity. *International Journal of Agricultural Research*. 7 (6): 303-314.
- Dewey, D.R and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal*. 51 (9): 515-518.
- Dhagat, N.K., Pathak, G.L., Srivastava, P.S and Joshi, R.C. 1972. Correlation and genetic variability in ragi (*Eleusine coracana* G.). *Jawaharlal Nehru Krishi Vishwa Vidyalyay Research Journal*. 6: 121-124.
- Dhamdhare, D.H., Pandey, P.K and Shrotria, P.K. 2011. Genetic variability, heritability and genetic advance of yield components and mineral nutrients in finger millet [*Eleusine coracana* (L.) Gaertn.]. *Pantnagar Journal of Research*. 9 (1): 46-48.
- Dhanalakshmi, T.N., Ramesh, S., Ravishankar, C.R., Upadhyaya, H.D and Rao, M.A. 2013. Genetic variability for morpho-agronomic traits in core germplasm collections of finger millet (*Eleusine coracana* (L.) Gaertn). *Global Journal of Biology, Agriculture and Health Sciences*. 2 (2): 83-85.
- Dineshkumar, S.P. 1986. Variation for protein content, its stability and association with yield and other characters in white and brown finger millet (*Eleusine coracana* G.) cultivar. *M.Sc (Ag.) Thesis*, University of Agricultural Sciences, Bangalore, India.
- Ehrenberg, A.S.C. 1985. *Data Reduction Analysis and Interpreting Statistical Data*. John Wiley and Sons Inc., New York.
- Falconer, D.S. 1964. *An Introduction to Quantitative Genetics*. 2nd ed. Oliver and Boyd Publishing Co. Pvt. Ltd. Edinburgh. 312-324.

- Falconer, D.S and Mackay, T.F.C. 1996. *An Introduction to Quantitative Genetics*. 4th ed. Dorling Kindersley Pvt. Ltd., New Delhi. 240.
- Fisher, R.A. 1936. The use of multiple measurements in taxonomic problems. *Annals of Eugenics*. 7: 179-188.
- Fisher, R.A and Yates, F. 1963. *Statistical Table for Biological, Agricultural and Medical Research*. Oliver and Boyd Publishing Co. Pvt. Ltd., Edinburgh. 46-63.
- Ganapathy, S., Nirmalakumari, A and Muthiah, A.R. 2011. Genetic variability and interrelationship analyses for economic traits in finger millet germplasm. *World Journal of Agricultural Sciences*. 7 (2): 185-188.
- Ganapathy, S., Nirmalakumari, A., Senthil, N., Devan, P., Muthiah, A.R and Raveendran, T.S. 2007. Variability studies in recombinant inbred lines of finger millet [*Eleusine coracana* (L.) Gaertn.]. *Research on Crops*. 8 (3): 795-796.
- Goswami, P and Asthana, A.N. 1984. Genetic variability in indigenous varieties of finger millet in Sikkim. *Indian Journal of Agricultural Sciences*. 54: 959-961.
- Goud, J.V and Lakshmi, P.V. 1977. Morphological and genetic variabilities for qualitative characters in ragi [*Eleusine coracana* (L.) Gaertn.]. *Mysore Journal of Agricultural Sciences*. 11: 438-443.
- Gowda, M.B., Gowda, B.T.S and Seetharam, B. 1999. Variability and inheritance of biochemical compounds determining resistance for blast, yield and other attributes in finger millet. *Mysore Journal of Agricultural Sciences*. 33: 197-200.
- Gowda, J., Shet, R.M., Suvarna and Somu, G. 2008. Genetic variability and correlation studies in interspecific crosses of finger millet [*Eleusine coracana* (L.) Gaertn.]. *Crop Research*. 36 (1, 2 & 3): 239-243.
- Hadimani, N.A and Malleshi, N.G. 1993. Studies on milling, physico-chemical properties, nutrient composition and dietary fibre content of millets. *Indian Journal of Food Science and Technology*. 30 (1): 17-20.
- Haider, Z.A., Mahto, J.L., Kumar, B and Ganguly, D.K. 1995. Genetic variability in finger millet (*Eleusine coracana* Gaertn.). *Journal of Research (BAU)*. 7: 43-47.
- Haider, Z.A and Mahto, J. 1995. Genetic association in finger millet (*Eleusine coracana*). *Indian Journal of Agricultural Sciences*. 65: 754-756.

- Hanson, G.H., Robinson, H.F and Comstock, R.E. 1956. Biochemical studies of yield in segregating populations of Korean Lespedeza. *Agronomy Journal*. 48: 267-272.
- Haradari, C., Ugalat, J and Nagabhushan. 2012. A study on character association, genetic variability and yield components finger millet (*Eleusine coracana* L.). *Journal of Crop and Weed*. 8 (2): 32-35.
- Harikrishna, G., Rao, C.P., Kumar, P.V.R and Rao, V.S. 2005. Correlation and path analyses in finger millet (*Eleusine coracana* (L.) Gaertn.). *The Andhra Agricultural Journal*. 52 (1&2): 75-85.
- Harti, M., Gowda, J., Mallikarjun, K., Basavaraja, T and Vijayakumar, L. 2013. Genetic variability and heritability for white seeded accession of finger millet. *Environment & Ecology*. 31(2A): 745-748.
- Hilu, K.W and De Wet, J.M.J. 1976. Racial evolution in *Eleusine coracana* subsp. *coracana* (finger millet). *American Journal of Botany*. 63: 1311-1318.
- Jackson, J.E., 1991. *A User's Guide to Principal Components*. John Wiley and Sons Inc., New York.
- Jackson, M.L. 1967. *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi. 282-289.
- Jain, A.K., Dhagat, N.K and Tiwari, A.S. 1981. Genetic divergence in finger millet. *Indian Journal of Genetics and Plant Breeding*. 41: 346-348.
- Jain, A.K., Yadav, H.S and Singh, S.B. 2002. Genetic diversity for morphological characters determining blast resistance in finger millet. *Mysore Journal of Agricultural Sciences*. 36: 135-140.
- Jaya Lakshmi, C. 2007. Genetic divergence studies in finger millet (*Eleusine coracana* (L.) Gaertn.). *M.Sc. (Ag.) Thesis*. Acharya N.G. Ranga Agricultural University, Hyderabad, India.
- Jayaprakash Naik, B. 1991. Genetic diversity in relation to evolution and domestication of finger millet (*Eleusine coracana* (L.) Gaertn.) in Africa and India. *Ph.D. Thesis*. University of Agricultural Sciences, Bangalore, India.
- John, K. 2006. Variability and correlation studies in quantitative traits of finger millet [*Eleusine coracana* (L.) Gaertn.]. *Agriculture Science Digest*. 26 (3): 166-169.

- John, K. 2007. Estimates of genetic parameters and character association in finger millet (*Eleusine coracana* Gaertn.). *Agriculture Science Digest*. 27 (2): 95-98.
- Johnson, H.W., Robinson, H.F and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agronomy Journal*. 47: 314-318.
- Kadam, D.D. 2008. Genetic divergence in finger millet (nachani/ragi/nagali/ *Eleusine coracana*). *Journal of Soil and Crops*. 18 (1): 138-142.
- Kadam, D.D., Kulkarni, S.R and Jadhav, B.S. 2009. Genetic variability correlation and path analysis in finger millet (*Eleusine coracana* Gaertn.). *Journal of Research, Maharashtra Agricultural Universities*. 34 (2): 131-134.
- Karad, S.R. and Patil, J.V. 2013. Assessement of genetic diversity among finger millet (*Eleusine coracana* L.) genotypes. *International Journal of Integrative Sciences, Innovation and Technology*. 4: 37-43.
- Kumar, B and Rai. 2005. Genetic divergence in Ragi (*Eleusine coracana* Gaertn.). *Journal of Research Rajendra Agricultural University*. 15: 22-24.
- Kumar, D., Tyagi, D., Ramesh, B and Pal, S. 2010. Genetic diversity in finger millet (*Eleusine coracana* L.). *Crop improvement*. 37 (1): 25-28.
- Kumar, R., Kumar, A and Akhtarali. 2000. Genetic variability in finger millet (*Eleusine coracana* Gaertn.). *Journal of Research, Rajendra Agricultural University*. 10: 10-12.
- Lal, C., Dawa, T., Plana, P and Sharma, S.K. 1996. Studies on genetic variability and component analysis in ragi [*Eleusine coracana* (L.) Gaertn.]. *Indian Journal of Genetics and Plant Breeding*. 56 (2): 162-168.
- *Legendre, L and Legendre, P. 1984. *Ecologia Numerique*. Presses de l'Universite du Quebec. Xv+260p, viii+335p.
- *Mahalanobis, P.C. 1928. A statistical study at Chinese head measurement. *Journal of Asiatic Society of Bengal*. 25: 301-307.
- Mahto, R.N., Mahto, J and Ganguli, D.K. 2000. Correlation and path coefficient analysis in ragi (*Eleusine coracana* Gaertn.) under rainfed condition. *Journal of Research, Birsa Agricultural University*. 12: 81-83.

- Mahto, R.N., Mahto J.L., Singh, K.D., Haider, Z.A and Haque, M.F. 1996. Yield attribute in ragi (*Eleusine coracana* Gaertn.) under rainfed conditions. *Journal of Research, Birsa Agricultural University*. 8: 173-174.
- Maloo, S.R., Solanki, J.S and Sharma, S.P. 1998. Genotypic variability for quality traits in finger millet [*Eleusine coracana* (L.) Gaertn.]. *International Journal of Sorghum and Millets*. 39: 126-128.
- Marimuthu, R. 1997. Correlation and path analysis in F₂ generation of finger millet. *Madras Agricultural Journal*. 84: 25-28.
- Ministry of Agriculture. 2013. <http://www.indiastat.com/agriculture/2/stats/asp>
- Mishra, D. 1996. Correlation and path analysis in finger millet. *Madras Agricultural Journal*. 83: 137-138.
- Mishra, H.P., Patnaik, M. C and Nayak, B. K. 1980. Variation in quantitative traits in finger millet. *Indian Journal of Agricultural Sciences*. 50 (4): 298-301.
- Muduli, K.C and Misra, R.C. 2008. Induced polygenic variability in M₂ generation and its relation with production of high-yielding mutants in finger millet. *Indian Journal of Genetics and Plant Breeding*. 68 (4): 419-425.
- Muduli, K.C and Misra, R.C. 2012. Genetic divergence analysis among micromutant lines in finger millet (*Eleusine coracana* G.). *Journal of Crop Science and Biotechnology*. 11 (1): 63-68.
- Muduli, K.C., Pradhan, K., Dash, G.B and Misra, R.C. 2012. Association analysis among micromutant lines in finger millet (*Eleusine coracana* Gaertn.). *Environment and Ecology*. 30 (2): 343-347.
- Nagaraja, A., Reddy, Y.A.N., Gowda, J and Reddy, B.A. 2010. Association of plant characters and weather parameters with finger millet blast. *Crop Research*. 39 (1, 2 & 3): 123-126.
- Nair, K.R and Mukherjee, H.K. 1960. Classification of natural and plantation teak (*Tectona grandis*) grown at different locations of India and Burma with respect to its physical and mechanical properties. *Sankhya*. 22: 1-20.

- Nandini, B., Ravishanker, C.R., Mahesha, B., Boranayaka, M.B and Shadakshari, T.V. 2010. An assessment of variability generated in F₂ generation of four crosses of finger millet [*Eleusine coracana* (Gaertn)]. *Electronic Journal of Plant Breeding*. 1 (4): 747-751.
- Nishit, D. 2013. Study of genetic divergence for grain yield and yield components in finger millet [*Eleusine coracana* (L.) Gaertn.]. *M.Sc. (Ag.) Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.
- Padmaja, G. 2006. Character association and selection indices in finger millet [*Eleusine coracana* (L.) Gaertn.]. *M.Sc. (Ag.) Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.
- Panse, V.G. 1957. Genetics of competitive characters in relation to plant breeding. *Indian Journal of Genetics and Plant Breeding*. 17: 318-328.
- Panse, V.G and Sukhatme, P.V. 1978. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi. 103-108.
- Patnaik, H.B and Jana, M. 1973. Genetic variability in ragi [*Eleusine coracana* (L.) Gaertn.]. *Madras Agricultural Journal*. 60: 1283-1286.
- Patnaik, M.C. 1968. Variation and correlation in finger millet. *Indian Journal of Genetics and Plant Breeding*. 28: 225-229.
- Pattnayak, V.K., Mahto, J.L and Haider, Z.A. 2004. Heritability studies in finger millet (*Eleusine coracana* Gaertn.). *Journal of Research, Birsa Agricultural University*. 16 (1): 127-129.
- Prabhakar, B and Prasad, M.N. 1983. Correlation and path analysis in segregating population of finger millet (*Eleusine coracana* G.). *Madras Agricultural Journal*. 70: 366-871.
- Prabhakar, B and Prasad, M. N. 1984. Variability, heritability, genetic advance and gene action studies in segregating population of ragi [*Eleusine coracana* (L.) Gaertn.]. *Madras Agricultural Journal*. 71: 285-288.
- Priyadharshini, C., Nirmalakumari, A., Joel, J and Raveendran, M. 2011. Genetic variability and trait relationships in finger millet [*Eleusine coracana* (L.) Gaertn.] hybrids. *Madras Agricultural Journal*. 98 (1-3): 18-21.

- Ramaswamy, P., Ramalingam, A., Shanmugavalli, N and Soundarapandian, G. 1994. Variation and character association of green fodder yield and component traits in ragi (*Eleusine coracana* G.). *Madras Agricultural Journal*. 81 (8): 411-413.
- Ranganathan, C.R., Sundaram, A and Menon, K.V. 1977. Correlation and path coefficient analysis on yield components of ragi. *Madras Agricultural Journal*. 65 (9): 591-592.
- Rao, C.R. 1952. *Advanced Statistical Methods in Biometrical Research*. John Wiley and sons. New York. 236-272.
- Rao, D.V.N and Pardhasarathi, A.V. 1968a. Studies on genetic variability in ragi, phenotype variation, genetic advance and heritability of certain quantitative characters. *Madras Agricultural Journal*. 55: 392-397.
- Rao, D.V.N and Pardhasarathi, A.V. 1968b. Studies on genetic variation in ragi. Eleven phenotypic, genotypic and environmental correlation between important characters and their implications in selection. *Madras Agricultural Journal*. 55: 397-400.
- Rao, P.K. 1992. Genetic divergence in germplasm accessions of finger millet (*Eleusine coracana* Gaertn). *M.Sc. (Ag) Thesis*, University of Agricultural Sciences, Bangalore, India.
- Ravindran, G.R., Gopalan, R.R., Moorthy, K.U.S and Vijayan, K.P. 1996. Correlation and path coefficient analysis in ragi (*Eleusine coracana* G.). *Crop Research*. 12: 359-361.
- Ravishankar, P. 1996. Evaluation of Zimbabwe germplasm of ragi (*Eleusine coracana* Gaertn.). *M.Sc. (Ag.) Thesis*. University of Agricultural Sciences. Bangalore, India.
- Ravikumar, R.L and Seetharam, A. 1993. Character association in segregation population of finger millet (*Eleusine coracana* G.). *Indian Journal of Agricultural Sciences*. 63: 96-99.
- Ravikumar, R.L and Seetharam, A. 1994. Genetic variation in yield and its components in relation to blast disease caused by *Pyricularia grisea* in finger millet (*Eleusine coracana*). *Indian Journal of Agricultural Sciences*. 64: 103-106.

- Reddy, C.V.C.M., Reddy, P.V.R.M., Munirathnam, P. and Gowda, J. 2012. Studies of genetic variability in yield & yield attributing traits of finger millet [*Eleusine coracana* (L.) Gaertn]. *Indian Journal of Agricultural research*. 47 (6).
- Reddy, G.V., Upadhyaya, H.D., Gowda, C.L.L and Singh, S. 2009. Characterization of eastern African finger millet germplasm for qualitative and quantitative characters at ICRISAT. *Journal of SAT Agricultural Research*. 7.
- Reddy, K.R., Reddy, C.R., Kumar, C.V.S and Sekhar, M.R. 1994. Association and path analysis in ragi [*Eleusine coracana* (L.)]. *Annals of Agricultural Research*. 15 (4): 428-431.
- Sadasivam, S and Manickam, A. 1996. *Biochemical Methods. Second edition*, New Age International (P) Limited, Publishers. New Delhi. 12-34.
- Sahu, S and Pradhan, K. 2012. Genetic divergence in finger millet (*Eleusine coracana* Gaertn.). *Environment & Ecology*. 30 (2): 291-294.
- Sarala, N. 2007. Phenotypic stability analysis in finger millet [*Eleusine coracana* (L.) Gaertn.]. *M.Sc. (Ag.) Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.
- Sarala, N., Rao, C.P., Kumar, P.V.R and Rao, V.S. 2008. Correlation and path analysis over environments in finger millet (*Eleusine coracana* (L.) Gaertn.). *The Andhra Agricultural Journal*. 55 (4): 430-434.
- Satish, D. 2003. Studies on genetic diversity based on productivity and variability for quality traits in finger millet (*Eleusine coracana* Gaertn.). *M.Sc. (Ag.) Thesis*, University of Agricultural Sciences, Dharwad.
- Satish, D., Shanthakumar, G., Salimath, P.M. and Prasad, S.G. 2007. Studies on genetic variability for productivity traits in finger millet. *International Journal of Plant sciences*. 2 (2): 19-22.
- Shanthakumar, G and Gowda, B.T.S. 1997. Character association and path analysis of grain yield and its components in a segregating population of finger millet (*Eleusine coracana* G.). *Karnataka Journal of Agricultural Sciences*. 10: 708-712.
- Sharathbabu, K.S., Kumar, G.S and Salimath, P.M. 2008. Genetic variability and character association studies in white ragi (*Eleusine coracana* Gaertn.). *Karnataka Journal of Agricultural Sciences*. 21 (4): 572-575.

- Sheriff, R.A. 1992. Divergence analysis in finger millet (*Eleusine coracana* Gaertn.). *The Indian Journal of Genetics and Plant Breeding*. 52 (1): 72-74.
- Shet, R.M., Gireesh, C., Jagadeesha, N., Lokesh, G.Y and Gowda, J. 2009. Genetic variability in segregating generation of inter-specific hybrids of finger millet [*Eleusine coracana* (L.) Gaertn.]. *Environment and Ecology*. 27 (3): 1013-1016.
- Shet, R.M., Jagadeesha, N., Lokesh, G.Y., Gireesh, C and Gowda, J. 2010. Genetic variability, association and path coefficient studies in two inter-specific crosses of finger millet [*Eleusine coracana* (L.) Gaertn.]. *International Journal of Plant Sciences*. 5 (1): 24-29.
- *Shigeta, M. 1985. The genetic diversity of finger millet (*Eleusine coracana* (L.) Gaertn. subsp. *Coracana*) and wild finger millet (subsp. *Africana*) *M.Sc. (Agri) Thesis*, Kyoto University, Japan.109.
- Shindey, A.K., Jadhav, B.B., Dalvi, V.V., Yadav, J.K and Ban, Y.G. 2010. Correlation and path coefficient analysis in finger millet (*Eleusine coracana* Gaertn.) under mango based agroforestry system. *Journal of Maharashtra Agricultural Universities*. 35 (2): 221-224.
- Singh, G. 1974. Variability in kangni-3. Association between plant characters and discriminant function for varietal selection in four environments. *Indian Journal of Genetics and Plant Breeding*. 34: 411-416.
- Singh, G., Singh, M., Bhutia, D.T and Awasthi. 1995. Genetic analysis of finger millet (*Eleusine coracana* G.) in Sikkim. *Indian Journal of Agricultural Sciences*. 65: 900-901.
- Singh, R.K and Chaudhary, B.D. 2010. *Biometrical Methods in Quantitative Genetic Analysis*. Kalyani publishers, New Delhi. 293-301.
- Sivasubramanian, P and Menon, P.M. 1973. Inheritance of short stature in rice. *Madras Agricultural Journal*. 60: 1129-1133.
- Smith, H.G. 1936. A discriminant function for plant selection. *Annals of Eugenics*. 7: 240-250.
- *Sorenson, T.A. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analysis of the vegetation on Danish Commons. *Biologiske Skrifter*. 5: 1-34.

