

**STUDIES ON GENETIC VARIABILITY, ASSOCIATION AND DIVERSITY IN
FINGER MILLET (*Eleusine coracana* (L.) Gaertn.) FOR YIELD,
YIELD ATTRIBUTES AND SALINITY TOLERANCE**

*Thesis submitted in part fulfillment of the requirements for the
Degree of Master of Science (Agriculture) in Plant Breeding and Genetics to the
Tamil Nadu Agricultural University, Coimbatore.*

By

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COIMBATORE – 641 003**

2001

CERTIFICATE

This is to certify that the thesis entitled **STUDIES ON GENETIC VARIABILITY, ASSOCIATION AND DIVERSITY IN FINGER MILLET (*Eleusine coracana* (L.) Gaertn.) FOR YIELD, YIELD ATTRIBUTES AND SALINITY TOLERANCE** submitted in part fulfillment of the requirement for the award of the degree of Master of Science (Agriculture) in Plant Breeding and Genetics to the Tamil Nadu Agricultural University, Coimbatore, is a record of bonafide research work carried out by **Mr. P. ANANTHARAJU** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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P. ANANTHARAJU

ABSTRACT

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STUDIES ON GENETIC VARIABILITY, ASSOCIATION AND DIVERSITY IN FINGER MILLET (*Eleusine coracana* (L.) Gaertn.) FOR YIELD, YIELD ATTRIBUTES AND SALINITY TOLERANCE

BY

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An investigation was carried out in finger millet (*Eleusine coracana* (L.) Gaertn.) to estimate the variability, correlation, direct and indirect effect and genetic diversity of yield, yield components and salinity tolerance in fifty genotypes. Studies were carried out on days to fifty per cent flowering, plant height, culm thickness, number of productive tillers, number of leaves, peduncle length, number of fingers, finger length, thousand grain weight and grain yield during kharif 2000 in a randomized block design at Millet Breeding Station, Coimbatore. A wide range of variability existed for all the traits studied indicating the presence of significant variation among the genotypes. The genotypes MS 3221, MS 3015, GE 1824, CO 11 and AF 268 were the best with regard to grain yield.

The top three ranking genotypes for grain yield viz., MS 3221, MS 3015 and GE 1824 also had higher number of productive tillers and they were among the five top ranking genotypes for number of productive tillers. High GCV estimates were recorded for the characters number of productive tillers, finger length and grain yield. The traits plant height, number of leaves, number of fingers and thousand grain weight had moderate GCV values. All the ten characters studied had high heritability indicating the high influence of genetic components.

All the characters except culm thickness and peduncle length had high heritability coupled with high genetic advance (per cent) indicating the governance of these eight characters by additive genes and thus these characters could be improved through selection in earlier generations. Culm thickness and number of productive tillers were significantly and positively correlated with grain yield. These two characters also showed high heritability and moderate and high genetic advance (per cent) respectively indicating that the selection for these two characters can be relied upon for increasing yield.

Number of productive tillers had high positive direct effect and culm thickness and number of leaves had moderate direct effect on grain yield indicating the true relationship of these traits with grain yield and direct selection, for these traits could be practised to reduce the undesirable effect of other component traits studied. Regarding the indirect effect of component traits on grain yield, finger length had high indirect effect on grain yield through number of leaves and days to 50 per cent flowering. The indirect effect of all the other traits were either low or negligible.

The fifty genotypes studied resolved into fourteen clusters through Mahalanobis D^2 analysis and the largest cluster (Cluster I) consisted of seventeen genotypes. Cluster XIV consisting of the sole genotype MS 3221 had the highest mean value for number of productive tillers and grain yield.

Salinity tolerance studies at germination stage revealed significant differences among the genotypes for salinity tolerance at different levels for the seedling characters viz., germination percentage, seedling root length, seedling shoot length, mean seedling length and seedling vigour index. At the highest level of salinity stress viz., 16 dSm⁻¹, TRY 1 showed the maximum percentage of germination followed by PY1. At 12 dSm⁻¹ also they performed well for germination. However, some of the genotypes which showed tolerance at 12 dSm⁻¹ became susceptible at 16 dSm⁻¹.

The seedling vigour index in terms of germination percentage and mean seedling length showed a gradual decrease under increasing salinity as observed for other seedling characters. The maximum seedling vigour was observed in TRY 1 and CO 12 at 16 dSm⁻¹ as well as at 12 dSm⁻¹. The seedling vigour of two genotypes PY1 and MS870 was much reduced at 16 dSm⁻¹ compared to that of 12 dSm⁻¹. Regarding the grain yield of tolerant genotypes at normal soil, TRY1 ranked 7th while, CO 12 ranked more than ten indicating its moderate yield level.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Finger millet (*Eleusine coracana* (L.) Gaertn.) is the most important small millet in Africa and South Asia. In India, it is widely grown in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, South Bihar, Maharashtra, Uttar Pradesh, Gujarat and Madhya Pradesh. The Karnataka state has the largest area of cultivation of around one million hectares (50 per cent of total area) with a productivity of 1.5 tonnes per hectare. In India it is cultivated with an annual acreage of 2 million hectares and production of 2.6 million tonnes, and productivity 1300 kg per hectare during the year 1999-2000 (Rai, 2000). In Tamil Nadu it is cultivated in an area of 1.23 lakhs hectares with a production of 2.46 lakhs tonnes and productivity of 2004 kg per hectare during the year 1999-2000 (Anon, 2000).

This crop being the major source of grain and fodder, in the area of their production is indispensable to tribal and hill agriculture. It has a high nutritive value in both grain and fodder. The content of important nutrients of finger millet per 100 g are protein (g) 7.3, carbohydrates (g) 72.0, fat (g) 1.3, crude fibre (g) 3.6, mineral matter 2.7, calcium (mg) 344.0, phosphorus (mg) 283.0 (Rai and Mauria, 1999).

In widest context, the stress environment is one of the major factors responsible for the current global environmental problems. Even at the early stages of modern agriculture the importance of the environment in affecting crop distribution and adaptation was recognized. In India the problem soils occupy 10 m ha, which include saline soils of 7.2 m.ha and alkali soils of 2.8 m.ha. The problem soils are the highest in Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh and followed by Orissa, Andhra Pradesh, Tamil Nadu and Karnataka (Biswas and Mukherjee, 1997). In Tamil Nadu salt affected soils are wide spread in almost all the districts and nearly 3 lakh hectares of land are affected by the soil salinization and sodicity. In Tamil Nadu area affected by alkalinity is 2 lakhs hectares

and salinity is 1 lakh hectare. The districts where the problem soils are more prevalent are Chengalpattu, Salem, Tanjore, Trichy, North arcot, Thirunelveli, Dharmapuri and Ramanathapuram (Vadivel *et al.*, 2001).

For the utilization of saline lands, it is essential to manage the salinity or to grow crops and their varieties resistant to salinity. Reclamation of saline soils is a time taking and costly affair. It is hence, urgently needed to identify crops and their genotypes which can resist salinity.