- Srilakshmi, P. 2013. Character association and selection indices in finger millet [*Eleusine coracana* (L.) Gaertn]. *M.Sc (Ag.) Thesis*. Acharya N.G. Ranga Agricultural University, Hyderabad, India.
- Sumathi, P., Joel, J.A and Muralidharan, V. 2006. Inter trait association and path coefficient analysis in irrigated finger millet [*Eleusine coracana* (L.) Gaertn]. *Madras Agricultural Journal*. 93 (1-6): 115-119.
- Suryanarayana, L., Sekhar, D and Rao V.N. 2014. Inter relationship and cause-effect analysis in finger millet (*Eleusine coracana* (L.) Gaertn.) Genotypes. *International Journal of Current Microbiology and Applied Sciences*. 3 (4): 937-941.
- Suryakumar, M., Ramaswamy, P and Shanmugasundaram, P. 1998. Cluster analysis in finger millet genotypes. *Madras Agricultural Journal*. 85 (34): 150-153.
- Suyambulingam, C and Jebarani, W. 1977. Genetic divergence in short duration ragi (*Eleusine coracana* Gaertn). *Madras Agricultural Journal*. 64: 816-818.
- Swarup and Chaugle, B.S. 1962. Studies on genetic variability in sorghum; phenotypic variation and heritable component in some quantitative characters contributing towards yield. *Indian Journal of Genetics and Plant Breeding*. 22: 31-36.
- Ulaganathan, V and Nirmalakumari, A. 2013. Phenotypic selection of elite genotypes based on genetic analysis in finger millet [*Eleusine coracana* (L.) Gaertn.] germplasm. *Plant Archives*. 13 (2): 1003-1008.
- Vadivoo, A.S., Joseph, R., Ganesan, N.M and Joseph, R. 1998. Genetic variability and diversity for protein and calcium contents in finger millet [*Eleusine coracana* (L.) Gaertn.] in relation to grain colour. *Plant Foods for Human Nutrition*. 52 (4): 353-364.
- Verma, V.S. 1989. Variability patterns in quantitative traits of ragi (*Eleusine coracana* Gaertn.). *Madras Agricultural Journal*. 76 (11): 626-629.
- Wolie, A and Dessalegn, T. 2011. Correlation and path coefficient analyses of some yield related traits in finger millet [*Eleusine coracana* (L.) Gaertn.] germplasm in northwest Ethiopia. *African Journal of Agricultural Research*. 6 (22): 5099-5105.

- Wolie, A., Dessalegn, T and Belete, K. 2013. Heritability, variance components and genetic advance of some yield and yield related traits in Ethiopian collections of finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes. *African Journal of Biotechnology*. 12 (36): 5529-5534.
- Wolie, A and Belete, K. 2013. Genetic divergence and variability studies in some Ethiopian finger millet germplasm collections. *Journal of Agricultural Science*. 3 (4): 110-116.
- Wright, S. 1921. Correlation and causation. *Journal of Agricultural Research*. 20: 557-585.

***Original not seen**

Note: The pattern of literature cited presented above is in accordance with the guidelines for Thesis presentation for Acharya N.G. Ranga Agricultural University, Hyderabad.

Table 2.2. Review of literature on heritability of yield and yield components in finger millet
[*Eleusine coracana* (L.) Gaertn.]

S. No.	Character	Heritability	Reference
1.	Plant height	High	Haider <i>et al.</i> (1995) Kumar <i>et al.</i> (2000) Satish (2003) Anand <i>et al.</i> (2005) Anuradha and Suryakumari (2005) Padmaja (2006) Ganapathy <i>et al.</i> (2007) John (2007) Sarala (2007) Satish <i>et al.</i> (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Kadam <i>et al.</i> (2009) Nandini <i>et al.</i> (2010) Shet <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Haradari <i>et al.</i> (2012) Dhanalakshmi <i>et al.</i> (2013) Karad and Patil (2013) Nishit (2013) Ulaganathan and Nirmalakumari (2013)
		Moderate	Patnaik and Jana (1973) Appadurai <i>et al.</i> (1977) Lal <i>et al.</i> (1996) Bandyopadhyay (1998) Bezaweletaw <i>et al.</i> (2006) Dhamdhere <i>et al.</i> (2011) Srilakshmi (2013) Wolie <i>et al.</i> (2013)
		Low	Agalodia <i>et al.</i> (1979) Harti <i>et al.</i> (2013)
2.	Days to 50% flowering	High	Mishra <i>et al.</i> (1980) Kumar <i>et al.</i> (2000) Satish (2003) Anuradha and Suryakumari (2005) John (2006) Padmaja (2006) Ganapathy <i>et al.</i> (2007) John (2007)

Table 2.2 (cont.)

S. No.	Character	Heritability	Reference
		High	Sarala (2007) Satish <i>et al.</i> (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Haradari <i>et al.</i> (2012) Dhanalakshmi <i>et al.</i> (2013) Harti <i>et al.</i> (2013) Karad and Patil (2013) Nishit (2013) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013)
3.	Productive tillers per plant	High	Mishra <i>et al.</i> (1980) Bandyopadhyay (1998) Kumar <i>et al.</i> (2000) Satish (2003) Anuradha and Suryakumari (2005) John (2006) Padmaja (2006) John (2007) Sarala (2007) Satish <i>et al.</i> (2007) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dhanalakshmi <i>et al.</i> (2013) Harti <i>et al.</i> (2013) Karad and Patil (2013) Nishit (2013) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013)
		Moderate	Appadurai <i>et al.</i> (1977) Prabhakar and Prasad (1984) Abraham <i>et al.</i> (1989) Ravikumar and Seetharam (1994) Gowda <i>et al.</i> (1999) Anand <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006)

Table 2.2 (cont.)

S. No.	Character	Heritability	Reference
		Low	Haider <i>et al.</i> (1995) Gowda <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)
4.	Fingers per ear	High	Mishra <i>et al.</i> (1980) Lal <i>et al.</i> (1996) Bandyopadhyay (1998) Kumar <i>et al.</i> (2000) Satish (2003) Anand <i>et al.</i> (2005) Anuradha and Suryakumari (2005) John (2006) Padmaja (2006) Ganapathy <i>et al.</i> (2007) John (2007) Sarala (2007) Arunprabhu <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Reddy <i>et al.</i> (2012) Dhanalakshmi <i>et al.</i> (2013) Karad and Patil (2013) Nishit (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013)
		Moderate	Gowda <i>et al.</i> (1999) Bezaweletaw <i>et al.</i> (2006) Gowda <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Srilakshmi (2013)
		Low	Patnaik and Jana (1973) Haider <i>et al.</i> (1995) Muduli and Misra (2008)
5.	Finger length	High	Mishra <i>et al.</i> (1980) Lal <i>et al.</i> (1996) Satish (2003) Pattnayak <i>et al.</i> (2004) Anuradha and Suryakumari (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Ganapathy <i>et al.</i> (2007) John (2007)

Table 2.2 (cont.)

S. No.	Character	Heritability	Reference
		High	Sarala (2007) Satish <i>et al.</i> (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Shet <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Haradari <i>et al.</i> (2012) Harti <i>et al.</i> (2013) Karad and Patil (2013) Nishit (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013)
		Moderate	Verma (1989) Anand <i>et al.</i> (2005) John (2006) Dhamdhare <i>et al.</i> (2011)
		Low	Patnaik and Jana (1973) John (2006) Muduli and Misra (2008)
6.	Ear weight per plant	High	Satish (2003) Padmaja (2006) Sarala (2007) Satish <i>et al.</i> (2007) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Dhamdhare <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)
		Moderate	Goud and Lakshmi (1977)
		Low	Haider <i>et al.</i> (1995)
7.	1000-seed weight	High	Satish (2003) Anand <i>et al.</i> (2005) Anuradha and Suryakumari (2005) John (2006) Padmaja (2006) John (2007) Ganapathy <i>et al.</i> (2007) Sarala (2007)

Table 2.2 (cont.)

S. No.	Character	Heritability	Reference
		High	Satish <i>et al.</i> (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Shet <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Dhanalakshmi <i>et al.</i> (2013) Karad and Patil (2013) Nishit (2013) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013)
		Low	Harti <i>et al.</i> (2013)
		Moderate	Ravishankar (1996) Bezaweletaw <i>et al.</i> (2006) Nandini <i>et al.</i> (2010)
8.	Days to maturity	High	Mishra <i>et al.</i> (1980) Satish (2003) Anuradha and Suryakumari (2005) Bezaweletaw <i>et al.</i> (2006) John (2006) John (2007) Sarala (2007) Satish <i>et al.</i> (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Dhamdhere <i>et al.</i> (2011) Karad and Patil (2013) Nishit (2013) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013)
9.	Seed yield per plant	High	Mishra <i>et al.</i> (1980) Satish (2003) Anand <i>et al.</i> (2005) John (2006) Padmaja (2006) Ganapathy <i>et al.</i> (2007) John (2007) Sarala (2007) Satish <i>et al.</i> (2007) Arunprabhu <i>et al.</i> (2008)

Table 2.2 (cont.)

S. No.	Character	Heritability	Reference
		High	Gowda <i>et al.</i> (2008) Prabhu <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Shet <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Srilakshmi (2013) Dhanalakshmi <i>et al.</i> (2013) Harti <i>et al.</i> (2013) Karad and Patil (2013) Nishit (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013)
		Moderate	Patnaik and Jana (1973) Prabhakar and Prasad (1984) Ravikumar and Seetharam (1994) Bezaweletaw <i>et al.</i> (2006) Dagnachew <i>et al.</i> (2012) Reddy <i>et al.</i> (2012)
		Low	Haider <i>et al.</i> (1995) Muduli and Misra (2008)
10.	Seed protein content	High	Maloo <i>et al.</i> (1998) Vadivoo <i>et al.</i> (1998) Gowda <i>et al.</i> (1999) Padmaja (2006) Sarala (2007) Priyadharshini <i>et al.</i> (2011) Karad and Patil (2013) Nishit (2013) Srilakshmi (2013)
11.	Seed calcium content	High	Maloo <i>et al.</i> (1998) Vadivoo <i>et al.</i> (1998) Padmaja (2006) Sarala (2007) Srilakshmi (2013)

Table 2.3. Review of literature on genetic advance and genetic advance as per cent of mean of yield and yield components in finger millet [*Eleusine coracana* (L.) Gaertn.]

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
1.	Plant height	High	High	Arunprabhu <i>et al.</i> (2008)
			High	Ravikumar and Seetharam (1994) Haider <i>et al.</i> (1995) Shet <i>et al.</i> (2009) Shet <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Haradari <i>et al.</i> (2012) Nishit (2013)
		High		Karad and Patil (2013)
		Moderate	High	Ramaswamy <i>et al.</i> (1994) Dagnachew <i>et al.</i> (2012)
		Moderate	Moderate	Appadurai <i>et al.</i> (1977) Goswami and Asthana (1984) Prabhakar and Prasad (1984) Anand <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) John (2007) Karad and Patil (2013) Wolie <i>et al.</i> (2013)
			Moderate	Lal <i>et al.</i> (1996) Padmaja (2006) Ganapathy <i>et al.</i> (2007) Sarala (2007) Satish <i>et al.</i> (2007) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Dhanalakshmi <i>et al.</i> (2013) Srilakshmi (2013)
		Low	High	Patnaik and Jana (1973)
		Low	Moderate	John (2006)
		Low	Low	Bandyopadhyay (1998)
			Low	Agalodia <i>et al.</i> (1979) Abraham <i>et al.</i> (1989) Verma (1989) Dhamdhere <i>et al.</i> (2011) Harti <i>et al.</i> (2013)

Table 2.3 (cont.)

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
			Low	Ulaganathan and Nirmalakumari (2013)
2.	Days to 50% flowering	High	High	Ramaswamy <i>et al.</i> (1994)
		High		Mishra <i>et al.</i> (1980) Karad and Patil (2013)
			High	Ramaswamy <i>et al.</i> (1994) Haider <i>et al.</i> (1995) Kumar <i>et al.</i> (2000) Satish (2003) Satish <i>et al.</i> (2007) Dhamdhare <i>et al.</i> (2011) Ganapathy <i>et al.</i> (2011) Nishit (2013)
			Low	Ulaganathan and Nirmalakumari (2013)
		Moderate	High	Appadurai <i>et al.</i> (1977) Abraham <i>et al.</i> (1989) John (2007)
			Moderate	Ravikumar and Seetharam (1994) Padmaja (2006) Ganapathy <i>et al.</i> (2007) Sarala (2007) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Priyadharshini <i>et al.</i> (2011) Dhanalakshmi <i>et al.</i> (2013) Harti <i>et al.</i> (2013) Srilakshmi (2013)
		Moderate	Moderate	Karad and Patil (2013) Wolie <i>et al.</i> (2013)
		Low	Moderate	John (2006)
		Low	Low	Arunprabhu <i>et al.</i> (2008)
			Low	Ravishankar (1996) Gowda <i>et al.</i> (2008)
3.	Productive tillers per plant		High	Verma (1989) Gowda <i>et al.</i> (1999) Kumar <i>et al.</i> (2000) Satish (2003) Anuradha and Suryakumari (2005) Padmaja (2006)

Table 2.3 (cont.)

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
			High	Sarala (2007) Satish <i>et al.</i> (2007) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Haradari <i>et al.</i> (2012) Srilakshmi (2013)
		High		Mishra <i>et al.</i> (1980)
		Moderate	Moderate	Prabhakar and Prasad (1984)
			Moderate	Gowda <i>et al.</i> (2008) Nishit (2013) Ulaganathan and Nirmalakumari (2013)
		Low	High	Appadurai <i>et al.</i> (1977) Bandyopadhyay (1998) Anand <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) John (2006) John (2007) Karad and Patil (2013) Wolie <i>et al.</i> (2013)
		Low	Moderate	Abraham <i>et al.</i> (1989) Dagnachew <i>et al.</i> (2012)
			Low	Ravikumar and Seetharam (1994) Haider <i>et al.</i> (1995)
4.	Fingers per ear		High	Agalodia <i>et al.</i> (1979) Lal <i>et al.</i> (1996) Satish (2003) Anuradha and Suryakumari (2005) Padmaja (2006) Ganapathy <i>et al.</i> (2007) Sarala (2007) Satish <i>et al.</i> (2007) Nandini <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dhanalakshmi <i>et al.</i> (2013) Nishit (2013)

Table 2.3 (cont.)

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
		High		Reddy <i>et al.</i> (2012)
		Moderate		Mishra <i>et al.</i> (1980)
			Moderate	Verma. (1989) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013)
		Low	High	Patnaik and Jana (1973) Abraham <i>et al.</i> (1989) Bandyopadhyay (1998) Anand <i>et al.</i> (2005) John (2006) John (2007) Arunprabhu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Wolie <i>et al.</i> (2013)
		Low	Moderate	Appadurai <i>et al.</i> (1977) Prabhakar and Prasad (1984) Bezaweletaw <i>et al.</i> (2006) Muduli and Misra (2008) Karad and Patil (2013)
			Low	Ravikumar and Seetharam (1994) Haider <i>et al.</i> (1995) Gowda <i>et al.</i> (1999) Kumar <i>et al.</i> (2000) Harti <i>et al.</i> (2013)
5.	Finger length		High	Lal <i>et al.</i> (1996) Satish (2003) Pattnayak <i>et al.</i> (2004) Anuradha and Suryakumari (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Ganapathy <i>et al.</i> (2007) Sarala (2007) Satish <i>et al.</i> (2007) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Shet <i>et al.</i> (2009)

Table 2.3 (cont.)

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
			High	Nandini <i>et al.</i> (2010) Shet <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Haradari <i>et al.</i> (2012) Harti <i>et al.</i> (2013) Nishit (2013) Srilakshmi (2013)
		High		Mishra <i>et al.</i> (1980)
		Low	High	John (2007) Arunprabhu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Karad and Patil (2013) Wolie <i>et al.</i> (2013)
		Low	Moderate	Prabhakar and Prasad (1984) Anand <i>et al.</i> (2005) John (2006)
			Moderate	Ulaganathan and Nirmalakumari (2013)
		Low	Low	Patnaik and Jana (1973)
			Low	Verma (1989) Muduli and Misra (2008)
6.	Ear weight per plant		High	Satish (2003) Padmaja (2006) Sarala (2007) Satish <i>et al.</i> (2007) Sharathbabu <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Haradari <i>et al.</i> (2012) Srilakshmi (2013)

Table 2.3 (cont.)

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
		Low		Goud and Lakshmi (1977) Dagnachew <i>et al.</i> (2012)
			Low	Haider <i>et al.</i> (1995)
7.	1000-seed weight		High	Agalodia <i>et al.</i> (1979) Lal <i>et al.</i> (1996) Satish (2003) Padmaja (2006) Ganapathy <i>et al.</i> (2007) Sarala (2007) Satish <i>et al.</i> (2007) Sharathbabu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Shet <i>et al.</i> (2009) Shet <i>et al.</i> (2010) Dhamdhare <i>et al.</i> (2011) Dhanalakshmi <i>et al.</i> (2013) Nishit (2013) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013)
			Moderate	Ravishankar (1996) Priyadharshini <i>et al.</i> (2011)
		Low	High	Abraham <i>et al.</i> (1989) Anand <i>et al.</i> (2005) John (2006) John (2007) Dagnachew <i>et al.</i> (2012) Karad and Patil (2013) Wolie <i>et al.</i> (2013)
		Low	Moderate	Prabhakar and Prasad (1984) Bezaweletaw <i>et al.</i> (2006) Arunprabhu <i>et al.</i> (2008)
			Low	Haider <i>et al.</i> (1995) Nandini <i>et al.</i> (2010) Harti <i>et al.</i> (2013)
8.	Days to maturity	High	High	Patnaik and Jana (1973)

Table 2.3 (cont.)

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
		High	High	Goswami and Asthana (1984) Abraham <i>et al.</i> (1989) Bandyopadhyay (1998) Dhamdhere <i>et al.</i> (2011)
		High		Karad and Patil (2013)
			High	Nishit (2013)
		Moderate	Moderate	Bezaweletaw <i>et al.</i> (2006) Karad and Patil (2013)
			Moderate	Agalodia <i>et al.</i> (1979) Lal <i>et al.</i> (1996) Kumar <i>et al.</i> (2000) Satish (2003) Satish <i>et al.</i> (2007) Sharathbabu <i>et al.</i> (2008) Srilakshmi (2013)
		Low	Low	Prabhakar and Prasad (1984) John (2006) John (2007) Arunprabhu <i>et al.</i> (2008) Wolie <i>et al.</i> (2013)
			Low	Pattnayak <i>et al.</i> (2004) Gowda <i>et al.</i> (2008) Ulaganathan and Nirmalakumari (2013)
9.	Seed yield per plant	High	High	Bandyopadhyay (1998) Arunprabhu <i>et al.</i> (2008) Wolie <i>et al.</i> (2013)
			High	Gowda <i>et al.</i> (1999) Satish (2003) Anuradha and Suryakumari (2005) Padmaja (2006) Sarala (2007) Satish <i>et al.</i> (2007) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Shet <i>et al.</i> (2009) Shet <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011)

Table 2.3 (cont.)

S. No.	Character	Genetic advance	Genetic advance as per cent of mean	Reference
			High	Priyadharshini <i>et al.</i> (2011) Dhamdhere <i>et al.</i> (2011) Haradari <i>et al.</i> (2012) Dhanalakshmi <i>et al.</i> (2013) Nishit (2013) Srilakshmi (2013)
		High		Mishra <i>et al.</i> (1980)
		Moderate	High	Anand <i>et al.</i> (2005)
		Moderate		Reddy <i>et al.</i> (2012)
		Low	High	Bezaweletaw <i>et al.</i> (2006) John (2007) Dagnachew <i>et al.</i> (2012) Karad and Patil (2013)
		Low	Moderate	John (2006) Muduli and Misra (2008)
		Low		Patnaik and Jana (1973) Goswami and Asthana (1984) Prabhakar and Prasad (1984) Abraham <i>et al.</i> (1989)
			Low	Ravikumar and Seetharam (1994) Ulaganathan and Nirmalakumari (2013)
10.	Seed protein content		High	Maloo <i>et al.</i> (1998) Padmaja (2006) Sarala (2007) Priyadharshini <i>et al.</i> (2011) Nishit (2013) Srilakshmi (2013)
			Moderate	Gowda <i>et al.</i> (1999)
		Low	High	Karad and Patil (2013)
11.	Seed calcium content		High	Maloo <i>et al.</i> (1998) Padmaja (2006) Sarala (2007) Srilakshmi (2013)

Table 2.4. Review of literature on association of component characters with seed yield per plant in finger millet [*Eleusine coracana* (L.) Gaertn.]

S. No.	Character	Direction	Significance	P/G	Reference
1.	Plant height	Positive	S	P, G	Patnaik (1968)
				P	Basavaraja and Sheriff (1991)
				P, G	Ramaswamy <i>et al.</i> (1994)
				P	Lal <i>et al.</i> (1996)
				G	Mahto <i>et al.</i> (1996)
				G	Mishra (1996)
				P	Marimuthu (1997)
				P, G	Harikrishna <i>et al.</i> (2005)
				P, G	Bedis <i>et al.</i> (2006)
				P, G	Padmaja (2006)
				P	Sarala <i>et al.</i> (2008)
				P, G	Shindey <i>et al.</i> (2010)
				P, G	Ganapathy <i>et al.</i> (2011)
				P, G	Wolie and Dessalegn (2011)
				P, G	Haradari <i>et al.</i> (2012)
				G	Srilakshmi (2013)
		Positive	NS	P	Appadurai <i>et al.</i> (1977)
				P	Ranganathan <i>et al.</i> (1977)
				G	Prabhakar and Prasad (1983)
				P	Abraham <i>et al.</i> (1989)
				P, G	Chaudhary (1989)
				P, G	Reddy <i>et al.</i> (1994)
				P, G	Haider <i>et al.</i> (1995)
				G	Lal <i>et al.</i> (1996)
				P, G	Ravindran <i>et al.</i> (1996)
				P	Shanthakumar and Gowda (1997)
				P, G	Bandyopadhyay (1998)
				G	Sarala <i>et al.</i> (2008)
				G	Priyadharshini <i>et al.</i> (2011)
				P, G	Nishit (2013)
		Negative	S	P	Mahto <i>et al.</i> (2000)
				G	Muduli <i>et al.</i> (2012)
		Negative	NS	G	Abraham <i>et al.</i> (1989)
				P, G	Bezaweletaw <i>et al.</i> (2006)
				P	John (2006)
				P, G	Sumathi <i>et al.</i> (2006)
				P	John (2007)
				P	Muduli <i>et al.</i> (2012)

Table 2.4 (cont.)

S. No.	Character	Direction	Significance	P/G	Reference
2.	Days to 50% flowering	Positive	S	P P, G G G P P P, G P, G P, G P P, G P P, G P, G G	Abraham <i>et al.</i> (1989) Ramaswamy <i>et al.</i> (1994) Mahto <i>et al.</i> (1996) Mishra (1996) Shanthakumar and Gowda (1997) Mahto <i>et al.</i> (2000) Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006) Padmaja (2006) Sarala <i>et al.</i> (2008) Kadam <i>et al.</i> (2009) Nagaraja <i>et al.</i> (2010) Nishit (2013)
		Positive	NS	P P, G G G P P P, G P G P, G P, G	Appadurai <i>et al.</i> (1977) Abraham <i>et al.</i> (1989) Haider <i>et al.</i> (1995) Haider and Mahto (1995) Mishra (1996) Marimuthu (1997) Sumathi <i>et al.</i> (2006) John (2007) Sarala <i>et al.</i> (2007) Ganapathy <i>et al.</i> (2011) Srilakshmi (2013)
		Negative	S	P G	Ravikumar and Seetharam (1993) Ravishankar (1996)
		Negative	NS	P, G P, G P P G P, G	Chaudhary (1989) Reddy <i>et al.</i> (1994) John (2006) Sharathbabu <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)
3.	Productive tillers per plant	Positive	S	G P P P	Prabhakar and Prasad (1983) Abraham <i>et al.</i> (1989) Basavaraja and Sheriff (1991) Ravikumar and Seetharam (1993)

Table 2.4 (cont.)

S. No.	Character	Direction	Significance	P/G	Reference
				P	Reddy <i>et al.</i> (1994)
				P	Marimuthu (1997)
				P	Shanthakumar and Gowda (1997)
				P	Satish (2003)
				P, G	Harikrishna <i>et al.</i> (2005)
				P, G	Bezaweletaw <i>et al.</i> (2006)
				P	John (2007)
				P, G	Ganapathy <i>et al.</i> (2011)
				G	Priyadharshini <i>et al.</i> (2011)
				P	Dagnachew <i>et al.</i> (2012)
				P, G	Srilakshmi (2013)
		Positive	NS	G	Abraham <i>et al.</i> (1989)
				G	Reddy <i>et al.</i> (1994)
				P, G	Bedis <i>et al.</i> (2006)
				P	John (2006)
				P, G	Padmaja (2006)
				P, G	Sarala <i>et al.</i> (2008)
				P	Gowda <i>et al.</i> (2008)
				P	Sharathbabu <i>et al.</i> (2008)
		Negative	S	G	Haider <i>et al.</i> (1995)
				P, G	Nishit (2013)
		Negative	NS	P	Haider <i>et al.</i> (1995)
				P, G	Bandyopadhyay (1998)
4.	Fingers per ear	Positive	S	P, G	Haider <i>et al.</i> (1995)
				P	Lal <i>et al.</i> (1996)
				P, G	Ravindran <i>et al.</i> (1996)
				P	Marimuthu (1997)
				P	Shanthakumar and Gowda (1997)
				P	Satish (2003)
				P	Anuradha and Suryakumari (2005)
				P, G	Bedis <i>et al.</i> (2006)
				G	Bezaweletaw <i>et al.</i> (2006)
				G	Sumathi <i>et al.</i> (2006)
				P	John (2007)
				P	Sharathbabu <i>et al.</i> (2008)
				P	Kadam <i>et al.</i> (2009)
				P, G	Shindey <i>et al.</i> (2010)
				G	Priyadharshini <i>et al.</i> (2011)

Table 2.4 (cont.)

S. No.	Character	Direction	Significance	P/G	Reference
				P, G P, G P, G	Wolie and Dessalegn (2011) Muduli <i>et al.</i> (2012) Srilakshmi (2013)
		Positive	NS	P, G P, G G P, G P, G P P P P,G P, G P, G	Chaudhary (1989) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Bandyopadhyay (1998) Harikrishna <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Gowda <i>et al.</i> (2008) Sarala <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Nishit (2013)
		Negative	S	P	Appadurai <i>et al.</i> (1977)
		Negative	NS	G P, G P P, G	Prabhakar and Prasad (1983) Abraham <i>et al.</i> (1989) John (2006) Padmaja <i>et al.</i> (2006)
5.	Finger length	Positive	S	P, G P P P P P, G P P P,G G P P P P, G P, G P P, G	Patnaik (1968) Agalodia <i>et al.</i> (1979) Singh <i>et al.</i> (1995) Lal <i>et al.</i> (1996) Marimuthu (1997) Bendale <i>et al.</i> (2002) Satish (2003) Anuradha and Suryakumari (2005) Bedis <i>et al.</i> (2006) Padmaja (2006) John (2007) Sharathbabu <i>et al.</i> (2008) Nagaraja <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)
		Positive	NS	P, G G P	Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Shanthakumar and Gowda (1997)

Table 2.4 (cont.)

S. No.	Character	Direction	Significance	P/G	Reference
				P, G P P, G P P, G G P, G P	Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Shindey <i>et al.</i> (2010) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012) Nishit (2013)
		Negative	S	P	Appadurai <i>et al.</i> (1977)
		Negative	NS	G P, G P P G	Prabhakar and Prasad (1983) Harikrishna <i>et al.</i> (2005) John (2006) Gowda <i>et al.</i> (2008) Sarala <i>et al.</i> (2008)
6.	Ear weight per plant	Positive	S	P P P P, G P P, G P, G P P P, G P, G P, G	Basavaraja and Sheriff (1991) Marimuthu (1997) Shanthakumar and Gowda (1997) Bendale <i>et al.</i> (2002) Satish (2003) Harikrishna <i>et al.</i> (2005) Padmaja (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Haradari <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Srilakshmi (2013)
				G P	Sarala <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)
				G	Haider <i>et al.</i> (1995)
				P	Haider <i>et al.</i> (1995)
7.	1000-seed weight	Positive	S	G P P P P P, G G P P P, G P G P, G	Prabhakar and Prasad (1983) Abraham <i>et al.</i> (1989) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Satish (2003) Harikrishna <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) John (2006) Sarala <i>et al.</i> (2008) Shet <i>et al.</i> (2010) Dagnachew <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
				P, G G	Patnaik (1968) Abraham <i>et al.</i> (1989)

Table 2.4 (cont.)

S. No.	Character	Direction	Significance	P/G	Reference
				G G P P P, G P G P P, G	Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Anuradha and Suryakumari (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Gowda <i>et al.</i> (2008) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
		Negative	NS	P P, G P, G P G	Ranganathan <i>et al.</i> (1977) Chaudhary (1989) Sumathi <i>et al.</i> (2006) John (2007) Priyadharshini <i>et al.</i> (2011)
8.	Days to maturity	Positive	S	P P P P, G P P, G P, G	Abraham <i>et al.</i> (1989) Lal <i>et al.</i> (1996) Mahto <i>et al.</i> (2000) Bedis <i>et al.</i> (2006) John (2007) Haradari <i>et al.</i> (2012) Nishit (2013)
				G G P, G P, G P, G	Abraham <i>et al.</i> (1989) Lal <i>et al.</i> (1996) Mishra (1996) Ganapathy <i>et al.</i> (2011) Wolie and Dessalegn (2011)
				G P, G P, G	Prabhakar and Prasad (1983) Bandyopadhyay (1998) Bezaweletaw <i>et al.</i> (2006)
		Negative	NS	P, G P P, G P P, G P, G	Reddy <i>et al.</i> (1994) John (2006) Sumathi <i>et al.</i> (2006) Gowda <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Srilakshmi (2013)
		Positive	NS		
		Negative	S		
9.	Seed protein content	Positive	NS	P, G	Nishit (2013)
		Negative	S	P P, G P P	Gowda <i>et al.</i> (2000) Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008) Nagaraja <i>et al.</i> (2010)
		Negative	NS	P, G G G P, G	Padmaja (2006) Sarala <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011) Srilakshmi (2013)

Table 2.4 (cont.)

S. No.	Character	Direction	Significance	P/G	Reference
10.	Seed calcium content	Positive	NS	P, G	Srilakshmi (2013)
		Negative	NS	P, G P, G P	Padmaja (2006) Sarala <i>et al.</i> (2008) Nagaraja <i>et al.</i> (2010)

S: Significant

NS: Non-significant

P: Phenotypic correlation

G: Genotypic correlation

Table 2.5. Review of literature on association of yield components among themselves in finger millet [*Eleusine coracana* (L.) Gaertn.]