The salinity is one of the most widespread stress hazards and occurs mostly in arid and semi arid regions (Abrol, 1986), though it also exists in some sub humid areas and coastal lands. Finger millet (*Eleusine coracana* (L.) Gaertn.) is a small grained tropical cereal of diverse ecological adaptation, with many cultivars grown in semi arid areas and has attracted research interest regarding its resistance to salt stress. Thus, some Indian cultivars of finger millet have been a subject of salt stress studies on germination, growth and grain yield (Onkware, 1993). Considering the importance of finger millet as food and fodder crop and its general capacity to withstand salinity, the present investigation was carried out involving a collection of fifty genotypes with the following objectives.

1. To assess the extent of variability in selected genotypes of finger millet for yield and yield attributes.
2. To know the magnitude of heritability and genetic advance of the above mentioned characters.
3. To estimate the direct and indirect effects of various component traits on yield by path co-efficient analysis.
4. To estimate the diversity existing among the genotypes based on the characters studied.
5. To estimate the level of salinity resistance existing among the genotypes for germination and early growth.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Finger millet, *Eleusine coracana* (L.) Gaertn. ($2n=4x=36$) is one of the important small millet crops which is very well adapted to marginal lands, hilly regions and shallow soils. The genetic variability within finger millet is very high. Many effective tools are available in the field of crop breeding and crop breeders round the world have extensively used such methods to study the genotypes, evaluate them and use them in order to achieve their objectives. Important findings relevant to the present study are briefly reviewed under the following topics.

1. Studies on genetic variability
2. Studies on heritability and genetic advance
3. Correlation studies
4. Path analysis
5. Studies on genetic divergence
6. Salinity tolerance studies

2.1. Studies on genetic variability

Assessment of variability is a pre-requisite for a plant breeder to select desirable genotypes based on their phenotypes. Phenotypic variability is the observable variation present in a character in a population. Genotypic variation is due to the genotypic differences among the individuals within a population and is the main concern of plant breeder.

The phenotypic and genotypic co-efficient of variation (PCV and GCV) obtained by different workers in finger millet are reviewed in Table 1.

Table 1. Genetic variability (PCV and GCV) for different characters in finger millet

Characters	Phenotypic co-efficient of variation	Genotypic co-efficient of variation	References
Tillers per plant and number of ears per plant	High	High	Ahluwalia <i>et al.</i> (1970)
Thousand grain weight, length of main ear and tiller number	High	High	Dhagat <i>et al.</i> (1972)
Days to maturity and grain yield	High	High	Patnaik and Jana (1973)
Grain yield, straw yield and number of productive tillers per plant	High	High	Mahudeswaran and Murugesan (1973)
Tiller number, ear weight and grain yield	High	High	Goud and Lakshmi (1977)
Plant height, days to flowering, finger number, ear weight and grain yield	High	High	Mallanna <i>et al.</i> (1978)
Plant height, productive tillers ear weight and harvest index	High	Moderate	Shantappa (1980)
Productive tillers and grain yield	High	High	Shanthappa (1980)
Days to heading, plant height, number of finger per ear and finger length	High	Moderate	Mishra <i>et al.</i> (1980a)
Days to maturity	Moderate	Low	Mishra <i>et al.</i> (1980a)
Grain yield and number of productive tillers	High	-	Prabhakar and Prasad (1983)
Grain yield and finger length	-	High	Goswami and Asthana (1984)

(Contd...)

Table 1. (Contd...)

Characters	Phenotypic co-efficient of variation	Genotypic co-efficient of variation	References
Productive tillers per plant, grain yield, number of fingers per ear and thousand grain weight	High	High	Abraham <i>et al.</i> (1989)
Grain yield	High	Moderate	Joshi and Mehra (1989)
Number of finger on main ear and finger length	Moderate	Moderate	Joshi and Mehra (1989)
Days to heading and plant height	Low	Low	Joshi and Mehra (1989)
Days to maturity, finger number and grain yield	High	-	Harinarayana <i>et al.</i> (1989)
Days to fifty per cent flowering plant height, finger number productive tillers, thousand grain weight and grain yield	High	High	Tyagi and Koranne (1989)
Grain yield and number of ear per plant	High	-	Verma (1989)
Productive tillers per plant	-	Moderate	Verma (1989)
Plant height, length of finger and number of finger	-	Low	Verma (1989)
Grain yield	Low	Low	Rao (1991)
Grain yield per plant	-	High	Gontia <i>et al.</i> (1992)
Spikelet density, glume length, grain density and thousand grain weight (African accessions)	High	High	Naik <i>et al.</i> (1993)
Ear weight, stem weight, stover weight total leaf dry weight and biomass per plant (Indian accessions)	High	High	Naik <i>et al.</i> (1993)
Days to fifty per cent flowering	High	High	Reddy <i>et al.</i> (1993)
Plant height and fodder yield	High	High	Dhanakodi (1994)

(Contd....)

Table 1. (Contd...)

Characters	Phenotypic co-efficient of variation	Genotypic co-efficient of variation	References
Plant height, productive tillers and days to fifty per cent flowering	-	High	Ravikumar and Seetharam (1994)
Days to fifty per cent flowering and green fodder yield	High	High	Ramasamy <i>et al.</i> (1994)
Number of leaf per plant	Low	Low	Ramasamy <i>et al.</i> (1994)
Grain yield	High	High	Thakur and Sanini (1995)
Grain yield per plant, finger per ear, thousand grain weight, finger length, tillers per plant, harvest index and biological yield per plant	Low	High	Chunilal <i>et al.</i> (1996)
Plant height, grain density and harvest index	High	High	Ravishankar <i>et al.</i> (1997)
Days to fifty per cent flowering, ear length and number of tillers	Low	Low	Ravi Shankar <i>et al.</i> (1997)
Number of productive tillers and number of finger per ear	High	High	Bandyopadhyay (1998a)
Grain yield per plant	-	High	Bandyopadhyay (1998a)
Plant height and days to maturity	High	-	Bandyopadhyay (1998a)
Days to flowering and grain yield per plant	High	High	Mahto <i>et al.</i> (2000)

2.2. Studies on heritability and genetic advance

Crop improvement depends on the magnitude of genetic variability and extent to which the desirable characters are heritable. An effective breeding programme could be planned on the basis of this information. The genetic variation of quantitative characters is influenced by environmental effects. The partitioning of the overall variances (phenotypic variability) into heritable (genotypic) and non-heritable (environmental variations) is necessary for any plant breeding programme.

Studies on heritability and genetic advance of different characters on finger millet carried out by different authors are listed in Table 2.

Table 2. Heritability and genetic advance for different characters in finger millet

Characters	Heritability (Broad sense)	Genetic advance (as percentage of mean)	References
Flowering	High	Moderate	Rao <i>et al.</i> (1971)
Plant height, number of tillers and days to fifty per cent flowering	High	Moderate	Dhagat <i>et al.</i> (1972)
Grain yield and thousand grain weight	Low	Low	Dhagat <i>et al.</i> (1972)
Plant height and thousand grain weight	High	High	Mahudeswaran and Murugesan (1973)
Yield	High	High	Setty <i>et al.</i> (1974)
Plant height, tiller number and number of fingers	Moderate	Moderate	Setty <i>et al.</i> (1974)
Plant height, days to fifty per cent flowering and grain yield	High	Moderate	Kempanna (1975)
Grain yield and days to fifty per cent flowering	High	Moderate	Chaudhari <i>et al.</i> (1977)
Plant height and number of fingers	High	High	Goud and Lakshmi (1977)
Tiller number	Moderate	High	Goud and Lakshmi (1977)
Grain yield and number of tillers	Moderate	High	Swamynath (1979)
Plant height and grain weight	High	High	Shanthappa (1980)

(Contd....)

Table 2. (Contd...)

Characters	Heritability (Broad sense)	Genetic advance (as percentage of mean)	References
Number of finger per ear, days to maturity, yield and number of productive tillers	High	High	Mishra <i>et al.</i> (1980a)
Days to flowering	High	Moderate	Goswami and Asthana (1984)
Days to fifty per cent flowering, finger length and finger per ear	High	Moderate	Sheriff <i>et al.</i> (1986)
Tillers number per plant	Moderate	Moderate	Sheriff <i>et al.</i> (1986)
Plant height	Low	Low	Sheriff <i>et al.</i> (1986)
Grain yield, days to fifty per cent flowering and plant height	High	Moderate	Ravikumar (1988)
Productive tillers	Low	Low	Ravikumar (1988)
Plant height, days to fifty per cent flowering and grain yield	High	-	Ravikumar (1988)
Productive tillers per plant	Low	-	Ravikumar (1988)
Plant height and days to fifty per cent flowering	High	Moderate	Suresh (1988)
Number of finger, productive tillers and finger length	Moderate	-	Suresh (1988)
Thousand grain weight	Low	-	Suresh (1988)
Days to maturity, days to fifty per cent flowering, number of finger per ear and thousand grain weight	High	Moderate	Abraham <i>et al.</i> (1989)
Grain yield	High	High	Abraham <i>et al.</i> (1989)

(Contd...)

Table 2. (Contd...)

Characters	Heritability (Broad sense)	Genetic advance (as percentage of mean)	References
Productive tiller per plant and finger length	Moderate	Low	Abraham <i>et al.</i> (1989)
Finger length, number of finger and days to heading	Moderate	Moderate	Joshi and Mehra (1989)
Plant height	Moderate	Low	Joshi and Mehra (1989)
Days to fifty per cent flowering and grain yield	High	High	Joshi and Mehra (1989)
Plant height, number of productive tillers, finger per ear, thousand grain weight and grain yield per plant	High	Moderate	Tyagi and Koranne (1989)
Grain yield per plant and number of ear per plant	High	High	Verma <i>et al.</i> (1989)
Plant height days to fifty per cent flowering	High	Moderate	Jayaprakash Naik (1991)
Tillers number	Moderate	Moderate	Jayaprakash Naik (1991)
Plant height	High	Moderate	Cauvery (1993)
Days to fifty per cent flowering	High	Low	Cauvery (1993)
Grain yield and number of productive tillers	Moderate	High	Cauvery (1993)
Days to fifty per cent flowering and plant height	High	Moderate	Marimuthu (1993)
Number of productive tillers	Moderate	High	Marimuthu (1993)
Days to fifty per cent flowering	High	Low	Ramasamy <i>et al.</i> (1994)

(Contd....)

Table 2. (Contd...)

Characters	Heritability (Broad sense)	Genetic advance (as percentage of mean)	References
Green fodder yield, number of leaves	High	High	Ramasamy <i>et al.</i> (1994)
Plant height, days to fifty per cent flowering ears per tillers, finger length, straw yield and grain yield	High	High	Suryakumar (1995)
Grain yield	High	High	Thakur and Saini (1995)
Plant height, days to fifty per cent flowering and ear length	High	-	Ravishankar (1997)
Number of tillers	Low	-	Ravishankar (1997)
Grain yield per plant and thousand grain weight	Moderate	-	Ravishankar (1997)
Grain yield. Harvest index, total dry matter, ear length and finger length		High	Ravishankar (1997)
Number of finger, days to fifty per cent flowering, plant height and number of tillers	-	Low	Ravishankar (1997)
Plant height, days to fifty per cent flowering and number of fingers	-	Low	Ravishankar (1997)
Grain yield per plant	High	High	Bandyopadhyay (1998a)
Number of productive tillers and number of finger per ear	Moderate	-	Bandyopadhyay (1998a)
Plant height and fodder yield	Low	-	Bandyopadhyay (1998a)

2.3. Correlation studies

A grain is a complex quantitative character. A knowledge of the association between yield and interrelationship among yield components will enable the breeder for simultaneous improvement of these traits. The breeder is always concerned with the selection of superior genotypes, which is dependent on phenotypic expression. Often, selection based on phenotypic expression of a particular character does not lead to expected genetic advance mainly due to the presence of genotype x environment interactions as well as due to undesirable negative associations between the component characters at genotypic level. Thus, a knowledge of the correlation between complex character like seed yield and its component characters could obviously be of considerable use for a rational approach to the improvement of yield (Lodhi *et al.*, 1979).

The correlation coefficients may help to identify characters that have little or no importance in the selection programme. Negative genotypic correlation between characters selected for in a breeding programme may result in a reduction in the rate of improvement for some of the characters in comparison to the improvement that could be attained if the correlations were positive or non-existent. So also, correlation between important and non important characters may reveal that some of the latter are useful as indicators of one or more of the former (Johnson *et al.*, 1955).

Genetic correlation between quantitative characters are one of the major determinants of the rate and direction of evolution of the average phenotype in a population in response to multivariate pattern of natural selection. The existence of correlation may be attributed to the presence of linkage or pleiotropic effects of genes or physiological and developmental relationship or environmental effect or in combination of all. The studies on the character association in finger millet are summarised in Table 3.

Table 3. Correlation studies in finger millet

Component characters	Dependent characters	Significant positive / negative relationship	References
Plant height and ear weight	Grain yield	Positive	Dhagat <i>et al.</i> (1972)
Length of main ear and days to maturity	Ear weight	Positive	Dhagat <i>et al.</i> (1972)
Number of productive tillers	Grain yield	Positive	Dhagat <i>et al.</i> (1972)
Number of fingers and hundred grain weight	Grain yield, number of productive tillers	Negative	Mahudeswaran and Murugesan (1973)
Number of productive tillers	Grain yield	Positive	Michael Raj <i>et al.</i> (1973)
Grain weight of main ear, seed number per ear and threshing percentage	Grain yield	Positive	M'shonga (1974)
Productive tillers	Grain yield	Positive	Appadurai <i>et al.</i> (1977)
Number of leaves on main culm	Number of fingers	Positive	Appadurai <i>et al.</i> (1977)
Number of seeds per ear	Grain weight of main ear	Positive	Appadurai <i>et al.</i> (1977)
Plant height	Number of tillers	Negative	Goud and Lakshmi (1977)
Number of fingers per ear, productive tillers and thousand grain weight	Grain yield	Positive	Subramaniam <i>et al.</i> (1977)
Number of finger per ear and grain weight of main ear	Grain yield	Positive	Agalodia <i>et al.</i> (1979)

(Contd...)

Table 3. (Contd...)