S.No.	Character	Direction	Significance	P/G	Reference
I. Association of plant height with					
1.	Days to 50% flowering	Positive	S	P, G G P, G G G P G P P P, G G P P P P, G G P, G P, G	Haider <i>et al.</i> (1995) Haider and Mahto (1995) Singh <i>et al.</i> (1995) Mahto <i>et al.</i> (1996) Mishra (1996) Mahto <i>et al.</i> (2000) Bendale <i>et al.</i> (2002) Anuradha and Suryakumari (2005) Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) John (2006) John (2007) Sarala <i>et al.</i> (2008) Kadam <i>et al.</i> (2009) Ganapathy <i>et al.</i> (2011) Priyadarshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012) Nishit (2013)
		Positive	NS	P P G G P P P P P P, G P, G	Appadurai <i>et al.</i> (1977) Abraham <i>et al.</i> (1989) Chaudhary (1989) Reddy <i>et al.</i> (1994) Mishra (1996) Shanthakumar and Gowda (1997) Padmaja (2006) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Shindey <i>et al.</i> (2010) Srilakshmi (2013)
		Negative	NS	P	Ravikumar and Seetharam (1993)
2.	Productive tillers per plant	Positive	S	P G P P G P P, G P, G	Ravikumar and Seetharam (1993) Appadurai <i>et al.</i> (1977) Shanthakumar and Gowda (1997) Gowda <i>et al.</i> (2008) Priyadarshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
		Positive	NS	P	Appadurai <i>et al.</i> (1977)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
				P G P P, G P, G P, G P P	Ranganathan <i>et al.</i> (1977) Prabhakar and prasad (1983) Abraham <i>et al.</i> (1989) Reddy <i>et al.</i> (1994) Ravindran <i>et al.</i> (1996) Bandyopadhyay (1998) Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006)
		Negative	S	P	John (2006)
		Negative	NS	G P, G P P P P P,G	Bedis <i>et al.</i> (2006) Bezaweletaw <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) John (2007) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011)
3.	Fingers per ear	Positive	S	P, G P P P P P, G P, G P P P P P, G P P, G P, G	Patnaik (1968) Goud and Lakshmi (1977) Chaudhary (1989) Ravikumar and Seetharam (1993) Lal <i>et al.</i> (1996) Ravindran <i>et al.</i> (1996) Bedis <i>et al.</i> (2006) Bezaweletaw <i>et al.</i> (2006) John (2006) John (2007) Sarala <i>et al.</i> (2008) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
		Positive	NS	P G P P P, G G P, G P G P P P, G G	Ranganathan <i>et al.</i> (1977) Prabhakar and prasad (1983) Abraham <i>et al.</i> (1989) Chaudhary (1989) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Bandyopadhyay (1998) Harikrishna <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Sharathbabu <i>et al.</i> (2008) Shindey <i>et al.</i> (2010) Priyadarshini <i>et al.</i> (2011)
		Negative	S	G P, G	Goud and Lakshmi (1977) Haider <i>et al.</i> (1995)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
				P P G	Anuradha and Suryakumari (2005) Gowda <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
		Negative	NS	P, G P P, G P P, G P	Appadurai <i>et al.</i> (1977) Shanthakumar and Gowda (1997) Sumathi <i>et al.</i> (2006) Kadam <i>et al.</i> (2009) Ganapathy <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)
4.	Finger length	Positive	S	P, G P P P P, G P, G P P P P, G G P, G P P, G P, G P, G	Patnaik (1968) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Shanthakumar and Gowda (1997) Bedis <i>et al.</i> (2006) Bezaweletaw <i>et al.</i> (2006) John (2006) Padmaja (2006) Kadam <i>et al.</i> (2009) Ganapathy <i>et al.</i> (2011) Priyadarshini <i>et al.</i> (2011) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Nishit (2013)
				P, G G G P P, G P P P P, G P, G	Appadurai <i>et al.</i> (1977) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Harikrishna <i>et al.</i> (2005) Sumathi <i>et al.</i> (2006) John (2007) Sarala <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Shindey <i>et al.</i> (2010) Srilakshmi (2013)
				G P	Prabhakar and prasad (1983) Sharathbabu <i>et al.</i> (2008)
		Positive	S	P G P P P	Goud and Lakshmi (1977) Haider <i>et al.</i> (1995) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2007)
				P, G G P P P, G	Padmaja (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)
		Negative	NS	G	Prabhakar and prasad (1983) Sharathbabu <i>et al.</i> (2008)
5.	Ear weight per plant	Positive	S	P G P P P	Goud and Lakshmi (1977) Haider <i>et al.</i> (1995) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2007)
		Positive	NS	P, G G P P P, G	Padmaja (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
6.	1000-seed weight	Negative	S	G G	Goud and Lakshmi (1977) Muduli <i>et al.</i> (2012)
		Negative	NS	P	Muduli <i>et al.</i> (2012)
		Positive	S	P, G P P P, G	Patnaik (1968) Lal <i>et al.</i> (1996) Harikrishna <i>et al.</i> (2005) Muduli <i>et al.</i> (2012)
		Positive	NS	P G P, G G P P, G P P G P, G	Ranganathan <i>et al.</i> (1977) Prabhakar and prasad (1983) Chaudhary (1989) Lal <i>et al.</i> (1996) Padmaja (2006) Sumathi <i>et al</i> (2006) John (2007) Sarala <i>et al.</i> (2008) Priyadarshini <i>et al.</i> (2011) Srilakshmi (2013)
		Negative	S	G P	Bezaweletaw <i>et al.</i> (2006) Gowda <i>et al.</i> (2008)
		Negative	NS	P P, G P P P P, G P	Abraham <i>et al.</i> (1989) Reddy <i>et al.</i> (1994) Bezaweletaw <i>et al.</i> (2006) John (2006) Sharathbabu <i>et al.</i> (2008) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012)
7.	Days to maturity	Positive	S	G P P G P P, G G P, G P P, G P P, G P, G G	Prabhakar and prasad (1983) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Mishra (1996) Anuradha and Suryakumari (2005) Bedis <i>et al.</i> (2006) Sumathi <i>et al</i> (2006) Bezaweletaw <i>et al.</i> (2006) John (2007) Ganapathy <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
		Positive	NS	P G G P P P	Abraham <i>et al.</i> (1989) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Mishra (1996) Sumathi <i>et al</i> (2006) John (2006)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
				P P	Sharathbabu <i>et al.</i> (2008) Wolie and Dessalegn (2011)
		Negative	NS	P, G P G	Bandyopadhyay (1998) Gowda <i>et al.</i> (2008) Wolie and Dessalegn (2011)
8.	Seed protein content	Positive	S	P, G	Nishit (2013)
		Negative	S	P P, G	Sarala <i>et al.</i> (2008) Srilakshmi (2013)
		Negative	NS	P P G	Harikrishna <i>et al.</i> (2005) Padmaja (2006) Priyadarshini <i>et al.</i> (2011)
9.	Seed calcium content	Positive	S	P P G	Padmaja (2006) Sarala <i>et al.</i> (2008) Srilakshmi (2013)
		Positive	NS	P	Sarala <i>et al.</i> (2008)
		Negative	NS	P G	Gowda <i>et al.</i> (2000) Padmaja (2007)
II. Association of Days to 50% flowering with					
1.	Productive tillers per plant	Positive	S	P, G G P P P, G P, G	Haider <i>et al.</i> (1995) Haider and Mahto (1995) Harikrishna <i>et al.</i> (2005) John (2007) Nishit (2013) Srilakshmi (2013)
		Positive	NS	P, G P P P P P, G	Appadurai <i>et al.</i> (1977) Abraham <i>et al.</i> (1989) Shanthakumar and Gowda (1997) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011)
		Negative	S	P P, G P	Ravikumar and Seetharam (1993) Bedis <i>et al.</i> (2006) John (2006)
		Negative	NS	P, G P G	Reddy <i>et al.</i> (1994) Padmaja (2006) Priyadarshini <i>et al.</i> (2011)
2.	Fingers per ear	Positive	S	P P, G P P, G P, G	Ravikumar and Seetharam (1994) Bedis <i>et al.</i> (2006) Kadam <i>et al.</i> (2009) Shindey <i>et al.</i> (2010) Nishit (2013)
		Positive	NS	P, G P P, G P	Appadurai <i>et al.</i> (1977) Abraham <i>et al.</i> (1989) Chaudhary (1989) Shanthakumar and Gowda (1997)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
				P P P P P P, G	Harikrishna <i>et al.</i> (2005) John (2006) John (2007) Sarala <i>et al.</i> (2008) Bandyopadhyay <i>et al.</i> (2009) Srilakshmi (2013)
		Negative	S	G	Haider and Mahto (1995)
		Negative	NS	P, G P P, G P P, G G P, G	Reddy <i>et al.</i> (1994) Padmaja (2006) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Priyadarshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)
3.	Finger length	Positive	S	G P P, G P, G P, G P P P P, G P, G P, G	Appadurai <i>et al.</i> (1977) Reddy <i>et al.</i> (1994) Singh <i>et al.</i> (1995) Bedis <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Kadam <i>et al.</i> (2009) Nagaraja <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Nishit (2013) Srilakshmi (2013)
				G P P P P P, G G P, G	Reddy <i>et al.</i> (1994) Harikrishna <i>et al.</i> (2005) John (2006) Padmaja (2006) John (2007) Shindey <i>et al.</i> (2010) Priyadarshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)
				P P P P P P, G	Appadurai <i>et al.</i> (1977) Shanthakumar and Gowda (1997) Sharathbabu <i>et al.</i> (2008) Harikrishna <i>et al.</i> (2005) Padmaja (2006) Srilakshmi (2013)
				P, G P, G G P P	Haider <i>et al.</i> (1995) Haider and Mahto (1995) Bendale <i>et al.</i> (2002) Harikrishna <i>et al.</i> (2005) Padmaja (2006)
4.	Ear weight per plant	Positive	S	P, G P, G G P P	Haider <i>et al.</i> (1995) Haider and Mahto (1995) Bendale <i>et al.</i> (2002) Harikrishna <i>et al.</i> (2005) Padmaja (2006)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
				P, G	Srilakshmi (2013)
		Positive	NS	P P	Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008)
		Negative	NS	P, G	Muduli <i>et al.</i> (2012)
5.	1000-seed weight	Positive	S	P G	John (2007) Priyadarshini <i>et al.</i> (2011)
		Positive	NS	P P P P P, G P, G	Abraham <i>et al.</i> (1989) Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012) Srilakshmi (2013)
		Negative	S	P P	Reddy <i>et al.</i> (1994) John (2006)
		Negative	NS	P, G G P P, G	Chaudhary (1989) Reddy <i>et al.</i> (1994) Padmaja (2006) Sumathi <i>et al.</i> (2006)
6.	Days to maturity	Positive	S	P P P, G P, G P, G P P, G P P, G P, G P, G P, G	Abraham <i>et al.</i> (1989) Reddy <i>et al.</i> (1994) Singh <i>et al.</i> (1995) Mishra (1996) Bedis <i>et al.</i> (2006) John (2006) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Muduli <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
		Positive	NS	G P	Reddy <i>et al.</i> (1994) John (2007)
		Negative	NS	P	Bandyopadhyay <i>et al.</i> (2009)
7.	Seed protein content	Positive	S	P, G P, G	Srilakshmi (2013) Nishit (2013)
		Negative	S	P, G	Sarala <i>et al.</i> (2008)
		Negative	NS	P P P G	Harikrishna <i>et al.</i> (2005) Padmaja (2006) Nagaraja <i>et al.</i> (2010) Priyadarshini <i>et al.</i> (2011)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
8.	Seed calcium content	Positive	S	P P, G	Nagaraja <i>et al.</i> (2010) Srilakshmi (2013)
		Positive	NS	P P	Padmaja (2006) Sarala <i>et al.</i> (2008)
III. Association of No. of productive tillers per plant with					
1.	Fingers per ear	Positive	S	P P, G G P G P, G	Ranganathan <i>et al.</i> (1977) Ravindran <i>et al.</i> (1996) Bandyopadhyay (1998) Harikrishna <i>et al.</i> (2005) Priyadarshini <i>et al.</i> (2011) Srilakshmi (2013)
		Positive	NS	P, G G P, G P P P P P, G P	Appadurai <i>et al.</i> (1977) Prabhakar and prasad (1983) Reddy <i>et al.</i> (1994) Shanthakumar and Gowda (1997) Bandyopadhyay (1998) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012)
		Negative	S	P G G P P P	Abraham <i>et al.</i> (1989) Haider <i>et al.</i> (1995) Bedis <i>et al.</i> (2006) John (2006) John (2007) Gowda <i>et al.</i> (2008)
		Negative	NS	P P P P, G P	Ravikumar and Seetharam (1993) Haider <i>et al.</i> (1995) Bedis <i>et al.</i> (2006) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006)
2.	Finger length	Positive	S	P P G G P P P, G P	John (2007) Gowda <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Priyadarshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
		Positive	NS	P P, G P, G P P	Appadurai <i>et al.</i> (1977) Reddy <i>et al.</i> (1994) Bezaweletaw <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011)
		Negative	S	G P G P P	Appadurai <i>et al.</i> (1977) Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006) John (2006) Padmaja (2006)
		Negative	NS	G P P P	Prabhakar and prasad (1983) Shanthakumar and Gowda (1997) Bedis <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)
3.	Ear weight per plant	Positive	S	P, G P, G P P P, G	Haider <i>et al.</i> (1995) Haider and Mahto (1995) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Srilakshmi (2013)
		Positive	NS	P P P	Padmaja (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008)
		Negative	S	G P	Bendale <i>et al.</i> (2002) Dagnachew <i>et al.</i> (2012)
4.	1000-seed weight	Positive	S	P G P, G	Reddy <i>et al.</i> (1994) Sarala <i>et al.</i> (2008) Srilakshmi (2013)
		Positive	NS	P G P G P, G P P P	Ranganathan <i>et al.</i> (1977) Prabhakar and Prasad (1983) Abraham <i>et al.</i> (1989) Reddy <i>et al.</i> (1994) Bezaweletaw <i>et al.</i> (2006) John (2007) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008)
		Negative	S	P G	Dagnachew <i>et al.</i> (2012) Nishit (2013)
		Negative	NS	P P P	Chaudhary (1989) Harikrishna <i>et al.</i> (2005) John (2006)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
				P G	Padmaja (2006) Priyadarshini <i>et al.</i> (2011)
5.	Days to maturity	Positive	S	P P, G	John (2007) Srilakshmi (2013)
		Positive	NS	P P, G P, G	Abraham <i>et al.</i> (1989) Bandyopadhyay (1998) Ganapathy <i>et al.</i> (2011)
		Negative	S	G	Bedis <i>et al.</i> (2006)
		Negative	NS	G P, G P P, G P P P P	Prabhakar and prasad (1983) Reddy <i>et al.</i> (1994) Bedis <i>et al.</i> (2006) Bezaweletaw <i>et al.</i> (2006) John (2006) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)
6.	Seed protein content	Positive	S	P P P, G	Harikrishna <i>et al.</i> (2005) Nishit (2013) Srilakshmi (2013)
		Positive	NS	P	Padmaja <i>et al.</i> (2006)
		Negative	NS	P P G	Gowda <i>et al.</i> (2000) Sarala <i>et al.</i> (2007) Priyadarshini <i>et al.</i> (2011)
7.	Seed calcium content	Positive	S	P P, G	Sarala <i>et al.</i> (2008) Srilakshmi (2013)
		Positive	NS	P P	Padmaja (2006) Sarala <i>et al.</i> (2008)
IV. Association of finger number with					
1.	Finger length	Positive	S	P, G G P P P, G P P P, G G G P P, G P, G	Patnaik (1968) Prabhakar and prasad (1983) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Bedis <i>et al.</i> (2006) John (2006) Kadam <i>et al.</i> (2009) Shindey <i>et al.</i> (2010) Priyadarshini <i>et al.</i> (2011) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
		Positive	NS	G G P P, G P P, G P P P P, G P	Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Harikrishna <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Wolie and Dessalegn (2011)
		Negative	S	P, G P P	Appadurai <i>et al.</i> (1977) Shanthakumar and Gowda (1997) John (2007)
		Negative	NS	P, G	Muduli <i>et al.</i> (2012)
2.	Ear weight per plant	Positive	S	G G P G P P P, G P, G	Goud and Lakshmi (1977) Haider <i>et al.</i> (1995) Shanthakumar and Gowda (1997) Bendale <i>et al.</i> (2002) Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008) Muduli <i>et al.</i> (2012) Srilakshmi (2013)
		Positive	NS	P P P	Goud and Lakshmi (1977) Padmaja (2006) Sharathbabu <i>et al.</i> (2008)
		Negative	NS	P P	Haider <i>et al.</i> (1995) Dagnachew <i>et al.</i> (2012)
3.	1000-seed weight	Positive	S	P P P G P, G	Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) John (2007) Sarala <i>et al.</i> (2008) Srilakshmi (2013)
		Positive	NS	P, G G G P P, G P P	Patnaik (1968) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) John (2006) Sumathi <i>et al.</i> (2006) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008)
		Negative	S	P P G P, G P	Abraham <i>et al.</i> (1989) Harikrishna <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
		Negative	NS	P G G P P P G P, G	Ranganathan <i>et al.</i> (1977) Prabhakar and prasad (1983) Chaudhary (1989) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Sarala <i>et al.</i> (2008) Priyadarshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)
4.	Days to maturity	Positive	S	P P G G P, G	Lal <i>et al.</i> (1996) Bandyopadhyay (1998) Bezaweletaw <i>et al.</i> (2006) Ganapathy <i>et al.</i> (2011) Srilakshmi (2013)
		Positive	NS	P G P, G P P P	Abraham <i>et al.</i> (1989) Lal <i>et al.</i> (1996) Bedis <i>et al.</i> (2006) Bezaweletaw <i>et al.</i> (2006) Gowda <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)
		Negative	S	G P	Bandyopadhyay (1998) John (2006)
		Negative	NS	G P, G P, G P P P P P, G P, G	Prabhakar and Prasad (1983) Reddy <i>et al.</i> (1994) Sumathi <i>et al.</i> (2006) John (2007) Sharathbabu <i>et al.</i> (2008) Bandyopadhyay <i>et al.</i> (2009) Ganapathy <i>et al.</i> (2011) Wolie and Dessalegn (2011) Muduli <i>et al.</i> (2012)
5.	Seed protein content	Positive	S	P, G	Nishit (2013)
		Positive	NS	P G P, G	Harikrishna <i>et al.</i> (2005) Priyadarshini <i>et al.</i> (2011) Srilakshmi (2013)
		Negative	NS	P P P	Gowda <i>et al.</i> (2000) Padmaja (2006) Sarala <i>et al.</i> (2008)
6.	Seed calcium content	Positive	S	P P, G	Padmaja (2006) Srilakshmi (2013)
		Positive	NS	P	Sarala <i>et al.</i> (2008)
V. Association of Finger length with					
1.	Ear weight per plant	Positive	S	P, G P P	Bendale <i>et al.</i> (2002) Bedis <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
				G	Srilakshmi (2013)
		Positive	NS	P P P P P P	Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Padmaja (2006) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
		Negative	S	P	Dagnachew <i>et al.</i> (2012)
		Negative	NS	P G	Sarala <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
2.	1000-seed weight	Positive	S	G P P, G	Prabhakar and prasad (1983) Lal <i>et al.</i> (1996) Srilakshmi (2013)
		Positive	NS	P, G P, G	Patnaik (1968) Reddy <i>et al.</i> (1994)
				G G P P G P P P, G	Lal <i>et al.</i> (1996) Bezaweletaw <i>et al.</i> (2006) John (2006) Padmaja (2006) Sumathi <i>et al.</i> (2006) John (2007) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
		Negative	S	P P	Gowda <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)
		Negative	NS	P P P G P, G	Harikrishna <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Priyadarshini <i>et al.</i> (2011) Wolie and Dessalegn (2011)
3.	Days to maturity	Positive	S	P P P P, G P, G P P, G G	Agalodia <i>et al.</i> (1979) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Bedis <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) John (2007) Ganapathy <i>et al.</i> (2011) Srilakshmi (2013)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
		Positive	NS	G G G P P, G P, G	Prabhakar and prasad (1983) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Bezaweletaw <i>et al.</i> (2006) Wolie and Dessalegn (2011) Muduli <i>et al.</i> (2012)
		Negative	NS	P P P P	John (2006) Gowda <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)
4.	Seed protein content	Positive	S	P, G	Srilakshmi (2013)
		Positive	NS	P	Harikrishna <i>et al.</i> (2005)
		Negative	NS	P P P P G	Gowda <i>et al.</i> (2000) Padmaja (2006) Sarala <i>et al.</i> (2008) Nagaraja <i>et al.</i> (2010) Priyadarshini <i>et al.</i> (2011)
5.	Seed calcium content	Positive	S	P P, G	Nagaraja <i>et al.</i> (2010) Srilakshmi (2013)
		Positive	NS	P P	Padmaja (2006) Sarala <i>et al.</i> (2007)
VI. Association of Ear weight per plant with					
1.	1000-seed weight	Positive	S	P, G G P P, G	Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)
		Positive	NS	P P P P, G	Padmaja (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
2.	Days to maturity	Positive	S	P P, G	Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)
		Positive	NS	P	Sharathbabu <i>et al.</i> (2008)
		Negative	NS	P, G	Muduli <i>et al.</i> (2012)
3.	Seed protein content	Positive	NS	P P, G	Padmaja (2006) Srilakshmi (2013)
		Negative	S	P P	Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008)
		Negative	NS	G	Padmaja (2006)
4.	Seed calcium content	Positive	S	P P, G	Sarala <i>et al.</i> (2008) Srilakshmi (2013)

Table 2.5 (cont.)

S.No.	Character	Direction	Significance	P/G	Reference
		Positive	NS	P P	Padmaja (2006) Sarala <i>et al.</i> (2008)
VII. Association of 1000-seed weight with					
1.	Days to maturity	Positive	S	P P P, G	Lal <i>et al.</i> (1996) John (2007) Nishit (2013)
		Positive	NS	G P G P P P, G	Prabhakar and prasad (1983) Abraham <i>et al.</i> (1989) Lal <i>et al.</i> (1996) John (2006) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
		Negative	S	P P, G	Reddy <i>et al.</i> (1994) Bezaweletaw <i>et al.</i> (2006)
		Negative	NS	G P, G P P, G P P, G	Reddy <i>et al.</i> (1994) Sumathi <i>et al.</i> (2006) Gowda <i>et al.</i> (2008) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)
2.	Seed protein content	Positive	S	P, G	Nishit (2013)
		Negative	S	P	Harikrishna <i>et al.</i> (2005)
		Negative	NS	P P G P, G	Padmaja (2006) Sarala <i>et al.</i> (2008) Priyadarshini <i>et al.</i> (2011) Srilakshmi (2013)
3.	Seed calcium content	Positive	NS	P, G	Srilakshmi (2013)
VIII. Association of Seed protein content with					
1.	Seed calcium content	Positive	S	P, G	Srilakshmi (2013)
		Positive	NS	P	Padmaja (2006)
		Negative	NS	P P	Sarala <i>et al.</i> (2008) Nagaraja <i>et al.</i> (2010)

S: significant

NS: Non-significant

P: Phenotypic correlation

G: Genotypic correlation

Table 2.6. Review of literature on direct effects of component characters on seed yield in finger millet [*Eleusine coracana* (L.) Gaertn.]

S. No.	Character	P/G	Positive direct effect	P/G	Negative direct effect
1.	Plant height	G	Goud and Lakshmi (1977)	G	Appadurai <i>et al.</i> (1977)
		G	Chaudhary (1989)	P	Ranganathan <i>et al.</i> (1977)
		G	Ramaswamy <i>et al.</i> (1994)	G	Prabhakar and Prasad (1983)
		P	Ravikumar and Seetharam (1993)	P	Shanthakumar and Gowda (1997)
		P,G	Reddy <i>et al.</i> (1994)	P,G	Bendale <i>et al.</i> (2002)
		P,G	Singh <i>et al.</i> (1995)	G	Sumathi <i>et al.</i> (2006)
		G	Mishra (1996)	G	Sarala <i>et al.</i> (2008)
		P	Marimuthu (1997)	P	Sharathbabu <i>et al.</i> (2008)
		P	Mahto <i>et al.</i> (2000)	G	Priyadharshini <i>et al.</i> (2011)
		P,G	Anuradha and Suryakumari (2005)	P	Wolie and Dessalegn (2011)
		P	Harikrishna <i>et al.</i> (2005)	P	Dagnachew <i>et al.</i> (2012)
		G	Bedis <i>et al.</i> (2006)	P	Srilakshmi (2013)
		G	Padmaja <i>et al.</i> (2006)		
		P,G	Ganapathy <i>et al.</i> (2011)		
		G	Muduli <i>et al.</i> (2012)		
		P	Nishit (2013)		
		G	Suryanarayana <i>et al.</i> (2014)		
2.	Days to 50% flowering	G	Ramaswamy <i>et al.</i> (1994)	G	Chaudhary (1989)
		P,G	Reddy <i>et al.</i> (1994)	P,G	Singh <i>et al.</i> (1995)
		P	Ravindran <i>et al.</i> (1996)	G	Mishra (1996)
		P	Marimuthu (1997)	P	Shanthakumar and Gowda (1997)
		P	Mahto <i>et al.</i> (2000)	G	Bedis <i>et al.</i> (2006)
		P,G	Bendale <i>et al.</i> (2002)	G	Sarala <i>et al.</i> (2008)
		P,G	Anuradha and Suryakumari (2005)	P	Sharathbabu <i>et al.</i> (2008)
		P	Harikrishna <i>et al.</i> (2005)	G	Muduli <i>et al.</i> (2012)
		G	Padmaja <i>et al.</i> (2006)	P,G	Nishit (2013)
		G	Sumathi <i>et al.</i> (2006)		
		G	Priyadharshini <i>et al.</i> (2011)		
		G	Srilakshmi (2013)		
		G	Suryanarayana <i>et al.</i> (2014)		
3.	Productive tillers per plant	P	Ranganathan <i>et al.</i> (1977)	P	Shanthakumar and Gowda (1997)
		G	Prabhakar and Prasad (1983)	P,G	Bendale <i>et al.</i> (2002)
		P	Ravikumar and Seetharam (1993)	P,G	Anuradha and Suryakumari (2005)

Table 2.6 (cont.)