Component characters	Dependent characters	Significant positive / negative relationship	References
Finger length	Grain yield	Positive	Agalodia <i>et al.</i> (1979)
Synchrony in flowering	Finger per ear	Positive	Mishra <i>et al.</i> (1980b)
Productive tiller number and grain weight of main ear	Grain yield	Positive	Prabhakar and Prasad (1983)
Plant height, tiller per plant, main ear weight and thousand grain weight	Grain yield	Positive	Sarvaiya <i>et al.</i> (1983)
Tiller per plant	Days to flowering	Negative	Sarvaiya <i>et al.</i> (1983)
Days to flowering	Thousand grain weight	Positive	Sarvaiya <i>et al.</i> (1983)
Drymatter production	Grain yield	Positive	Sundram <i>et al.</i> (1985)
Plant height, days to flowering, leaf number and tiller number	Straw yield	Positive	Dhanakodi (1988)
Plant height, productive tillers and finger per ear	Grain yield	Positive	Ravikumar (1988)
Days to fifty per cent flowering	Grain yield	Negative	Ravikumar (1988)
Plant height, productive tillers and number of fingers	Earhead weight	Positive	Suresh (1988)
Days to fifty per cent flowering, days to maturity, productive tillers per plant and thousand grain weight	Grain yield	Positive	Abraham <i>et al.</i> (1989)

(Contd....)

Table 3. (Contd...)

Component characters	Dependent characters	Significant positive / negative relationship	References
Effective tillers per plant	Finger per ear	Negative	Abraham <i>et al.</i> (1989)
Plant height and days to fifty per cent flowering	Fodder yield	Positive	Dhanakodi and Chandrasekaran (1989)
Plant height based tiller, Number of finger and finger length	Grain yield	Positive	Harinarayana <i>et al.</i> (1989)
Finger number and days to maturity	Plant height	Negative	Harinarayana <i>et al.</i> (1989)
Plant height, productive tillers per plant and ear weight	Grain yield	Positive	Basavraraja and Sheriff (1991)
Ear weight, finger length and thousand grain weight	Grain yield	Positive	Jayaprakash Naik (1991)
Harvest index	Grain yield	Negative	Gontia <i>et al.</i> (1992)
Number of productive tillers and finger length	Grain yield	Positive	Marimuthu (1993)
Plant height, days to fifty per cent flowering, number of productive tillers, finger length and hundred grain weight	Grain yield	Positive	Marimuthu (1993)
Productive tillers	Ear weight per plant	Positive	Marimuthu (1993)
Productive tiller number	Grain yield	Positive	Cauvery (1993)
Productive tillers, days to fifty per cent flowering and number of fingers	Thousand grain weight	Positive	Tamilcovane (1994)
Productive tillers, finger length and thousand grain weight	Green yield	Positive	Tamilcovane (1994)

(Contd...)

Table 3. (Contd...)

Component characters	Dependent characters	Significant positive / negative relationship	References
Days to fifty flowering, plant height, number of tillers per plant, number of leaves per plant and leaf weight per plant	Green yield	Positive	Ramasamy <i>et al.</i> (1994)
Days to germination, heading and maturity	Seed yield	Negative	Thakur and Saini (1995)
Ears per plant	Seed yield	Positive	Thakur and Saini (1995)
Productive tillers	Grain yield	Positive	Suryakumar (1995)
Productive tillers	Straw yield	Positive	Suryakumar (1995)
Tillers per plant and ear per plant	Grain yield	Positive	Gyanendra Singh <i>et al.</i> (1995)
Plant height, days to fifty per cent flowering, days to maturity, seed yield per plant and leaves per plant	Harvest index	Positive	Haider and Mahto (1995a)
Plant height, grain per ear and grain yield per plant	Grain yield	Positive	Chunilal <i>et al.</i> (1996)
Days to flowering	Grain yield	Negative	Chunilal <i>et al.</i> (1996)
Biological yield and harvest index maturity duration	Grain yield	Positive	Chunilal <i>et al.</i> (1996)
Plant height, days to fifty per cent flowering, days to maturity and number of tillers per plant	Grain yield	Positive	Mahto <i>et al.</i> (1996)
Number of productive tillers per plant and number of finger per ear	Grain yield	Positive	Ravindran <i>et al.</i> (1996)

(Contd...)

Table 3. (Contd...)

Component characters	Dependent characters	Significant positive / negative relationship	References
Plant height	Grain yield	Negative	Ravindran <i>et al.</i> (1996)
Days to maturity, tillers per plant, finger length and thousand grain weight	Grain yield	Positive	Misra (1997)
Plant height, number of tillers, ear length, finger length and yield	Grain yield	Positive	Ravishankar <i>et al</i> (1997)
Days to maturity	Grain yield	Negative	Bandyopadhyay (1998b)
Number of productive tillers and number of finger per ear	Grain yield	Positive	Bandyopadhyay (1998b)

2.4. Path analysis

The concept of path co-efficient was originally developed by Wright (1921), but the technique was first used for plant selection by Dewey and Lu (1959). The complex character of yield is associated with a number of component characters which are interrelated among themselves. Such interdependence of the contributory factors often affects their direct relationship with yield, thereby making correlation coefficients unreliable as selection indices. Path coefficient analysis permits the separation of direct effects from the indirect effects through other related characters by partitioning the correlation coefficients. Direct effects are independent of the interrelationships among the variables independent and dependent variables (eg. grain yield). Indirect effects influence the dependent variable through another independent variable. The path analysis has been used by several workers in finger millet and the studies are summarised in Table 4.

Table 4. Path - Coefficient analysis in finger millet on grain yield

Characters	Direct effect	Indirect effect	References
Grain weight, number of fingers, days to maturity and thousand grain weight	Positive and high	-	Dhagat <i>et al.</i> (1972)
Ear bearing tillers	Positive and high	-	Michael Raj <i>et al.</i> (1973)
Plant height and tiller number	Positive and high	-	Mahudeswaran and Murugesan (1973)
Plant height	Negative and high	Positively through tiller number	Appadurai <i>et al.</i> (1977)
Ear bearing tillers	Positive and high	-	Appadurai <i>et al.</i> (1977)
Number of fingers per ear	Positive and high	-	Subramaniam <i>et al.</i> (1977)
Plant height	Negative	Positively through fingers per ear	Subramaniam <i>et al.</i> (1977)
Grain weight of main ear	Positive and high	-	Agalodia <i>et al.</i> (1979)
Ear weight per plant and harvest index	Positive and high	-	Shanthappa (1980)
Productive tillers and thousand grain weight	Positive and high	-	Prabhakar and Prasad (1983)
Total and productive tillers	Positive and high	-	Ravikumar (1988)
Productive tillers	Positive and high	-	Suresh (1988)
Ear weight per plant	Positive and high	-	Shanthakumar (1988)
Productive tillers and grain weight of main ear	Positive and high	-	Chaudhary (1989)

(Contd...)

Table 4. (Contd...)

Characters	Direct effect	Indirect effect	References
Ear weight per plant	Positive	-	Basavaraja and Sheriff (1991)
Floret number, productive tillers and ear weight	Positive	-	Jayaprakash Naik (1991)
Finger width and grain density	Negative	Positively through ear weight	Jayaprakash Naik (1991)
Plant height and number of productive tillers	Positive and high	-	Cauvery (1993)
Productive tillers, finger length and ear weight	Positive	-	Marimuthu (1993)
Finger per ear	Negative	Positively through ear weight	Marimuthu (1993)
Productive tillers, finger length and thousand grain weight	Positive	-	Tamilcovane (1994)
Plant height	Negative	-	Tamilcovane (1994)
Plant height, days to fifty per cent flowering, days to maturity, leaves per plant and seed yield per plant	Positive	-	Haider <i>et al.</i> (1995b)
Tillers per plant	Positive and high	-	Thakur and Saini (1995)
Days to maturity, biological yield, harvest index and grain yield	Positive	-	Chunilal <i>et al.</i> (1996)
Number of productive tillers per plant and finger per ear	Positive and high	-	Ravindran <i>et al.</i> (1996)
Plant height	-	Negative	Ravindran <i>et al.</i> (1996)

2.5. Genetic diversity through mahalanobis D^2 analysis

Mahalanobis D^2 statistic (Mahalanobis, 1936) was found to be a potent biometrical tool in quantifying the degree of divergence between biological populations and to assess the relative contribution of different components to the total divergence both at intra and inter cluster level. Genetic diversity arises either due to geographical separation or due to genetic barriers to crossability. The studies on genetic divergence through mahalanobis D^2 analysis carried out in finger millet are listed in table 5.

Table 5. Genetic diversity studies in finger millet

Number of genotypes studied	Number of characters studied	Number of clusters observed	Maximum contributing traits to total divergence	References
50	6	6	Number of tillers	Suyambulingam and Jebarani (1977)
64	18	12	-	Hussaini <i>et al.</i> (1977)
60	11	20	Straw yield and days to fifty per cent flowering	Xavier (1979)
175	15	21	-	Swamynath (1979)
30	12	13	-	Jain <i>et al.</i> (1981)
150	-	2	-	Shigeta (1985)
120	6	10	-	Patel (1989)
100	13	18	-	Singh and Singh (1991)
20	9	4 (rainfed) 11 (irrigated)	Days to fifty per cent flowering, plant height, ear length, ear weight and grain weight	Sheriff (1992)
50	11	12	Days to fifty per cent flowering	Reddy <i>et al.</i> (1993)

(Contd....)

Table 5. (Contd...)

Number of genotypes studied	Number of characters studied	Number of clusters observed	Maximum contributing traits to total divergence	References
46	8	5	Number of days to maturity, followed by ear length, number of finger per ear and harvest index	Jaylal and Haider (1994)
48	1	6	Grain yield	Ramasamy <i>et al.</i> (1996)
36	7	7	-	Kailash Kumar <i>et al.</i> (1997)
50	11	14	Seed yield	Gupta and Srivastava (1997)
99	7	10	-	Suryakumar <i>et al.</i> (1997)
57	6	7	Days to maturity, seed yield per plant and productive tillers per plant	Hanumanaram <i>et al.</i> (1997)
48	6 environments	10	-	Ramasamy <i>et al.</i> (1997)
36	2	8	-	Vadivoo <i>et al.</i> (1998)

2.6. Salinity tolerance studies

Salinisation is a process of accumulation of soluble salts in the surface soils in the vicinity of roots. Salinity stress has simply been defined as the presence of excessive concentration of soluble salts which suppresses plant growth (Man and Nieman 1978). Excessive salt concentration in soil solution decrease the water potential of soil water and thus reduces water availability to the plants affecting vital metabolic processes like photosynthesis (Downton, 1977), under such situation, though water is present in the soil,

plant often show wilting and this situation is called as physiological drought. High amount of NaCl in growth media can lead to deficiencies of essential nutrients like phosphate or nitrate (Munns and Termaat, 1986).

One requirement for breeding for salt tolerance is that genetic variation exists for the character in the gene pool. Such variation may be between individual varieties or even species that have some degree of sexual compatibility so that genes may be transferred from one individual to another (Shannon, 1997). Seed germination is the most critical and sensitive stage to salinity stress. Poor germination in saline soils leads to poor crop and hence low productivity. Increased salinity levels have been found to reduce germination in wheat, barely, triticale and pearl millet genotypes (Sharma, 1993; Ayman, 1995 and Ram, 1996).

Hayward and Bernstein (1958) reported that seedling stage of rice is most sensitive stage to salinity. Pearson *et al.* (1966) found seedling height was reduced significantly by salinity. Kaliappan *et al.* (1967) observed reduced germination in finger millet due to salinity.

Kaliappan and Rajagopal (1968) assessed the effect of salinity on the duration and grain setting in finger millet with five treatments *viz.*, rain water (control), 2000, 4000, 6000 and 8000 ppm of chlorides of sodium and calcium. Three varieties of finger millet *viz.* CO 7, CO 8 and ECW 840 were tried. Variety ECW 840 was much affected by salinity and CO 7 was least affected. The grain setting was progressively decreased due to increased salinity levels. All the three varieties were influenced by salinity, and resulted in the reduction of grain setting.

Steward and Lee (1974) suggested that the capacity of plant species to accumulate proline is correlated with their salt tolerance and proline acts as an intercellular osmoticum. It has also been speculated that proline might serve as N source,

for growth and survival under saline conditions, and thereby inducing salinity resistance to rice cultivars. Bal (1974) stated that proline, which accumulated under osmotic stress condition supplies energy for growth and survival under saline conditions and thereby induces salt resistance in rice varieties.

Jennings (1976) reported increased succulence in response to salinity in monocotyledonous plants. Mathan and Rao (1982) in pot trials with *E. coracana* grown in two acidic, Mg-deficient soil types, Mg uptake was increased with lime in the absence of applied Mg, but was decreased in its presence.

Influence of saline water irrigation (1 to 16 mmhos/c.m) on germination, and yield of finger millet crop was studied for three rabi seasons on light soils by Sarma *et al.* (1983). When saline water of 4 mmhos / cm was used, 25 per cent increase in seed rate was found to be necessary to compensate the loss in population. Increasing salinity of water decreased germination, infiltration rate and yield of finger millet. Infiltration rate decreased from 6.0 cm/hr to 3.0 cm/hr as the EC of irrigation water increased from 1 to 16 mmhos/cm. Reduction in yield of finger millet did not exceed 52 per cent when irrigated with saline water of EC 8 mmhos/cm. They suggested that finger millet crop could be grown satisfactorily using saline water having EC upto 4 mmhos/cm on light soils of coastal regions. EC of the soil increased from 0.85 to 3.40 mmhos/cm as EC of irrigation water increased from 1 to 16 mmhos/cm.

Stark (1985) reported that early growth in rice was not related to salt tolerance as measured by grain yield, but the shoot and root ratio (low in resistant varieties) and the dry matter content (high in resistant varieties) were related to salt tolerance. Krishnamurthy *et al.* (1987) observed lesser reduction of total leaf area in tolerant genotypes compared to that of susceptible varieties of rice.

Ramayya *et al.* (1987) found linear decreases in yields of finger millet, sunflower and groundnut with increasing salinity of irrigation water from 1 to 2, 4, 6, 8, 12 and 16 dS/m. Finger millet was more tolerant in kharif than in rabi season.

Balakrishnan *et al.* (1988) conducted studies with finger millet in an alkali soil (pH 10.3) EC 4.2 mmhos/cm and observed transplanting of 18 and 25 days old seedlings at 2-4 seedlings / hill increased tillering and 1000 grain weight and gave grain yields of 2.92 to 4.03 t/ha compared with 1.24 to 1.54 t/ha for crops sown broadcast or in rows in the alkali soil. The yields were the highest with three seedlings / hill irrespective of seedling age.

✓ Krishnamurthy *et al.* (1988) have observed a higher rate of accumulation of polyamines in salt tolerant varieties and this accumulation was consistently associated with salt tolerance in rice. Gill and Singh (1988) studied the growth recovery from salt stress during early seedlings stage in rice.