S. No.	Character	P/G	Positive direct effect	P/G	Negative direct effect
		P P P G G G G P P,G G P P P,G	Ravindran <i>et al.</i> (1996) Marimuthu (1997) Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006) Bezaweletaw <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Shet <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Haradari <i>et al.</i> (2012) Srilakshmi (2013)	P P	Sharathbabu <i>et al.</i> (2008) Nishit (2013)
4.	Fingers per ear	G P G P P,G P,G P P,G G G G G P P G P P G P,G P,G G	Goud and Lakshmi (1977) Ranganathan <i>et al.</i> (1977) Chaudhary (1989) Ravikumar and Seetharam (1993) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Ravindran <i>et al.</i> (1996) Anuradha and Suryakumari (2005) Bezaweletaw <i>et al.</i> (2006) Bedis <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Shet <i>et al.</i> (2010) Priyadharshini <i>et al.</i> (2011) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Anuradha <i>et al.</i> (2013) Nishit (2013) Srilakshmi (2013) Suryanarayana <i>et al.</i> (2014)	G P P P,G P G	Prabhakar and Prasad (1983) Marimuthu (1997) Shanthakumar and Gowda (1997) Bendale <i>et al.</i> (2002) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006)
5.	Finger length	P,G P,G P P,G	Singh <i>et al.</i> (1995) Lal <i>et al.</i> (1996) Shanthakumar and Gowda (1997) Bendale <i>et al.</i> (2002)	G P,G P G G G	Prabhakar and Prasad (1983) Reddy <i>et al.</i> (1994) Marimuthu (1997) Bedis <i>et al.</i> (2006) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)

Table 2.6 (cont.)

S. No.	Character	P/G	Positive direct effect	P/G	Negative direct effect
		P,G G G G P P P P G	Anuradha and Suryakumari (2005) Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013) Suryanarayana <i>et al.</i> (2014)	P,G	Nishit (2013)
6.	Ear weight per plant	G P P,G P P G G P P P G P,G	Goud and Lakshmi (1977) Shanthakumar and Gowda (1997) Bendale <i>et al.</i> (2002) Satish (2003) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Haradari <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Srilakshmi (2013)		
7.	1000-seed weight	G P,G P P G G P P P G P,G P,G	Prabhakar and Prasad (1983) Reddy <i>et al.</i> (1994) Harikrishna <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Shet <i>et al.</i> (2010) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)	P G P,G P,G P,G G P	Ranganathan <i>et al.</i> (1977) Chaudhary (1989) Lal <i>et al.</i> (1996) Bendale <i>et al.</i> (2002) Anuradha and Suryakumari (2005) Priyadharshini <i>et al.</i> (2011) Wolie and Dessalegn (2011)
8.	Days to maturity	P,G P G P P G G G	Lal <i>et al.</i> (1996) Mahto <i>et al.</i> (2000) Bedis <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Haradari <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Anuradha <i>et al.</i> (2013) Suryanarayana <i>et al.</i> (2014)	G P,G P,G G P,G G G P,G P	Prabhakar and Prasad (1983) Reddy <i>et al.</i> (1994) Singh <i>et al.</i> (1995) Mishra (1996) Anuradha and Suryakumari (2005) Bezaweletaw <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Ganapathy <i>et al.</i> (2011) Wolie and Dessalegn (2011)

Table 2.6 (cont.)

S. No.	Character	P/G	Positive direct effect	P/G	Negative direct effect
				P,G P,G	Nishit (2013) Srilakshmi (2013)
9.	Seed Protein content	G G P,G	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Nishit (2013)	P G P,G	Harikrishna <i>et al.</i> (2005) Priyadharshini <i>et al.</i> (2011) Srilakshmi (2013)
10.	Seed Calcium content	G	Sarala <i>et al.</i> (2008)	G P,G	Padmaja <i>et al.</i> (2006) Srilakshmi (2013)

P: Phenotypic level
G: Genotypic level

Table 2.7. Review of literature on indirect effects of component characters on seed yield per plant in finger millet [*Eleusine coracana* (L.) Gaertn.]

S.No.	Character	Positive indirect effect	Negative indirect effect
I. Plant height on seed yield per plant through			
1.	Days to 50% flowering	Appadurai <i>et al.</i> (1977) Chaudhary (1989) Ramaswamy <i>et al.</i> (1994) Reddy <i>et al.</i> (1994) Singh <i>et al.</i> (1995) Mishra (1996) Mahto <i>et al.</i> (2000) Anuradha and Suryakumari (2005) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012) Srilakshmi (2013) Nishit (2013)	Marimuthu (1997) Shanthakumar and Gowda (1997) Bedis <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011)
2.	Productive tillers per plant	Ranganathan <i>et al.</i> (1977) Basavaraja and Sheriff (1991) Ravikumar and Seetharam (1993) Reddy <i>et al.</i> (1994) Marimuthu (1997) Harikrishna <i>et al.</i> (2005) Sharathbabu <i>et al.</i> (2008) Srilakshmi (2013) Nishit (2013)	Shanthakumar and Gowda (1997) Anuradha and Suryakumari (2005) Bedis <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012)
3.	Fingers per ear	Appadurai <i>et al.</i> (1977) Ranganathan <i>et al.</i> (1977) Chaudhary (1989) Ravikumar and Seetharam (1993) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006)	Marimuthu (1997) Mahto <i>et al.</i> (2000) Anuradha and Suryakumari (2005) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)

Table 2.7 (cont.)

S.No.	Character	Positive indirect effect	Negative indirect effect
		Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)	
4.	Finger length	Reddy <i>et al.</i> (1994) Singh <i>et al.</i> (1995) Lal <i>et al.</i> (1996) Shanthakumar and Gowda (1997) Bedis <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) Ganapathy <i>et al.</i> (2011) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012)	Marimuthu (1997) Mahto <i>et al.</i> (2000) Anuradha and Suryakumari (2005) Harikrishna <i>et al.</i> (2005) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
5.	Ear weight per plant	Marimuthu (1997) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)	Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
6.	1000-seed weight	Ranganathan <i>et al.</i> (1977) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Wolie and Dessalegn (2011) Muduli <i>et al.</i> (2012) Srilakshmi (2013)	Chaudhary (1989) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Anuradha and Suryakumari (2005) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Nishit (2013)
7.	Days to maturity	Reddy <i>et al.</i> (1994) Singh <i>et al.</i> (1995) Lal <i>et al.</i> (1996) Mishra (1996) Bedis <i>et al.</i> (2006)	Anuradha and Suryakumari (2005) Sumathi <i>et al.</i> (2006) Dagnachew <i>et al.</i> (2012) Nishit (2013)

Table 2.7 (cont.)

S.No.	Character	Positive indirect effect	Negative indirect effect
		Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)	Srilakshmi (2013)
8.	Seed protein content	Sarala <i>et al.</i> (2007) Nishit (2013) Srilakshmi (2013)	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Priyadharshini <i>et al.</i> (2011)
9.	Seed calcium content	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Padmaja <i>et al.</i> (2007) Sarala <i>et al.</i> (2008) Srilakshmi (2013)
II. Days to 50% flowering on seed yield per plant through			
1.	Productive tillers per plant	Anuradha and Suryakumari (2005) Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Nishit (2013) Srilakshmi (2013)	Reddy <i>et al.</i> (1994) Marimuthu (1997) Shanthakumar and Gowda (1997) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008)
2.	Fingers per ear	Chaudhary (1989) Harikrishna <i>et al.</i> (2005) Sharathbabu <i>et al.</i> (2008) Nishit (2013) Srilakshmi (2013)	Reddy <i>et al.</i> (1994) Marimuthu (1997) Shanthakumar and Gowda (1997) Mahto <i>et al.</i> (2000) Anuradha and Suryakumari (2005) Bedis <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012)
3.	Finger length	Reddy <i>et al.</i> (1994) Singh <i>et al.</i> (1995) Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011)	Marimuthu (1997) Shanthakumar and Gowda (1997) Mahto <i>et al.</i> (2000) Anuradha and Suryakumari (2005)

Table 2.7 (cont.)

S.No.	Character	Positive indirect effect	Negative indirect effect
		Priyadharshini <i>et al.</i> (2011) Srilakshmi (2013)	Harikrishna <i>et al.</i> (2005) Bedis <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Muduli <i>et al.</i> (2012) Nishit (2013)
4.	Ear weight per plant	Marimuthu (1997) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Srilakshmi (2013)	Sarala <i>et al.</i> (2008) Muduli <i>et al.</i> (2012)
5.	1000-seed weight	Harikrishna <i>et al.</i> (2005) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)	Reddy <i>et al.</i> (1994) Anuradha and Suryakumari (2005) Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011)
6.	Days to maturity	Reddy <i>et al.</i> (1994) Sumathi <i>et al.</i> (2006) Muduli <i>et al.</i> (2012)	Singh <i>et al.</i> (1995) Mishra (1996) Anuradha and Suryakumari (2005) Bedis <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Nishit (2013) Srilakshmi (2013)
7.	Seed protein content	Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008) Nishit (2013)	Padmaja <i>et al.</i> (2006) Priyadharshini <i>et al.</i> (2011) Srilakshmi (2013)
8.	Seed calcium content	Padmaja <i>et al.</i> (2006)	Sarala <i>et al.</i> (2008) Srilakshmi (2013)
III. No. of productive tillers per plant on seed yield per plant through			
1.	Fingers per ear	Ranganathan <i>et al.</i> (1977) Basavaraja and Sheriff (1991) Reddy <i>et al.</i> (1994) Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012)	Ravikumar and Seetharam (1993) Marimuthu (1997) Shanthakumar and Gowda (1997) Bedis <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008)

Table 2.7 (cont.)

S.No.	Character	Positive indirect effect	Negative indirect effect
		Nishit (2013) Srilakshmi (2013)	
2.	Finger length	Basavaraja and Sheriff (1991) Reddy <i>et al.</i> (1994) Marimuthu (1997) Anuradha and Suryakumari (2005) Harikrishna <i>et al.</i> (2005) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Srilakshmi (2013)	Shanthakumar and Gowda (1997) Bedis <i>et al.</i> (2006) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Nishit (2013)
3.	Ear weight per plant	Basavaraja and Sheriff (1991) Marimuthu (1997) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Srilakshmi (2013)	Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)
4.	1000-seed weight	Ranganathan <i>et al.</i> (1977) Reddy <i>et al.</i> (1994) Sarala <i>et al.</i> (2008) Srilakshmi (2013)	Anuradha and Suryakumari (2005) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Nishit (2013)
5.	Days to maturity	Reddy <i>et al.</i> (1994) Anuradha and Suryakumari (2005) Ganapathy <i>et al.</i> (2011)	Bedis <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
6.	Seed protein content	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Nishit (2013)	Sarala <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011) Srilakshmi (2013)
7.	Seed calcium content	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Srilakshmi (2013)
IV. Number of fingers per ear on seed yield per plant through			
1.	Finger length	Agalodia <i>et al.</i> (1979) Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Harikrishna <i>et al.</i> (2005) Sumathi <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Marimuthu (1997) Shanthakumar and Gowda (1997) Anuradha and Suryakumari (2005) Bedis <i>et al.</i> (2006)

Table 2.7 (cont.)

S.No.	Character	Positive indirect effect	Negative indirect effect
		Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Wolie and Dessalegn (2011) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Srilakshmi (2013)	Padmaja <i>et al.</i> (2006) Nishit (2013)
2.	Ear weight per plant	Marimuthu (1997) Shanthakumar and Gowda (1997) Harikrishna <i>et al.</i> (2005) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Muduli <i>et al.</i> (2012) Srilakshmi (2013)	Padmaja <i>et al.</i> (2006) Dagnachew <i>et al.</i> (2012)
3.	1000-seed weight	Ranganathan <i>et al.</i> (1977) Reddy <i>et al.</i> (1994) Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Wolie and Dessalegn (2011) Srilakshmi (2013)	Chaudhary (1989) Lal <i>et al.</i> (1996) Anuradha and Suryakumari (2005) Sarala <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Nishit (2013)
4.	Days to maturity	Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996) Bedis <i>et al.</i> (2006) Sumathi <i>et al.</i> (2006) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012)	Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Muduli <i>et al.</i> (2012) Nishit (2013) Srilakshmi (2013)
5.	Seed protein content	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Priyadharshini <i>et al.</i> (2011) Nishit (2013)	Sarala <i>et al.</i> (2008) Srilakshmi (2013)
6.	Seed calcium content	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Srilakshmi (2013)
V. Finger length on seed yield per plant through			
1.	Ear weight per plant	Marimuthu (1997) Shanthakumar and Gowda (1997) Padmaja <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Srilakshmi (2013)	Sarala <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012)
2.	1000-seed weight	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006)	Reddy <i>et al.</i> (1994) Lal <i>et al.</i> (1996)

Table 2.7 (cont.)

S.No.	Character	Positive indirect effect	Negative indirect effect
		Sharathbabu <i>et al.</i> (2008) Wolie and Dessalegn (2011) Priyadharshini <i>et al.</i> (2011) Muduli <i>et al.</i> (2012) Srilakshmi (2013)	Sumathi <i>et al.</i> (2006) Dagnachew <i>et al.</i> (2012) Nishit (2013)
3.	Days to maturity	Singh <i>et al.</i> (1995) Lal <i>et al.</i> (1996) Bedis <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011)	Reddy <i>et al.</i> (1994) Sumathi <i>et al.</i> (2006) Wolie and Dessalegn (2011) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Nishit (2013)
4.	Seed protein content	Priyadharshini <i>et al.</i> (2011) Nishit (2013)	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Srilakshmi (2013)
5.	Seed calcium content	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Srilakshmi (2013)
VI. Ear weight per plant on seed yield per plant through			
1.	1000-seed weight	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008) Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012) Muduli <i>et al.</i> (2012) Srilakshmi (2013)	
2.	Days to maturity	Sharathbabu <i>et al.</i> (2008) Dagnachew <i>et al.</i> (2012)	Muduli <i>et al.</i> (2012) Srilakshmi (2013)
3.	Seed protein content	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2007) Sarala <i>et al.</i> (2008) Srilakshmi (2013)
4.	Seed calcium content	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Srilakshmi (2013)
VII. 1000-seed weight on seed yield per plant through			
1.	Days to maturity	Reddy <i>et al.</i> (1994) Sumathi <i>et al.</i> (2006) Sharathbabu <i>et al.</i> (2008) Wolie and Dessalegn (2011) Muduli <i>et al.</i> (2012) Srilakshmi (2013)	Lal <i>et al.</i> (1996) Anuradha and Suryakumari (2005) Dagnachew <i>et al.</i> (2012) Nishit (2013)
2.	Seed protein content	Priyadharshini <i>et al.</i> (2011) Nishit (2013) Srilakshmi (2013)	Harikrishna <i>et al.</i> (2005) Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)
3.	Seed calcium content	Padmaja <i>et al.</i> (2006) Sarala <i>et al.</i> (2008)	Srilakshmi (2013)

Table 2.7 (cont.)

S.No.	Character	Positive indirect effect	Negative indirect effect
VIII. Seed protein content on seed yield per plant through			
1.	Seed calcium content	Padmaja <i>et al.</i> (2006)	Sarala <i>et al.</i> (2008) Srilakshmi (2013)

Table 2.1. Review of literature on genetic variability of yield and yield components in finger millet [*Eleusine coracana* (L.) Gaertn.]

S.No.	Character	Coefficient of variation		Reference
		GCV	PCV	
1.	Plant height	High	High	Kadam <i>et al.</i> (2009) Dhanalakshmi <i>et al.</i> (2013)
		Moderate	Moderate	Prabhakar and Prasad (1984) Ramaswamy <i>et al.</i> (1994) Ravikumar and Seetharam (1994) Bendale <i>et al.</i> (2002) Bezaweletaw <i>et al.</i> (2006) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Nishit (2013) Ulaganathan and Nirmalakumari (2013)
		Moderate		Goud and Lakshmi (1977)
		Low	Moderate	Lal <i>et al.</i> (1996) Bandyopadhyay (1998) Satish (2003) Padmaja (2006) John (2007) Sarala (2007) Dhamdhere <i>et al.</i> (2011) Harti <i>et al.</i> (2013) Wolie <i>et al.</i> (2013) Karad and Patil (2013) Srilakshmi (2013)
		Low	Low	Abraham <i>et al.</i> (1989) Verma (1989) Kumar <i>et al.</i> (2000) Anand <i>et al.</i> (2005) John (2006) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Shet <i>et al.</i> (2009) Nandini <i>et al.</i> (2010) Shet <i>et al.</i> (2010)
		Low		Appadurai <i>et al.</i> (1977) Agalodia <i>et al.</i> (1979) Goswami and Asthana (1984)
2.	Days to 50% flowering	High	High	Kadam <i>et al.</i> (2009) Dhanalakshmi <i>et al.</i> (2013)
		Moderate	Moderate	Mishra <i>et al.</i> (1980)

Table 2.1 (cont.)

S.No.	Character	Coefficient of variation		Reference
		GCV	PCV	
		Moderate	Moderate	Abraham <i>et al.</i> (1989) Ramaswamy <i>et al.</i> (1994) Bendale <i>et al.</i> (2002) Dhamdhare <i>et al.</i> (2011) Ganapathy <i>et al.</i> (2011) Nishit (2013)
		Moderate		Appadurai <i>et al.</i> (1977)
		Low	Moderate	John (2007) Karad and Patil (2013)
		Low	Low	Ravikumar and Seetharam (1994) Ravishankar (1996) Satish (2003) John (2006) Padmaja (2006) Sarala (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Shet <i>et al.</i> (2009) Nandini <i>et al.</i> (2010) Shet <i>et al.</i> (2010) Priyadharshini <i>et al.</i> (2011) Harti <i>et al.</i> (2013) Ulaganathan and Nirmalakumari (2013) Wolie <i>et al.</i> (2013) Srilakshmi (2013)
3.	Productive tillers per plant	High	High	Mishra <i>et al.</i> (1980) Verma (1989) Ravikumar and Seetharam (1994) Bandyopadhyay (1998) Bendale <i>et al.</i> (2002) Satish (2003) Anand <i>et al.</i> (2005) John (2006) Padmaja (2006) Sarala (2007) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011)

Table 2.1 (cont.)

S.No.	Character	Coefficient of variation		Reference
		GCV	PCV	
		High	High	Wolie <i>et al.</i> (2013) Karad and Patil (2013)
		High		Appadurai <i>et al.</i> (1977)
		Moderate	Moderate	Sarala (2007) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013)
		Moderate	High	Prabhakar and Prasad (1984) Abraham <i>et al.</i> (1989) Gowda <i>et al.</i> (1999) Kumar <i>et al.</i> (2000) Anuradha and Suryakumari (2005) Bezaweletaw <i>et al.</i> (2006) John (2007) Gowda <i>et al.</i> (2008) Dhanalakshmi <i>et al.</i> (2013) Harti <i>et al.</i> (2013)
		Low	Low	Nishit (2013)
4.	Fingers per ear	High	High	Ravikumar and Seetharam (1994) Lal <i>et al.</i> (1996) Bandyopadhyay (1998) John (2006) John (2007) Reddy <i>et al.</i> (2012) Wolie <i>et al.</i> (2013)
		High		Agalodia <i>et al.</i> (1979)
			High	Anuradha and Suryakumari (2005)
		Moderate	High	Dhamdhare <i>et al.</i> (2011)
		Moderate		Goud and Lakshmi (1977) Muduli and Misra (2008)
		Moderate	Moderate	Mishra <i>et al.</i> (1980) Prabhakar and Prasad (1984) Abraham <i>et al.</i> (1989) Bendale <i>et al.</i> (2002) Satish (2003) Anand <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006)

Table 2.1 (cont.)

S.No.	Character	Coefficient of variation		Reference
		GCV	PCV	
		Moderate	Moderate	Sarala (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Karad and Patil (2013) Nishit (2013) Dhanalakshmi <i>et al.</i> (2013) Srilakshmi (2013)
		Low	Moderate	Gowda <i>et al.</i> (1999) Kumar <i>et al.</i> (2000) Harti <i>et al.</i> (2013) Ulaganathan and Nirmalakumari (2013)
		Low	Low	Verma (1989)
		Low		Appadurai <i>et al.</i> (1977)
5.	Finger length	High	High	Lal <i>et al.</i> (1996) Bendale <i>et al.</i> (2002) Satish (2003) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Sarala (2007) Dhamdhere <i>et al.</i> (2011) Harti <i>et al.</i> (2013) Wolie <i>et al.</i> (2013)
		High		Agalodia <i>et al.</i> (1979) Goswami and Asthana (1984)
		High	Moderate	Arunprabhu <i>et al.</i> (2008)
		Moderate	High	Prabhakar and Prasad (1984)
		Moderate		Appadurai <i>et al.</i> (1977)
		Moderate	Moderate	Gowda <i>et al.</i> (2008) Nandini <i>et al.</i> (2010) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Nishit (2013) Karad and Patil (2013) Ulaganathan and Nirmalakumari (2013)
		Low	Low	Verma (1989)

Table 2.1 (cont.)

S.No.	Character	Coefficient of variation		Reference
		GCV	PCV	
		Low		Muduli and Misra (2008)
6.	Ear weight per plant	High	High	Bendale <i>et al.</i> (2002) Satish (2003) Sarala (2007) Nandini <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011)
		High		Goud and Lakshmi (1977)
		Moderate	High	Padmaja (2006)
		Moderate	Moderate	Chaudhari and Acharya (1969) Srilakshmi (2013)
7.	1000- seed weight	High	High	Lal <i>et al.</i> (1996) Satish (2003) Sarala (2007) Dhanalakshmi <i>et al.</i> (2013)
		Low	High	Nandini <i>et al.</i> (2010)
		Moderate	High	Dhamdhere <i>et al.</i> (2011)
		Moderate	Moderate	Prabhakar and Prasad (1984) Abraham <i>et al.</i> (1989) Ravishankar (1996) Bendale <i>et al.</i> (2002) Anand <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) John (2006) Padmaja (2006) John (2007) Gowda <i>et al.</i> (2008) Karad and Patil (2013) Harti <i>et al.</i> (2013) Nishit (2013) Srilakshmi (2013) Ulaganathan and Nirmalakumari (2013)
		Low	Low	Anuradha and Suryakumari (2005) Arunaprabhu <i>et al.</i> (2008) Priyadharshini <i>et al.</i> (2011)
		Low		Agalodia <i>et al.</i> (1979)
8.	Days to maturity	Moderate	Moderate	Bandyopadhyay (1998)

Table 2.1 (cont.)

S.No.	Character	Coefficient of variation		Reference
		GCV	PCV	
		Moderate	Moderate	Dhamdhere <i>et al.</i> (2011) Nishit (2013)
		Moderate		Goswami and Asthana (1984)
		Low	Low	Mishra <i>et al.</i> (1980) Prabhakar and Prasad (1984) Abraham <i>et al.</i> (1989) Lal <i>et al.</i> (1996) Kumar <i>et al.</i> (2000) Satish (2003) Bezaweletaw <i>et al.</i> (2006) John (2006) John (2007) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Ganapathy <i>et al.</i> (2011) Wolie <i>et al.</i> (2013) Karad and Patil (2013) Ulaganathan and Nirmalakumari (2013)
		Low		Agalodia <i>et al.</i> (1979)
9.	Seed yield per plant	High	High	Mishra <i>et al.</i> (1980) Prabhakar and Prasad (1984) Abraham <i>et al.</i> (1989) Verma (1989) Ravikumar and Seetharam (1994) Bandyopadhyay (1998) Gowda <i>et al.</i> (1999) Bendale <i>et al.</i> (2002) Satish (2003) Anand <i>et al.</i> (2005) Bezaweletaw <i>et al.</i> (2006) Padmaja (2006) Arunprabhu <i>et al.</i> (2008) Gowda <i>et al.</i> (2008) Kadam <i>et al.</i> (2009) Shet <i>et al.</i> (2009) Shet <i>et al.</i> (2010) Dhamdhere <i>et al.</i> (2011) Harti <i>et al.</i> (2013) Wolie <i>et al.</i> (2013) Karad and Patil (2013) Ulaganathan and Nirmalakumari (2013)
		High		Goswami and Asthana (1984)

Table 2.1 (cont.)

S.No.	Character	Coefficient of variation		Reference
		GCV	PCV	
			High	Anuradha and Suryakumari (2005)
		Moderate	High	Patnaik (1968) Kumar <i>et al.</i> (2000) Sarala (2007) Srilakshmi (2013)
		Moderate	Moderate	John (2006) John (2007) Ganapathy <i>et al.</i> (2011) Priyadharshini <i>et al.</i> (2011) Nishit (2013)
		Low	Low	Dhanalakshmi <i>et al.</i> (2013)
		Moderate		Agalodia <i>et al.</i> (1979) Muduli and Misra (2008)
10.	Seed protein content	High	High	Maloo <i>et al.</i> (1998) Srilakshmi (2013)
		Moderate	Moderate	Padmaja (2006) Sarala (2007) Priyadharshini <i>et al.</i> (2011) Nishit (2013) Karad and Patil (2013)
		Low	Moderate	Gowda <i>et al.</i> (1999)
11.	Seed calcium content	Moderate	Moderate	Maloo <i>et al.</i> (1998) Padmaja (2006) Sarala (2007) Srilakshmi (2013)

PCV: Phenotypic coefficient of variation

GCV: Genotypic coefficient of variation

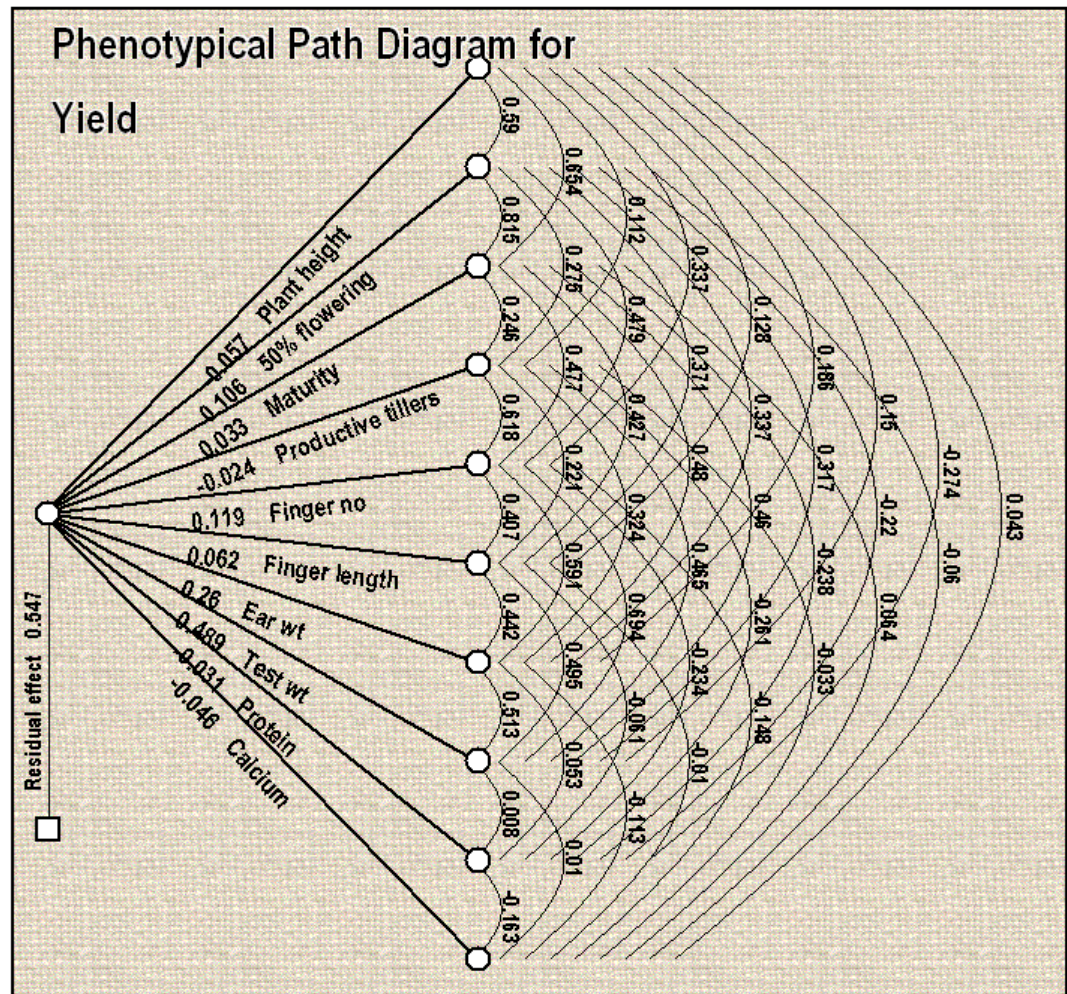


Fig. 4.1. Phenotypic path diagram showing direct and indirect effects of yield components of seed yield per plant in finger millet (*Eleusine coracana* (L.) Gaertn.)

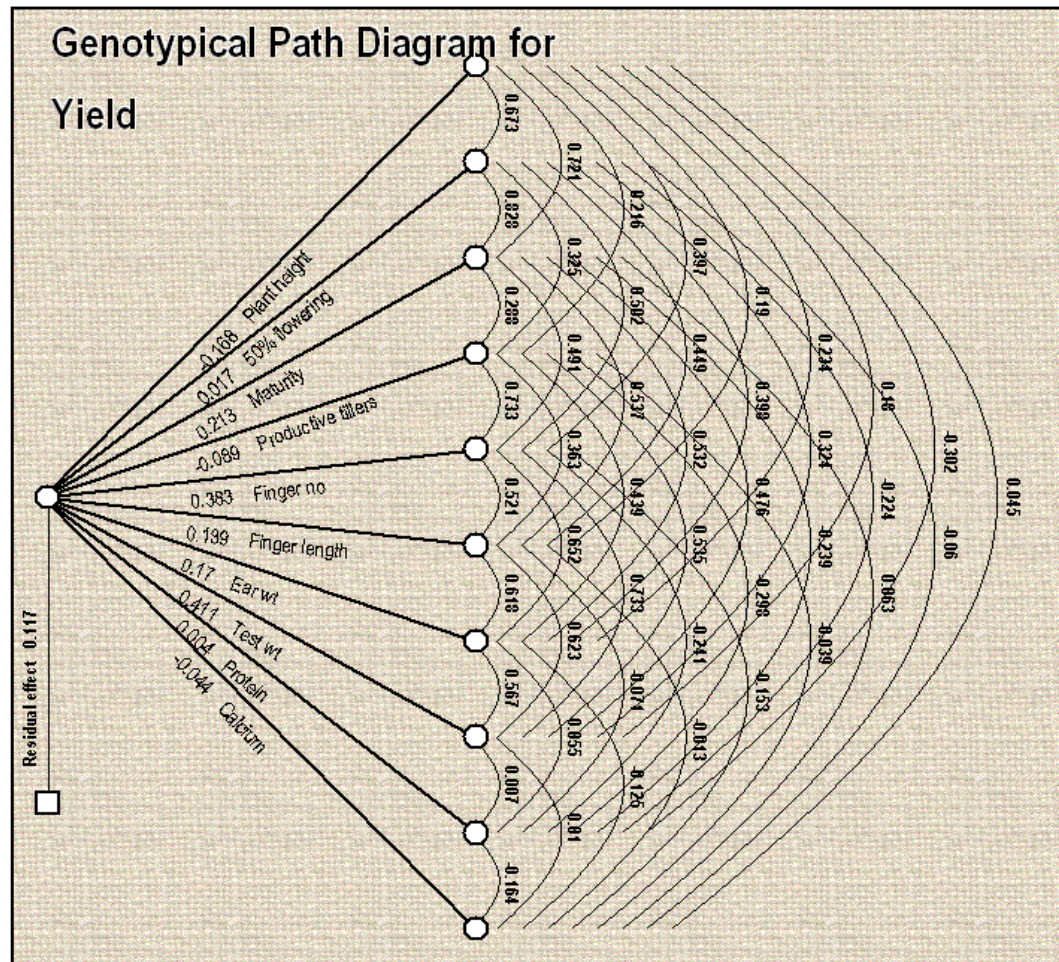


Fig. 4.2. Genotypic path diagram showing direct and indirect effects of yield components of seed yield per plant in finger millet (*Eleusine coracana* (L.) Gaertn.)

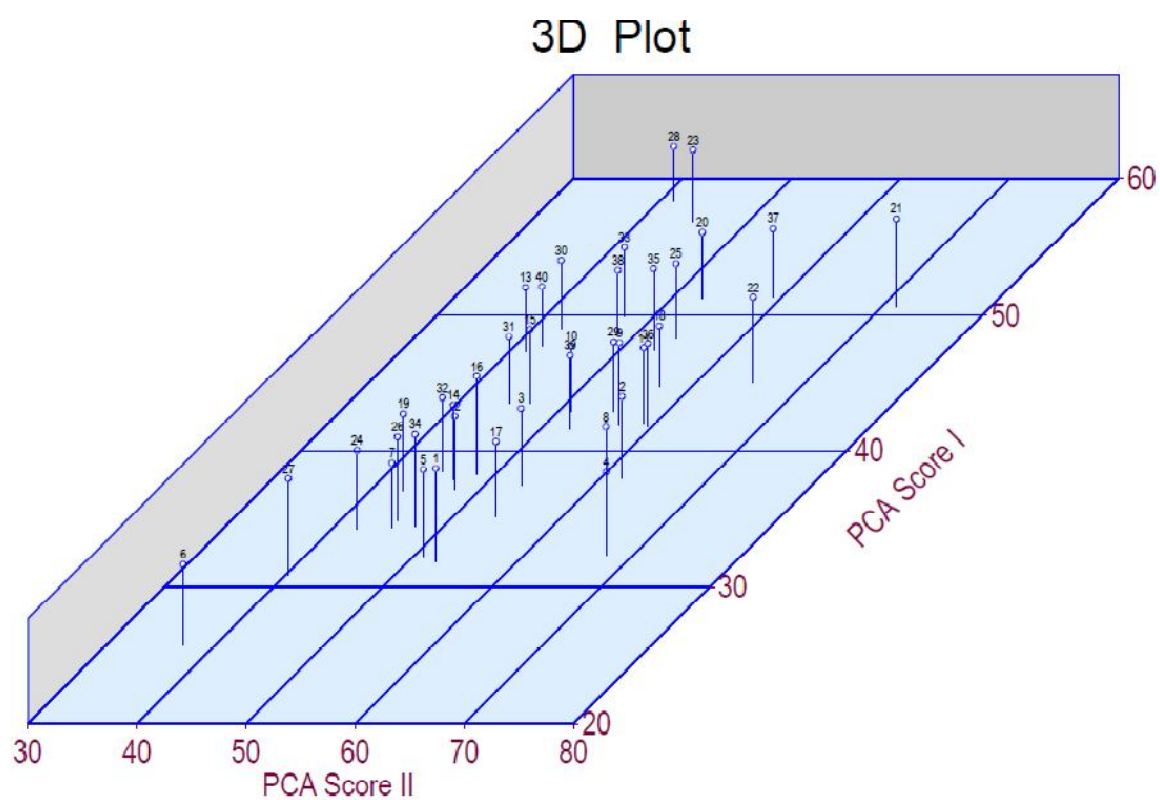


Fig. 4.6. Three dimensional graph showing relative position of 40 finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes based on PCA scores

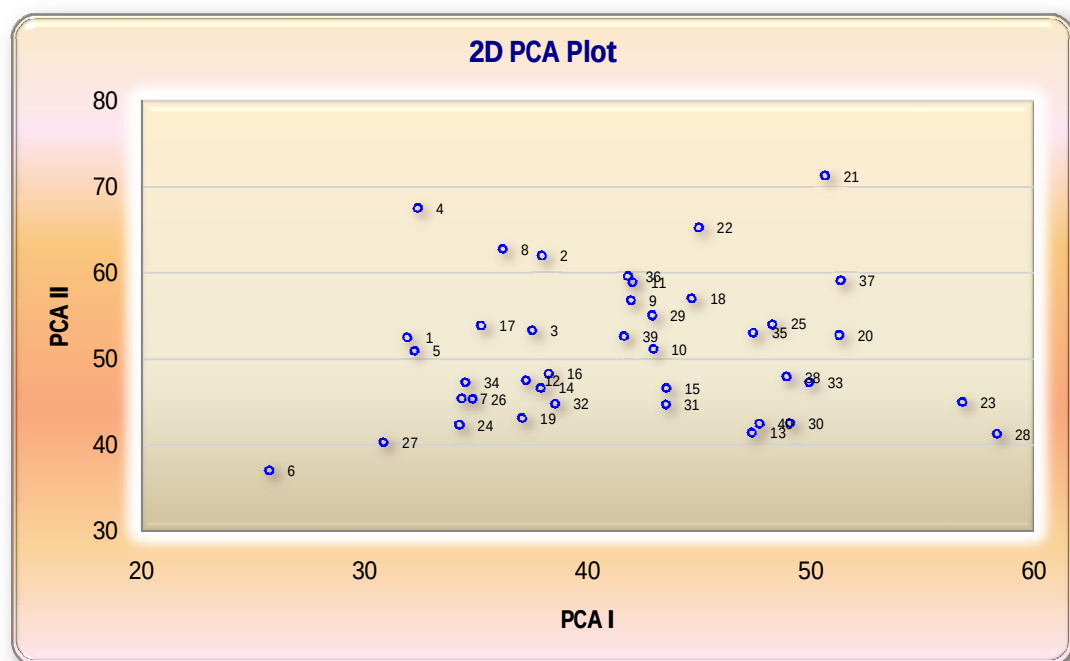


Fig. 4.5. Two dimensional graph showing relative position of 40 finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes based on PCA scores