Abraham *et al.* (1989) reported the existence of genetic variability and character association of yield and its components in finger millet in an acidic soil of Meghalaya. PCV and GCV were high for effective tillers / plant, grain yield / plant, 1000 grain weight and number of fingers / ear. Broad sense heritability was high for days to maturity (99.5%), days to fifty per cent flowering (97.7%), fingers per ear (83.3%) and 1000 grain weight (98.1%). Genetic advance was high for grain yield / plant (56.3%), 1000 grain weight (39.7%) and finger / ear (33.9%). Grain yield was significantly and positively correlated with days to fifty per cent flowering, days to maturity, effective tillers / plant and 1000 grain weight.

Number of authors have reported a decrease in total chlorophyll content in plant grown in saline media (Nieves *et al.*, 1991) and attributed this decrease to an increased water content (succulence), especially in case of chloride salinity.

Bay *et al.* (1992) stated that in salt sensitive varieties, sodium is accumulated at the cost of potassium, which is evaded by salt resistant varieties by an osmoregulatory process.

Taneja *et al.* (1992) observed a progressive decline in relative water content (RWC) with increase in salinity. The decrease in the RWC by salinity was compensated by the decrease in the osmotic potential through an increase in total soluble solids and thereby the pressure potential was maintained.

Kannan and Oblisami (1992) grew maize (CO 1), finger millet (CO 11), cowpea (CO 4) and cotton (MCU5), in cups containing 200 g red loamy soil watered with 0, 25, 50, 75 (or) 100 per cent concentration of combined effluent from paper and pulp mills or with the effluent following aerobic treatment. Treated effluent did not affect seed germination in any species. While undiluted raw effluent decreased germination in finger millet, cowpea and cotton. Raw effluent decreased seedling growth and vigour in maize, cowpea and cotton, while growth of finger millet was the highest with 75 per cent effluent. Treated effluent increased seedling growth and vigour in all species. The optimum concentrations were 100, 75, 50 and 25 per cent in maize, finger millet, cowpea and cotton respectively.

Jagadev and Jena (1993) suggested that most cultivars would tolerate salinity levels of upto 11 dSm^{-1} .

Gupta *et al.* (1993) found that root growth was variously affected or unaffected by salinity levels in rice, an effect most noticeable with the susceptible genotypes.

Onkware (1993) conducted germination studies in finger millet at different salinity levels. Seeds of two cultivars *viz.*, Enakuru and Ekalakala-1 were germinated in the presence of 0.0, 0.4, 0.8 (or) 1.2 S/m NaCl. In pot experiments cv. Enakuru and Ekalakala-1 were grown on non-saline loam soil and irrigated with the same

concentrations of salt as above. Thousand grain weight, at 0.1 S/m, was 3.6g for Enakuru and 2.6g for Ekalakala-1, decreasing with increasing salinity to 1.7 and 1.6g, respectively, at 1.2 S/m. Germination first took place at 48hr after soaking with germination percentage increasing with time. Germination on percentage decreased with increasing salinity, with Ekalakala-1, having higher germination percentage than Enakuru. Alpha-amylase activity was the highest at 48hr in the 0.0 and 0.4 S/m treatment. At 0.8 S/m, activity was similar to that at 48 and 72 hr and at 1.2 S/m, the activity was the highest at 96 hr after soaking.

Torres and Echevarria (1994) observed that seedling growth was reduced by increasing NaCl concentration in rice.

Rizwan *et al.* (1994) exposed *Sesbania aegyptica*, *S. aculeata*, *Eleusine coracana* and sorghum, to salinity levels of 5, 10, 15 or 20 dS/m in a pot experiment. The shoot dry weight decreased with increasing salinity level in all the species. *S. aegyptica* and *S. aculeata* were the most tolerant species to salinity. Leaf Na and Cl concentration increased and K and Ca concentration decreased with increasing salinity.

Uma *et al.* (1995) found marked differences among 28 finger millet genotypes for acquired tolerance of osmotic stress as assessed by the recovery of root growth from severe stress of -1.2 MPa polyethylene glycol (PEG) or 400 mM NaCl. The differences in tolerance were observed only when the seedlings were subjected to preceding mild induction stress of -0.6 MPa PEG or 200 mM NaCl. Stress proteins were estimated and were found to correlate with the observed variation in acquired tolerance of two of the genotypes, *viz.*, GE 415 and VL 481.

Chloride dominated salinity was proved more deleterious to seed germination and seedling growth as indicated by relatively more reduction in per cent germination, radicle and coleoptile length (Sharma *et al.*, 1996). This may be due to lack of mobilization of stored food materials from the endosperm to the embryo axis.

Khan *et al.* (1997a) observed a decrease in the germination especially the speed of germination in rice. Khan *et al.* (1997b) reported that plant height, green leaf area, leaf weight, shoot and root growth were seriously decreased by salinity. However leaf area was decreased more than other growth parameters.

Powar and Mehta (1997) observed that root length decreased significantly with increasing salinity. Geetha and Vembu (1998) treated seeds of *Eleusine coracana* with 0, 10, 25, 50, 75 and 100 per cent concentrations of tannery effluent. Germination percentage and rate, vigour index, tolerance index, percentage of phytotoxicity and length of shoots and roots decreased with increasing effluent concentration. Contents of total chlorophyll, carotenoids, sugars, starch, aminoacid and protein decreased at higher effluent concentration. However, at lower concentration, contents of some of these compounds increased and it is suggested that the effluent could be used as a liquid fertilizer at low concentration.

Srivastava (1998) reported that crops and their genotypes respond differently to salinity stress. Different developmental stages also respond differently to the stress. In a study conducted in wheat, barley and pearl millet, he found that dry matter production under salinity got reduced due to reduction in photosynthetic area and the photochemical reactions were also affected adversely under salinity stress. The morphological responses due to salinity stress observed were the reduction in height and leaf area. He suggested that, the LAR (Leaf Area Ratio), which is based on morphophysiological parameters of plants may be taken as a parameter for screening salt resistant and susceptible genotypes

of crops. The absorption of Na increased under salinity stress. In poaceae, leaf sheath contain more Na and electrolytes than the lamina of the same leaf. The accumulation of injurious ions was more in root or older parts of the plant and salt resistant genotypes tend to restrict the entry of the injurious ions at root level.

Jayaprakash *et al.* (1999) quantified LEA2 and LEA3 proteins in finger millet and rice and showed the existence of genetic variability in these proteins. There was a correlation between LEA protein content and stress response to salinity. Partial code for LEA 2 proteins was higher in tolerant genotypes than in susceptible genotypes. They discussed the possible relevance of LEA 2 and LEA 3 protein in stress tolerance.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1. Materials

Fifty genotypes of finger millet (*Eleusine corucana* (L.) Gaertn.) obtained from the germplasm collection of the Department of Millets, Tamil Nadu Agricultural University, Coimbatore were chosen for the study. The genotypes are furnished in table 6.