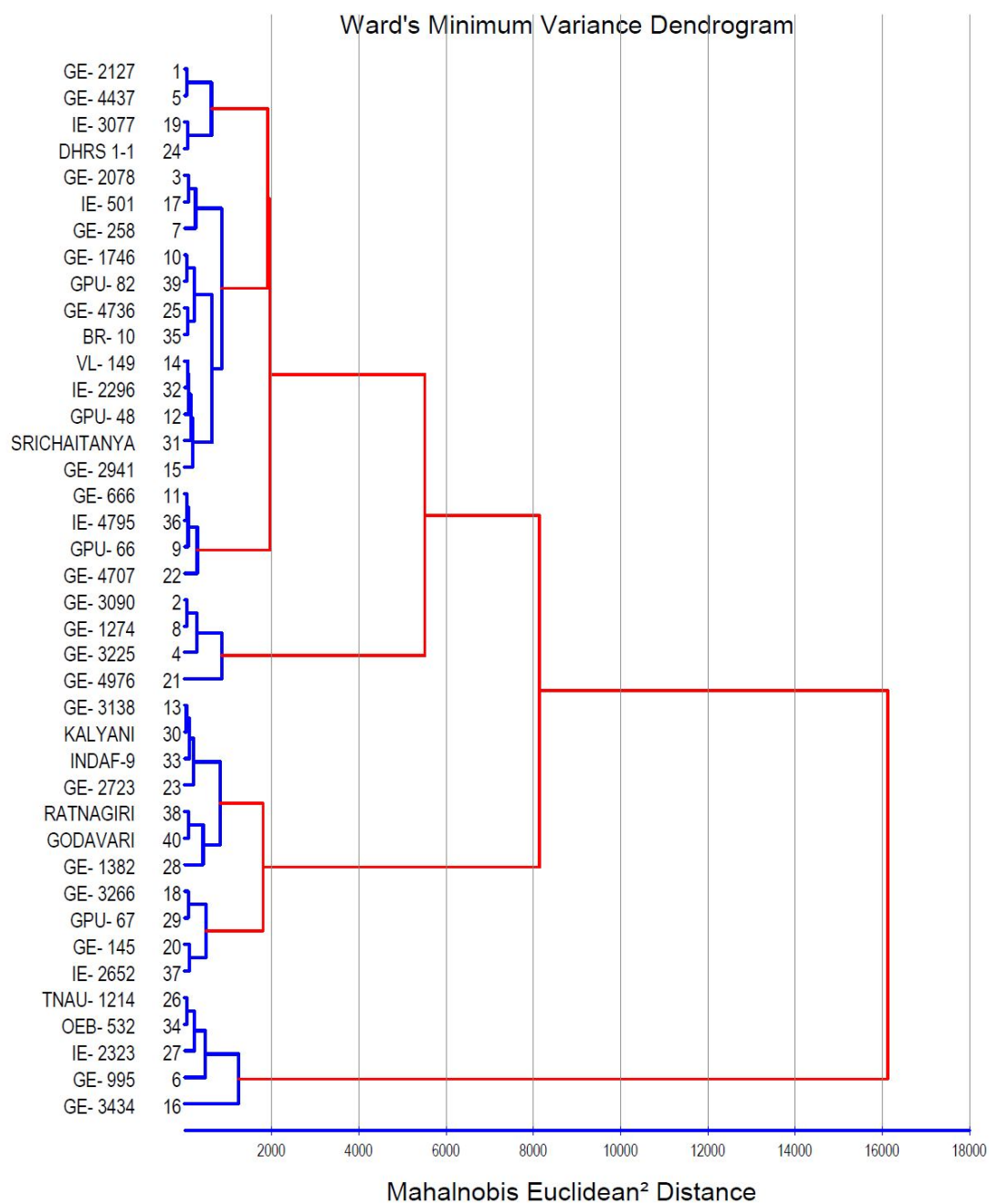
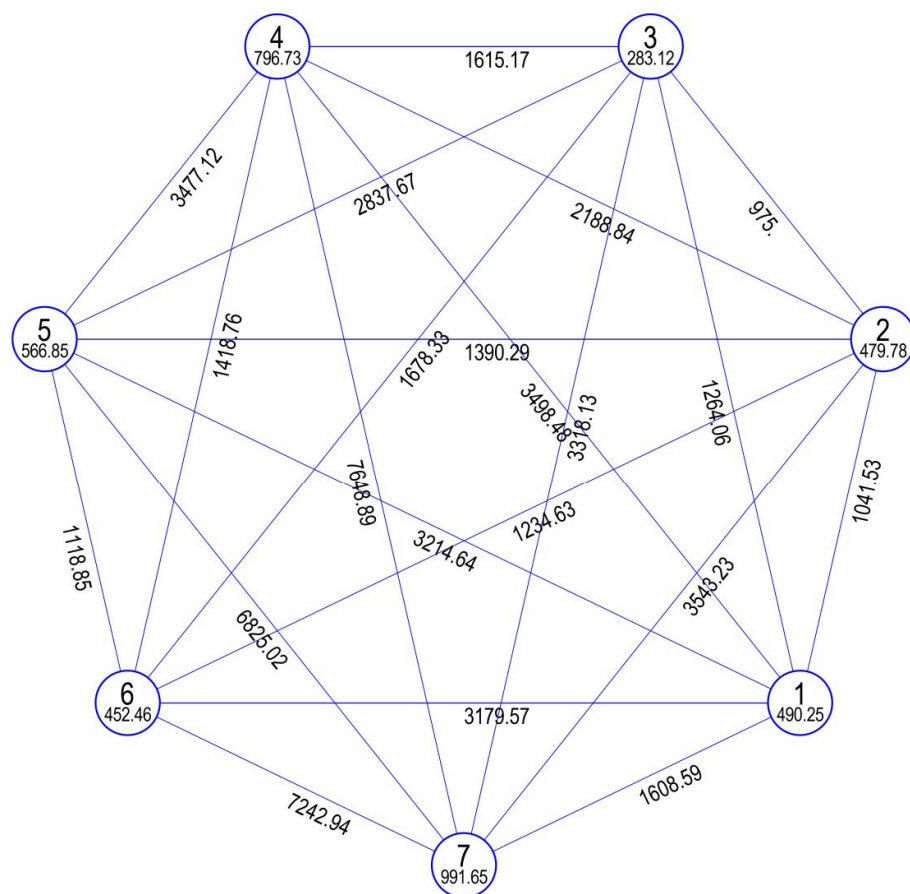


Fig. 4.7. Dendrogram showing relationship of 40 finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes in seven clusters based on Euclidean² distance



Euclidean² Distance (Not to the Scale)

Fig. 4.8. Intra and inter-cluster distance of 40 finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes in seven clusters based on Euclidean² distance

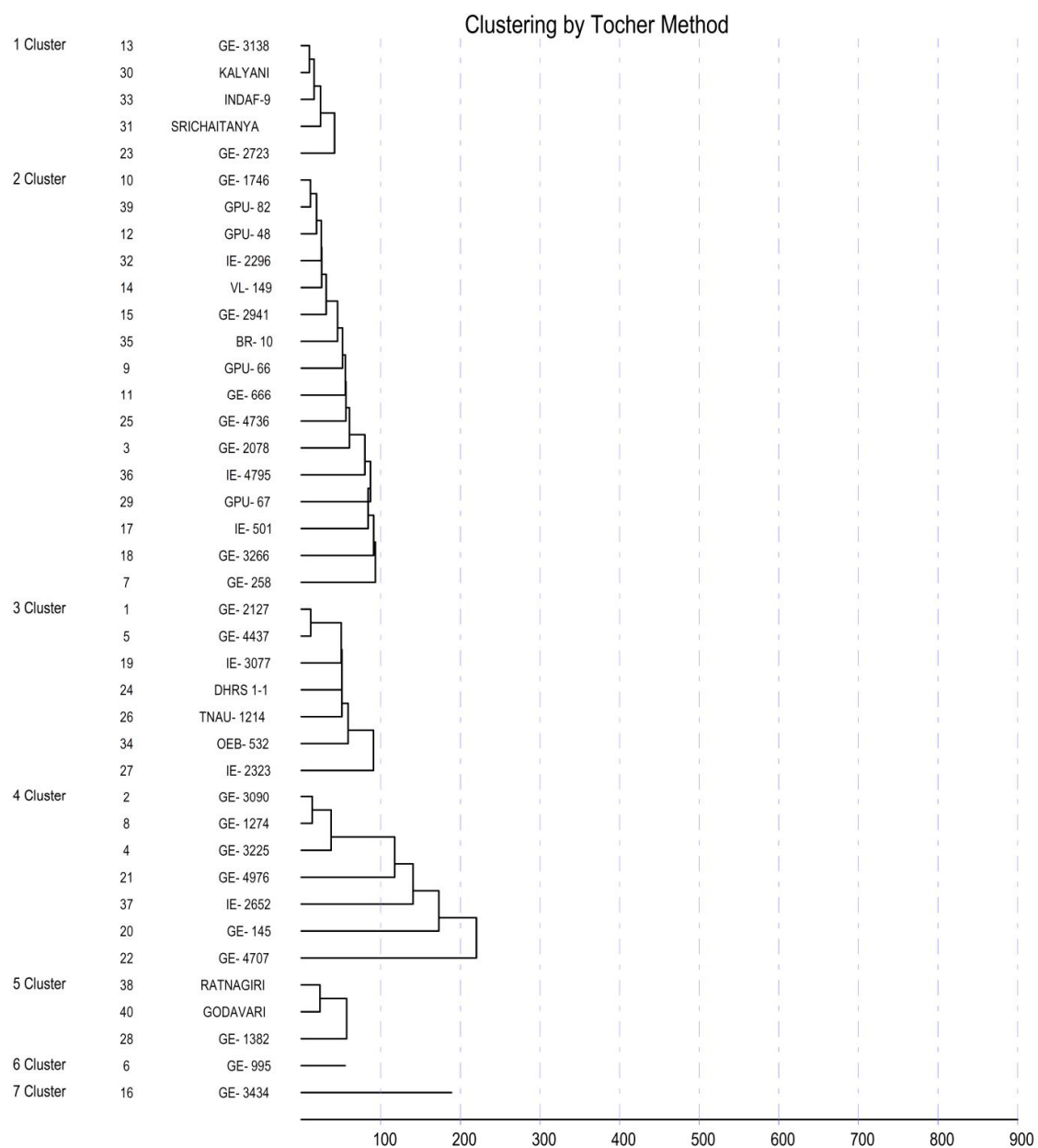
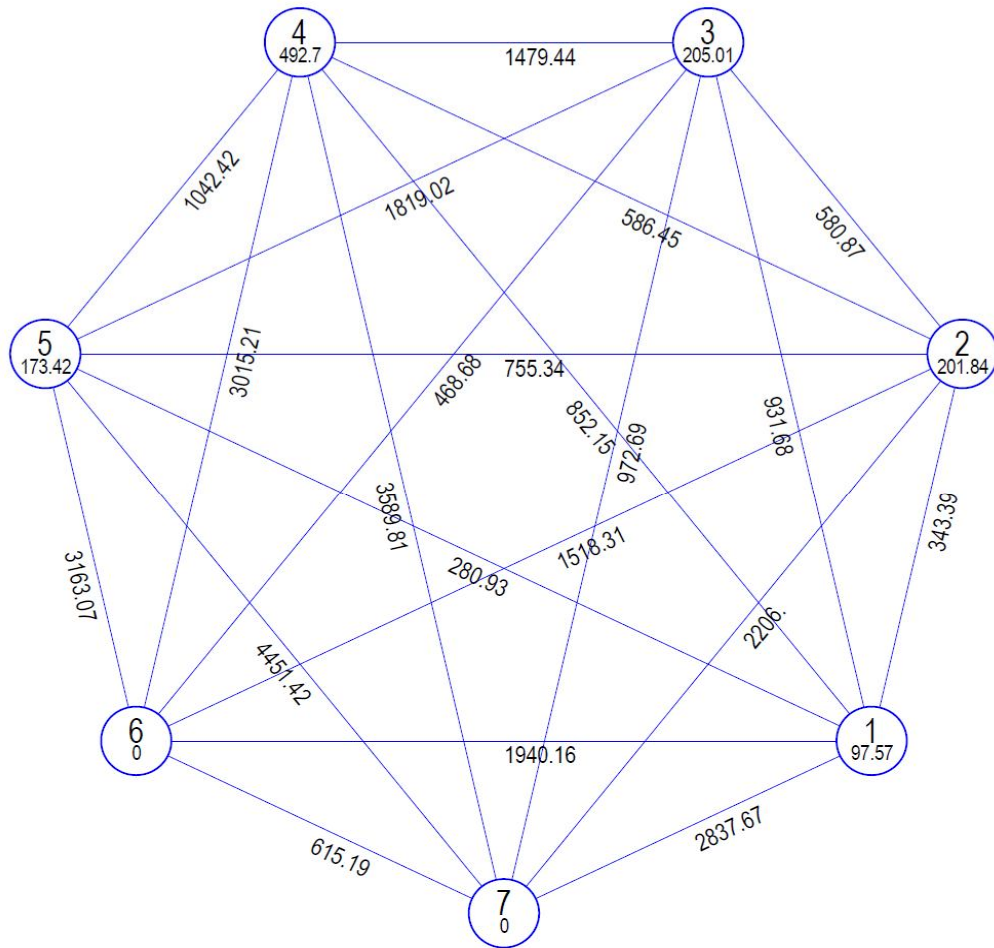


Fig. 4.4. Dendrogram showing relationship among 40 finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes in seven clusters based on Mahalanobis' D^2 values

Tocher Method



Mahalanobis Euclidean Distance (Not to the Scale)

Fig. 4.3. Intra and inter-cluster distance of 40 finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes in seven clusters based on Tocher's method

Table 4.2. Analysis of variance for seed yield and yield component characters in finger millet [*Eleusine coracana* (L.) Gaertn.]

Source of variations	d.f.	Plant height (cm)	Days to 50% flowering	Days to maturity	Productive tillers per plant	Fingers per ear	Finger length (cm)	Ear weight per plant (g)	1000-seed weight (g)	Seed protein content (%)	Seed calcium content (mg/100g)	Seed yield per plant (g)
		Mean sum of squares										
Replications	2	29.01	8.93	6.00	0.40	0.006	0.20	11.67	0.005	0.03	10.43	7.47
Treatments	39	508.75 ^{**}	184.18 ^{**}	321.43 ^{**}	1.79 ^{**}	2.22 ^{**}	4.65 ^{**}	53.44 ^{**}	0.40 ^{**}	8.57 ^{**}	9941.62 ^{**}	51.19 ^{**}
Error	78	37.54	1.95	1.26	0.17	0.04	0.71	3.08	0.007	0.004	12.58	6.64

^{**} Significant at 1% level

Table 4.3. Estimates of variability, heritability and genetic advance as per cent of mean for seed yield and yield components in finger millet [*Eleusine coracana* (L.) Gaertn.]

S. No.	Character	Mean	Range		Coefficient of variation		Heritability (broad sense) (%)	Genetic advance as per cent of mean
			Minimum	Maximum	PCV (%)	GCV (%)		
1.	Plant height (cm)	105.02	78.90	138.20	13.28	11.93	80.70	28.30
2.	Days to 50% flowering	70.03	54.00	84.00	11.30	11.12	96.80	28.91
3.	Days to maturity	103.05	88.00	122.33	10.08	10.02	98.80	26.30
4.	Productive tillers per plant	3.65	2.20	5.40	23.18	20.10	75.20	46.03
5.	Fingers per ear	5.73	3.73	7.60	15.27	14.86	94.70	38.20
6.	Finger length (cm)	6.87	4.89	9.44	20.72	16.67	64.70	35.41
7.	Ear weight per plant (g)	19.11	10.52	27.71	23.32	21.43	84.40	52.02
8.	1000-seed weight (g)	3.91	3.24	4.80	9.51	9.24	94.40	23.73
9.	Seed protein content (%)	8.36	5.70	13.65	20.22	20.20	99.80	53.29
10.	Seed calcium content (mg/100g)	331.31	234.00	478.66	17.39	17.36	99.60	45.75
11.	Seed yield per plant (g)	14.15	7.30	22.75	32.75	27.21	69.00	59.72

PCV = Phenotypic coefficient of variation

GCV = Genotypic coefficient of variation

Table 4.4.. Phenotypic and Genotypic correlations among seed yield and yield contributing characters in finger millet [*Eleusine coracana* (L.) Gaertn.]

Character	Correlation	Days to 50% flowering	Days to maturity	Productive tillers per plant	Fingers per ear	Finger length	Ear weight per plant	1000-seed weight	Seed protein content	Seed calcium content	Seed yield per plant
Plant height	G P	0.6730** 0.5896**	0.7207** 0.6537**	0.2156* 0.1121	0.3965** 0.3366**	0.1898* 0.1283	0.2342** 0.1859*	0.1805* 0.1497	-0.3022** -0.2741	0.0450 0.0432	0.2665** 0.2006*
Days to 50% flowering	G P		0.8277** 0.8148**	0.3252** 0.2754	0.5025** 0.4791	0.4485** 0.3714	0.3978** 0.3369	0.3238** 0.3170	-0.2241** -0.2196*	-0.0605 -0.0599	0.5079** 0.4249**
Days to maturity	G P			0.2883** 0.2458**	0.4912** 0.4771	0.5375** 0.4271	0.5316** 0.4799	0.4755** 0.4600	-0.2392** -0.2375	0.0635 0.0638	0.6245** 0.5137**
Productive tillers per plant	G P				0.7332** 0.6178	0.3625** 0.2211	0.4388** 0.3236	0.5353** 0.4648	-0.2983** -0.2612	-0.0387 -0.0334	0.5669** 0.4148
Fingers per ear	G P					0.5211** 0.4068	0.6516** 0.5911	0.7330** 0.6944	-0.2406** -0.2341*	-0.1527 -0.1479	0.8534** 0.6838
Finger length	G P						0.6181** 0.4416	0.6233** 0.4950	-0.0711 -0.0609	-0.0127 -0.0098	0.7573** 0.5103
Ear weight per plant	G P							0.5671** 0.5130	0.0549 0.0531	-0.1252 -0.1125	0.7850** 0.6450
1000-seed weight	G P								0.0068 0.0075	0.0101 0.0099	0.9021** 0.7640**
Seed protein content	G P									-0.1638 -0.1634	-0.0558 -0.0467
Seed calcium content	G P										-0.1139 -0.0891

G: Genotypic correlation
P: Phenotypic correlation

* Significant at 5% level
** Significant at 1% level

Table 4.5. Direct and indirect effects of different traits on yield per plant in finger millet [*Eleusine coracana* (L.) Gaertn.]

Character		Plant height	Days to 50% flowering	Days to maturity	Productive tillers per plant	Fingers per ear	Finger length	Ear weight per plant	1000-seed weight	Seed protein content	Seed calcium content
Plant height	G	-0.1676	-0.1128	-0.1208	-0.0361	-0.0664	-0.0318	-0.0392	-0.0302	0.0506	-0.0075
	P	-0.0568	-0.0335	-0.0371	-0.0064	-0.0191	-0.0073	-0.0106	-0.0085	0.0156	-0.0025
Days to 50% flowering	G	0.0112	0.0166	0.0138	0.0054	0.0084	0.0075	0.0066	0.0054	-0.0037	-0.0010
	P	0.0624	0.1059	0.0863	0.0292	0.0507	0.0393	0.0357	0.0336	-0.0232	-0.0063
Days to maturity	G	0.1535	0.1762	0.2129	0.0614	0.1046	0.1144	0.1132	0.1012	-0.0509	0.0135
	P	0.0218	0.0271	0.0333	0.0082	0.0159	0.0142	0.0160	0.0153	-0.0079	-0.0021
Productive tillers per plant	G	-0.0193	-0.0291	-0.0258	-0.0894	-0.0655	-0.0324	-0.0392	-0.0478	0.0267	0.0035
	P	-0.0027	-0.0067	-0.0060	-0.0243	-0.0150	-0.0054	-0.0079	-0.0113	0.0064	0.0008
Fingers per ear	G	0.1517	0.1923	0.1879	0.2805	0.3826	0.1994	0.2493	0.2805	-0.0921	-0.0584
	P	0.0401	0.0571	0.0568	0.0736	0.1191	0.0485	0.0704	0.0827	-0.0279	-0.0176
Finger length	G	0.0264	0.0624	0.0748	0.0504	0.0725	0.1391	0.0860	0.0867	-0.0099	-0.0018
	P	0.0079	0.0230	0.0264	0.0137	0.0252	0.0619	0.0273	0.0306	-0.0038	-0.0006
Ear weight per plant	G	0.0398	0.0675	0.0902	0.0745	0.1106	0.1049	0.1698	0.0963	0.0093	-0.0213
	P	0.0483	0.0875	0.1246	0.0840	0.1535	0.1147	0.2597	0.1332	0.0138	-0.0292
1000-seed weight	G	0.0741	0.1329	0.1952	0.2197	0.3009	0.2559	0.2398	0.4105	0.0028	0.0041
	P	0.0732	0.1550	0.2249	0.2273	0.3396	0.2421	0.2509	0.4890	0.0037	0.0048
Seed protein content	G	-0.0013	-0.0009	-0.0010	-0.0012	-0.0010	-0.0003	0.0002	0.0000	0.0041	-0.0007
	P	0.0084	0.0068	0.0073	0.0080	0.0072	0.0019	-0.0016	-0.0002	-0.0308	0.0050
Seed calcium content	G	-0.0020	0.0027	-0.0028	0.0017	0.0068	0.0006	0.0056	-0.0004	0.0073	-0.0444
	P	-0.0020	0.0027	-0.0029	0.0015	0.0068	0.0051	-0.0005	0.0075	-0.0457	-0.0481
Seed yield per plant	G	0.2665**	0.5079**	0.6245**	0.5669**	0.8534**	0.7573**	0.7850**	0.9021**	-0.0558	-0.1139
	P	0.2006**	0.4249**	0.5137**	0.4148**	0.6838**	0.5103**	0.6450**	0.7640**	-0.0467	-0.0891

* Significant at 1% level

** Significant at 5% level

Diagonal values indicate direct effects

Residual effect at genotypic level = 0.1166

Residual effect at phenotypic level = 0.5475

G: at genotypic level

P: at phenotypic level

Table 4.6. Contribution of different characters towards genetic divergence in 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes

Sl.no	Source	No. of times ranked first	Per cent contribution
1	Plant height	0.01	0.00 %
2	Days to 50% flowering	10.00	1.28 %
3	Days to maturity	54.00	6.92 %
4	Productive tillers per plant	0.01	0.00 %
5	Fingers per ear	5.00	0.64 %
6	Finger length	0.01	0.00 %
7	Ear weight per plant	1.00	0.13 %
8	1000-seed weight	6.00	0.77 %
9	Seed protein content	449.00	57.56 %
10	Seed calcium content	255.00	32.69 %
11	Seed yield per plant	0.01	0.00 %

Table 4.7. Clustering pattern of 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes by Tocher's method

Cluster number	No. of genotypes	Name of genotype (s)
I	5	GE-3138, Kalyani, Indaf-9, Srichaitanya, GE-2723
II	16	GE-1746, GPU- 82, GPU-48, IE- 2296, VL-149, GE-2941, GPU-66, BR-10, GE-666, GE-4736, GE-2078, IE-4795, GPU-67, IE-501, GE-3266, GE-258
III	7	GE-2127, GE-4437, IE-3077, DHRS-1-1, TNAU-12-14, OEB-532, IE-2323
IV	7	GE-3090, GE-1274, GE- 3225, GE-4976, IE-2652, GE-145, GE-4707
V	3	Ratnagiri, Godavari, GE-1382
VI	1	GE-995
VII	1	GE-3434

Table 4.8. Average intra and inter-cluster D^2 values among seven clusters with 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes

Cluster No.	I	II	III	IV	V	VI	VII
I	97.57	343.39	931.68	852.15	280.93	1940.16	2837.67
II		201.84	580.87	586.45	755.34	1518.31	2206.00
III			205.01	1479.44	1819.02	468.68	972.69
IV				492.70	1042.42	3015.21	3589.81
V					173.42	3163.07	4451.42
VI						0.00	615.19
VII							0.00

Note: Diagonal values are intra-cluster distances. Off-diagonal values are inter-cluster distances.

Table 4.9. The nearest and the farthest cluster from each cluster based on D^2 values using Tocher's method in 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes

Cluster No.	Nearest cluster with D^2 values	Farthest cluster with D^2 values
I	V (280.93)	VII (2837.67)
II	I (343.39)	VII (2206.00)
III	VI (468.68)	V (1819.02)
IV	II (586.45)	VII (3589.81)
V	I (280.93)	VII (4451.42)
VI	III (468.68)	V (3163.07)
VII	VI (615.19)	V (4451.42)

Table 4.10. Mean values of seven clusters estimated by Tocher's method from 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes

Cl No.	Plant height (cm)	Days to 50% flowering	Days to maturity	No. of productive tillers	Fingers per ear	Finger length (cm)	Ear weight per plant (g)	1000-seed weight (g)	Seed protein content (%)	Seed calcium content (mg/100g)	Seed yield per plant (g)
I	111.33	75.20	108.93	4.40	6.70	7.23	21.60	4.23	7.69	274.40	18.73
II	107.68	69.71	103.58	3.61	5.45	6.41	18.84	3.74	8.24	338.69	12.57
III	90.15	63.57	92.29	3.40	5.65	6.81	18.09	3.98	10.18	313.90	13.49
IV	105.45	71.29	106.81	3.53	5.66	7.22	18.06	4.06	7.04	414.05	15.25
V	115.34	77.22	108.22	4.07	6.59	8.00	20.55	3.95	6.17	260.67	14.79
VI	85.32	58.00	88.00	2.83	3.73	5.86	14.49	3.36	11.72	253.00	9.51
VII	121.00	76.33	114.00	2.90	6.13	8.08	25.97	4.17	13.66	331.00	16.50

Note: Bold figures indicate minimum and maximum values in each character.

Table 4.11. Eigen values, proportion of the total variance represented by first four Principal components, cumulative per cent variance and component loading of different characters in finger millet [*Eleusine coracana* (L.) Gaertn.]

	PCA₁	PCA₂	PCA₃	PCA₄
Eigen Value (Root)	5.135	1.768	1.500	0.920
% Var. Exp.	46.687	16.081	13.643	8.372
Cum. Var. Exp.	46.687	62.768	76.412	84.785
Plant height (cm)	0.306	0.220	0.306	0.031
Days to 50% flowering	0.374	0.138	0.201	0.195
Days to maturity	0.379	0.184	0.092	0.174
No. of productive tillers	0.411	0.098	-0.004	-0.031
Fingers per ear	0.318	-0.169	-0.289	-0.183
Finger length (cm)	0.095	-0.191	-0.642	-0.207
Ear weight per plant (gm)	0.393	0.021	-0.088	0.216
1000-seed weight (gm)	0.305	-0.005	-0.433	0.129
Seed protein content (%)	-0.193	-0.116	-0.208	0.864
Seed calcium content (mg/100g)	-0.084	0.689	-0.231	-0.160
Seed yield per plant (gm)	0.223	-0.576	0.259	-0.127

PC = Principal component

Table 4.12. PCA scores of 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes

S. No.	GENOTYPE	PCA I X Vector	PCA II Y Vector	PCA III Z Vector
1	GE- 2127	31.912	52.519	-40.047
2	GE- 3090	37.945	62.031	-35.374
3	GE- 2078	37.515	53.321	-32.826
4	GE- 3225	32.390	67.523	-35.623
5	GE- 4437	32.228	50.966	-37.623
6	GE- 995	25.730	37.085	-34.920
7	GE- 258	34.368	45.426	-28.017
8	GE-1274	36.190	62.761	-32.711
9	GPU- 66	41.939	56.811	-35.347
10	GE- 1746	42.933	51.147	-28.041
11	GE- 666	42.008	58.964	-32.778
12	GPU- 48	37.239	47.572	-31.164
13	GE- 3138	47.356	41.429	-27.479
14	VL- 149	37.886	46.653	-32.026
15	GE- 2941	43.518	46.619	-31.970
16	GE- 3434	38.251	48.343	-42.498
17	IE- 501	35.227	53.894	-32.047
18	GE- 3266	44.669	57.056	-26.707
19	IE- 3077	37.061	43.112	-33.191
20	GE- 145	51.261	52.756	-28.259
21	GE- 4976	50.647	71.317	-37.497
22	GE- 4707	44.974	65.282	-37.153
23	GE- 2723	56.788	45.006	-31.302
24	DHRS-1-1	34.252	42.353	-34.070
25	GE- 4736	48.283	54.072	-32.122
26	TNAU- 1214	34.848	45.340	-36.185
27	IE- 2323	30.864	40.307	-41.727
28	GE- 1382	58.320	41.334	-23.810
29	GPU-67	42.879	55.104	-30.150
30	Kalyani	49.064	42.565	-29.016
31	Srichaitanya	43.505	44.721	-28.830
32	IE- 2296	38.534	44.833	-31.434
33	INDAF- 9	49.917	47.302	-29.540
34	OEB- 532	34.518	47.354	-39.251
35	BR-10	47.429	53.081	-35.137
36	IE- 4795	41.788	59.620	-35.830
37	IE- 2652	51.345	59.139	-29.308
38	Ratnagiri	48.927	47.946	-25.594
39	GPU- 82	41.636	52.677	-31.635
40	Godavari	47.691	42.512	-25.796

Table 4.13. Clustering pattern of 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes by Ward's minimum variance method.

Cluster No	No. of genotypes	Name of genotypes
I	4	GE- 2127, GE- 4437, IE- 3077, DHRS -1-1
II	12	GE- 2078, IE- 501, GE- 258, GE- 1746, GPU- 82, GE- 4736, BR- 10, VL- 149, IE- 2296, GPU- 48, Srichaitanya, GE-2941
III	4	GE-666, IE- 4795, GPU-66, GE- 4707
IV	4	GE- 3090, GE-1274, GE- 3225, GE- 4976
V	7	GE- 3138, Kalyani, INDAF- 9, GE- 2723, Ratnagiri, Godavari, GE- 1382
VI	4	GE- 3266, GPU- 67, GE- 145, IE- 2652
VII	5	TNAU- 1214, OEB-532, IE- 2323, GE- 995, GE- 3434

Table 4.14. Average intra and inter-cluster Euclidean² values among seven clusters in 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes

Cluster No.	I	II	III	IV	V	VI	VII
I	490.25	1041.53	1264.05	3498.48	3214.63	3179.56	1608.58
II		79.77	975.00	2188.83	1390.29	1234.63	3543.23
III			283.12	1615.16	2837.67	1678.33	3318.13
IV				796.73	3477.12	1418.75	7648.89
V					566.85	1118.85	6825.01
VI						452.46	7242.93
VII							991.64

Note: Diagonal values are intra-cluster distances. Off-diagonal values are inter-cluster distances.

Table 4.15. Mean values of seven clusters estimated by Ward's minimum variance method from 40 finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes

Cluster No.	Plant height (cm)	Days to 50% flowering	Days to maturity	Productive tillers per plant	Fingers per ear	Finger length (cm)	Ear weight per plant (g)	1000-seed weight (g)	Seed protein content (%)	Seed calcium content (mg/100g)	Seed yield per plant (g)
I	92.296	62.500	91.000	3.508	5.642	6.080	16.212	3.933	9.540	319.417	11.876
II	105.375	67.750	102.167	3.606	5.411	6.417	18.436	3.797	8.224	319.667	12.951
III	117.083	76.333	110.083	3.500	5.642	6.646	19.375	3.966	9.017	394.417	14.017
IV	103.492	66.000	98.083	3.783	5.525	6.640	15.614	3.919	6.845	442.167	13.222
V	112.581	76.143	109.857	4.457	6.738	7.810	21.709	4.161	6.984	267.667	17.534
VI	107.225	76.667	111.667	3.275	5.842	7.122	21.068	3.757	6.737	353.833	14.680
VII	93.643	65.867	96.800	3.107	5.373	7.455	20.446	3.925	11.697	300.733	14.584

Note: Bold figures indicate minimum and maximum values in each character

Table 4.1. Mean performance of 40 genotypes in finger millet [*Eleusine coracana* (L.) Gaertn.] for 11 characters

S. No	Genotype	Plant height (cm)	Days to 50% flowering	Days to maturity	Productive tillers per plant	Fingers per ear	Finger length (cm)	Ear weight per plant (g)	1000-seed weight (g)	Seed protein content (%)	Seed calcium content (mg/100g)	Seed yield per plant (g)
1.	GE-2127	83.08	55.00	88.00	3.56	6.06	5.52	18.12	4.26	9.27	368.00	13.75
2.	GE-3090	106.16	60.33	91.00	4.00	6.13	5.90	15.33	3.95	6.66	423.00	14.96
3.	GE-2078	99.93	61.00	100.33	3.13	4.76	7.61	10.52	4.03	7.54	349.33	10.54
4.	GE-3225	95.70	60.00	97.00	2.56	4.03	6.32	13.67	3.51	7.54	457.33	8.56
5.	GE-4437	89.13	60.66	88.00	3.76	5.16	7.71	16.88	3.83	9.26	348.33	10.86
6.	GE-995	85.31	58.00	88.00	2.83	3.73	5.85	14.49	3.36	11.72	253.00	9.51
7.	GE-258	103.83	58.00	92.66	2.53	4.30	5.90	12.82	3.33	7.53	292.66	8.20
8.	GE-1274	101.46	68.66	91.00	3.16	4.76	4.89	11.09	3.70	6.84	409.66	7.30
9.	GPU-66	108.33	76.33	100.33	4.10	5.76	6.37	21.22	4.09	8.75	372.33	16.22
10.	GE-1746	122.03	74.66	109.33	3.46	5.03	5.62	15.09	3.45	8.23	318.00	8.92
11.	GE-666	138.20	73.66	109.33	3.23	5.43	6.32	17.55	3.58	8.76	381.00	8.68
12.	GPU-48	78.90	71.00	97.00	3.86	5.16	5.63	17.81	3.43	8.76	307.33	10.15
13.	GE-3138	107.86	73.66	109.33	4.13	6.43	7.40	17.33	3.85	7.80	257.33	17.26
14.	VL-149	105.30	61.33	91.00	4.26	5.53	6.46	20.69	3.72	8.05	307.66	13.38
15.	GE-2941	116.26	72.66	106.00	4.40	5.83	5.69	19.10	4.08	9.20	297.00	15.94
16.	GE-3434	121.00	76.33	114.00	2.90	6.13	8.07	25.97	4.16	13.65	331.00	16.50
17.	IE-501	94.80	54.00	94.00	3.03	4.96	5.99	24.89	3.43	7.34	362.00	10.53
18.	GE-3266	112.76	76.00	111.66	3.33	4.83	5.62	20.62	3.24	7.17	357.33	10.60
19.	IE-3077	102.60	67.33	94.00	3.80	6.06	5.41	14.62	3.80	9.46	282.33	11.07
20.	GE-145	102.16	77.33	117.33	2.90	6.00	8.48	24.45	4.20	6.48	328.66	19.70
21.	GE-4976	110.63	75.00	113.33	5.40	7.16	9.44	22.35	4.51	6.33	478.66	22.06
22.	GE-4707	106.10	79.66	120.66	3.46	5.23	7.56	20.58	4.32	9.26	428.00	17.01
23.	GE-2723	118.63	80.00	120.66	5.33	7.60	9.44	27.71	4.80	7.89	276.00	22.75
24.	DHRS-1-1	94.36	67.00	94.00	2.90	5.26	5.66	15.21	3.82	10.16	279.00	11.84
25.	GE-4736	120.70	70.66	120.66	4.20	6.46	5.90	22.25	4.19	8.43	348.66	16.75

Table 4.1 (cont.)

S.No.	Genotype	Plant height (cm)	Days to 50% flowering	Days to maturity	Productive tillers per plant	Fingers per ear	Finger length (cm)	Ear weight per plant (g)	1000-seed weight (g)	Seed protein content (%)	Seed calcium content (mg/100g)	Seed yield per plant (g)
26.	TNAU-1214	101.10	71.00	97.00	2.20	5.20	7.73	18.08	3.84	10.70	304.66	15.46
27.	IE-2323	80.03	55.00	88.00	3.20	6.20	7.96	26.38	4.26	11.37	291.33	17.34
28.	GE-1382	121.73	84.00	122.33	3.50	6.80	8.98	25.23	4.35	6.47	234.00	20.40
29.	GPU-67	98.03	75.33	100.33	3.66	6.23	6.48	20.29	3.37	7.16	356.33	11.28
30.	Kalyani	105.86	72.00	106.00	4.90	6.76	6.16	23.73	4.32	7.52	264.66	20.34
31.	Srichaitanya	114.60	74.66	100.33	3.00	6.10	5.51	17.67	3.85	8.04	280.33	15.27
32.	IE-2296	94.16	64.33	98.66	3.16	5.30	5.49	16.18	4.06	8.43	288.00	12.90
33.	Indaf-9	109.66	75.66	108.33	4.63	6.60	7.64	21.53	4.29	7.16	293.66	18.01
34.	OEB-532	80.76	69.00	97.00	4.40	5.60	7.63	17.30	4.00	11.03	323.66	14.09
35.	BR-10	108.36	74.66	110.00	4.96	6.73	8.47	25.07	4.30	8.56	348.00	19.53
36.	IE-4795	115.70	75.66	110.00	3.20	6.13	6.32	18.14	3.86	9.28	396.33	14.15
37.	IE-2652	115.93	78.00	117.33	3.20	6.30	7.88	18.90	4.20	6.12	373.00	17.13
38.	Ratnagiri	111.86	74.33	102.00	4.70	6.23	7.14	18.69	3.81	5.70	286.00	8.61
39.	GPU-82	105.60	76.00	106.00	3.23	4.73	8.68	19.11	3.66	8.53	337.00	13.27
40.	Godavari	112.43	73.33	100.33	4.00	6.73	7.89	17.72	3.68	6.33	262.00	15.34
	Mean	105.02	70.03	103.05	3.65	5.73	6.87	19.11	3.91	8.36	331.31	14.15
	CV(%)	5.83	1.99	1.09	11.54	3.49	12.30	9.18	2.24	0.79	1.07	18.21
	CD at 5%	9.95	2.27	1.82	0.68	0.32	1.37	2.85	0.14	0.10	5.76	4.19

Annexure : Monthly meteorological data during the crop growth period 2013-14.

Month	Temperature (⁰C)		Relative Humidity (%)	Rain fall (mm)	No. of rainy days
	Max.	Min.			
August 2013	35.00	25.20	73.71	24.60	2
September 2013	33.00	24.73	81.92	89.44	3
October 2013	31.72	24.35	87.12	97.25	3
November 2013	30.60	21.15	83.48	0	0
December 2013	29.98	17.82	78.54	0	0

Source: Agricultural College Farm, Bapatla.