Table 6. List of genotypes used in the study

Sl.No.	Genotypes	Sl.No.	Genotypes
1.	CO 9	26.	GE 15
2.	CO 10	27.	GE 1824
3.	CO 11	28.	GE 1323
4.	CO 12	29.	GE 1462
5.	CO 13	30.	GE 1622
6.	TNAU 1	31.	GE 1823
7.	TNAU 3	32.	GE 1524
8.	TNAU 4	33.	MS 3019
9.	TNAU 5	34.	MS 899
10.	TRY 1	35.	MS 3015
11.	TNAU 8	36.	MS 3221
12.	TNAU 896	37.	MS 870
13.	TNAU 915	38.	MS 3236
14.	TNAU 946	39.	MS 3016
15.	TNAU 972	40.	VL 149
16.	AF 260	41.	PES 400
17.	AF 261	42.	DPI 1984
18.	AF 262	43.	HR 374
19.	AF 263	44.	Indaf 11
20.	AF 265	45.	PES 110
21.	AF 266	46.	RAU 8
22.	AF267	47.	PY 1
23.	AF 268	48.	L 211
24.	GE 1989	49.	OUAT 2
25.	GE 1914	50.	PR 202

3.2. Methods

3.2.1. Field plot technique

The experiment was conducted at the Millets Breeding Station, Tamil Nadu Agricultural University in Coimbatore, during *kharif* 2000. A randomised block design with three replications was adopted. Each genotype was sown in three rows, the plot size being 3m x 1.5 m with a spacing of 22.5 x 15 cm. All recommended cultural practices were followed for getting a normal crop.

3.2.2. Observations recorded

Five plants in each replication were selected at random in each genotype and observations were recorded on individual plants for the following attributes.

(i) Days to fifty per cent flowering

The number of days taken from sowing to stage when the ears have emerged on fifty per cent of the main tillers was recorded.

(ii) Plant height at maturity

Height was measured in centimetre from the ground level to the tip of the primary panicle at the time of harvest.

(iii) Culm thickness at maturity

Diameter of internode ten centimetre above the ground at the time of harvest was measured in centimetres.

(iv) Total number of productive tillers

The total number of productive tillers per hill was counted at the time of harvest.

(v) Total number of leaves per tiller

The total number of leaves on main tiller at flowering stage was counted.

(vi) Peduncle length

The length of peduncle was measured in centimetres from the tip of node to the base of the thumb in the primary ear head.

(vii) Number of finger per ear head

The number of fingers present in the primary earhead was counted.

(viii) Finger length

The length of finger in the primary ear head was measured in centimetres from the junction of peduncle to the tip of the finger.

(ix) Thousand grain weight

The weight of one thousand grains was expressed in grams.

(x) Grain yield per plant

The earheads of each plant were threshed by hand and the weight of the grains per plant was recorded in grams.

3.2.3. Statistical analysis

The mean of all the five plants for each character under each replication was subjected to statistical analysis.

3.2.3.1. Analysis of variance

The data collected on fifty genotypes for 10 biometrical traits were subjected to the analysis of variance as suggested by Panse and Sukhatme (1967).

Source	Degrees of freedom	Mean sum of squares	Expected mean squares
Replication (r)	(r-1)		$\sigma^2_e + g. \sigma^2_r$
Genotype (g)	(g-1)	M_g	$\sigma^2_e + r. \sigma^2_g$
Error	(r-1)(g-1)	M_e	σ^2_e
Total	(rg-1)		

3.2.3.2. Estimation of variability parameters

The estimates of variability parameters were worked out according to the method suggested by Johnson *et al.* (1955), utilizing the mean square values from the variance table.

$$(i) \quad \text{Genotypic Variance } (\sigma^2_g) = \frac{M_g - M_e}{r}$$

$$(ii) \quad \text{Phenotypic Variance } (\sigma^2_P) = \sigma^2_g + \sigma^2_e$$

where,

r = Number of replications

M_g = Mean sum of squares for genotypes

M_e = Mean sum of squares for error

σ^2_e = Expected mean sum of squares for error

Phenotypic and genotypic coefficient of variations were calculated based on the method advocated by Burton (1952)

$$(iii) \quad \text{Phenotypic co-efficient of variation (PCV)} = \frac{\sqrt{\text{Phenotypic variance}}}{\text{Grand mean}} \times 100 = \frac{\sigma_p}{\text{Grand mean}} \times 100$$

$$(iv) \quad \text{Genotypic co-efficient of variation (GCV)} = \frac{\sqrt{\text{Genotypic variance}}}{\text{Grand mean}} \times 100 = \frac{\sigma_g}{\text{Grand mean}} \times 100$$

3.2.3.3. Estimation of genetic parameters

Heritability in the broad sense was estimated following the method described by Lush (1940) and expressed in percentage

$$(i) \quad \text{Heritability broad sense } (h^2) = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

The range of heritability was categorised as suggested by Robinson *et al.* (1949)

Low - <30

Moderate - 30 to 60

High - >60

Genetic advance (GA) was estimated by the method suggested by Johnson *et al.* (1955).

$$GA = \frac{\sigma_g^2}{\sigma_p} \times k = kh^2 \sqrt{\sigma_p^2}$$

where,

k = Selection differential which is equal to 2.06 at 5 per cent level

h^2 = Heritability (broad sense)

σ_p = Phenotypic standard deviation

Genetic advance was expressed as percentage of mean by using the following formula (Johnson *et al.*, 1955).

$$(ii) \quad \text{GA as per cent of mean} = \frac{\text{Genetic advance}}{\text{Grand mean}} \times 100$$

(GA per cent)

Genetic advance was also categorised as suggested by Johnson *et al.* (1955)

Low - <1

Moderate - 10 to 20

High - >20

3.2.3.4. Correlation

The association between yield and component traits and among themselves was computed based on genotypic and phenotypic correlation co-efficients (Goulden, 1952). For each of the ten traits, analysis of variance was done and the mean square expectations were obtained. The estimates of variance components were obtained as given below (Al-Jibouri *et al.*, 1958) and genotypic and phenotypic correlation co-efficients were estimated.

Phenotypic correlation co-efficient

$$r_p = \frac{\text{Cov } p_{x,y}}{\sqrt{(\sigma^2 p_x)(\sigma^2 p_y)}}$$

where,

- r_p = phenotypic correlation co-efficient
 $\text{Cov } p_{x,y}$ = phenotypic covariance between the characters 'x' and 'y'
 $\sigma^2 p_x$ = Phenotypic variance of x
 $\sigma^2 p_y$ = Phenotypic variance of y

Genotypic correlation co-efficient

$$r_g = \frac{\text{Cov } g_{x,y}}{\sqrt{(\sigma^2 g_x)(\sigma^2 g_y)}}$$

- r_g = Genotypic correlation co-efficient
 $\text{Cov } g_{x,y}$ = Genotypic covariance between the characters 'x' and 'y'
 $\sigma^2 g_x$ = Genotypic variance of x
 $\sigma^2 g_y$ = Genotypic variance of y

Referring to the standard table given by Snedecor (1961) the significance of phenotypic and genotypic correlation co-efficient was tested.

3.2.3.5. Path co-efficient analysis

Path co-efficient analysis was used to partition the correlation coefficient into components of direct and indirect effects.

By keeping yield as a dependent variable and the other traits as independent variables, simultaneous equation, which express the basic relationship between path coefficients were solved to estimate the direct and indirect effects. The direct and indirect effects were classified as follows based on the scale given by Lenka and Misra (1973).

Very high = More than 1.0

High = 0.3 – 0.99

Moderate = 0.2 – 0.29

Low = 0.1 – 0.19

Negligible = 0.0 – 0.09

3.2.3.6. Mahalanobis D^2 Analysis

The square of the Mahalanobis (1936) generalised distance between any two population is given by the formula.

$$\Delta^2 = \sum_{i,j} v_i v_j \gamma_{ji}$$

where,

Δ^2 square of generalised distance

v_j is the reciprocal of the common dispersion matrix

v_i is $(M_{i1} - M_{i2})$

v_j is $(M_{j1} - M_{j2})$

where M is the vector of mean values for all characters.

The estimation of distance D for a sample is given by formula,

$$D^2_p = d' s^{-1} d$$

where,

D^2_p is the square of the distance considering p variables.

d' is the vector of difference of the mean values of all the characters = $\frac{1}{(X_{i1} - X_{i2})}$

where, X_i is the vector of the mean values of all the characters.

s^{-1} is the inverse of variance, co-variance matrix. Since, inverting matrix is complicated, the original correlated variables (X_i) were transformed to non-correlated variables (Y_i). So, the computation of D^2 values reduced the differences between the values of transformed variable of the two populations.

This transformation was done by pivotal condensation method. These newly transformed uncorrelated variables were used to calculate the square of distance using the formula,

$$D^2 = \Sigma(\overline{Y_{i1}} - \overline{Y_{i2}})^2$$

where, \overline{Y} is the vector of transformed mean values.

The square roots of these D^2 values gave the general distance (d^1) between the two populations.

Clustering of the D^2 values

All the $\frac{n(n-1)}{2}$ D^2 values were clustered using Tocher's method (Rao, 1952).

The D^2 values of all the 49 combinations for each entry were arranged in the descending order. The two genotypes having the lowest D^2 values between them were selected and a third genotype which had on an average the smallest D^2 value from the first two was added. Similarly, a fourth entry was picked which showed a least average D^2 from the first three. This was continued till when a genotype if added, increased the average D^2 value more than the average of those included and that genotype was taken out. The genotypes already included in the group were considered as the first cluster. The procedure was repeated for other genotypes, omitting those that were already included in the earlier clusters.

Inter and Intra Cluster Distance

After establishing the clusters, the intra-cluster distance was worked out by taking the average of the component genotypes in that cluster. Taking the average intra cluster divergences arrived into consideration, all the component D^2 values possible among the members of the two clusters considered. The square root of the average D^2 values gave the genetic distance 'D' between the clusters.

Based on the average D values in the present study, for the purpose of analysis of results, the following rating of the distances as close, medium and high as adopted by Tocher (Rao, 1952) was followed.

Category		D value
Close	-	<10.0
Medium	-	10.01 to 20.00
High	-	>20.01

Ranking of component D^2 values and contribution of characters

Ranking of individual D^2 values contributed by each character was worked out for ten characters by using the principle that the highest contribution of a particular character is indicated by its lowest rank total and vice versa (Murty *et al.*, 1965).

3.3. Salinity tolerance studies

The fifty genotypes of finger millet were grown in cups with neutral sterile sand in Millets Breeding Station, for assessing their salinity tolerance for germination. A completely randomized design with three replications was adopted. Each replication consisted of one cup sown with ten seeds for each genotype. Four levels of salinity stress *viz.*, 4 dSm^{-1} , 8 dSm^{-1} , 12 dSm^{-1} and 16 dSm^{-1} of electrical conductivity were imposed by adding a salt solution consisting of NaCl, $CaCl_2$, Na_2SO_4 in the ratio of 7:2:1 w/v (Singh and Singh, 1999). The different electrical conductivity of levels were created in the sand filled in the germination cups by gradually adding salt solution (7:2:1 of NaCl, $CaCl_2$ and Na_2SO_4) and measuring the electrical conductivity periodically in the conductivity metre. After standardizing for each salinity level, rest of the cups were added with standardized volume of salt solution for each salinity level. The EC values were expressed in deciSiemens per metre (dSm^{-1}). For each replication, ten seeds were sown in each cup for each genotype for each salinity level. The cups were kept inside the germination chamber. The cups were irrigated every day by adding distilled water just sufficient to soak the sand to 80 per cent of the depth of the cup.

Observations recorded

(i) Germination (%)

Germination percentage was recorded on seventh day after sowing (Anon, 1999). The number of seeds germinated was expressed as percentage for each salinity level under each replication for each genotype. The seeds were considered germinated when radicle and plumule have clearly protruded.

(ii) Seedling root length

Five seedlings were taken at random from each cup and the distance between the collar and tip of the primary root was measured and the mean value was expressed in cm.

(iii) Seedling shoot length

The seedlings used for root measurement were measured for the distance between collar and tip of the primary shoot. The mean value was expressed in cm.

(iv) Mean seedling length

The root length and shoot length of each seedling measured was added and the mean of five seedlings in each cup was taken as mean seedling length and expressed in cm.

Vigour index (VI)

The vigour index of each genotype in each replication for each salinity level was worked out using the following formula (Abdul-Baki and Anderson, 1973) and expressed in whole number.

$$\text{Vigour index (VI)} = \text{Germination (percentage)} \times \text{mean seedling length (cm)}$$

Statistical analysis

The data were analysed statistically by factorial completely randomized design, with five levels including control (Panse and Sukhatme, 1961). Angular transformation was made for the values of germination percentage before analysing the data.

EXPERIMENTAL RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

The experimental results of the investigation carried out on fifty genotypes of finger millet are presented under the following headings.

- 4.1. *Per se* performance
- 4.2. Variability studies
- 4.3. Correlation studies
- 4.4. Path analysis
- 4.5. Studies on genetic divergence
- 4.6. Salinity tolerance studies

4.1. *Per se* performance

Analysis of variance for the genotypes presented in Table 7, revealed highly significant differences between the genotypes for all the ten characters studied in the present investigation.

The mean performance of fifty finger millet genotypes for ten characters is presented in Table 8.

4.1.1. Days to 50 per cent flowering

Days to 50 per cent flowering ranged from 61.33 (TNAU 915, AF 265) to 87.0 (CO 12, AF 263) days. The general mean was 73.43 days. Twenty seven genotypes exceeded the general mean significantly.

4.1.2. Plant height

The plant height at the time of harvest ranged from 84.10 cm (MS 3236) to 136.88 cm (PY 1). The general mean was 107.85 cm. Fifteen genotypes exceeded the general mean significantly.

Table 7. Analysis of variance for ten agronomic characters of fifty genotypes of finger millet

S. No	Character	Grand mean	Genotypes Mean sum of square	Error mean sum of square	S.E.of mean	S.E.of mean diff.	C.D 5%	CV%
1	Daysto fifty per cent flowering	73.433	155.81**	0.1198	0.19	0.28	0.56	0.47
2	Plant height (cm)	107.85	491.51**	7.2955	1.54	2.20	4.37	2.50
3	Culm thickness(cm)	3.4603	0.1802**	0.0118	0.06	0.088	0.17	3.13
4	Number of productive tillers	7.9211	12.901**	0.6780	0.47	0.67	1.33	10.39
5	Number of leaves	16.174	14.420**	0.0439	0.11	0.17	0.33	1.29
6	Peduncle length(cm)	22.246	15.336**	1.7328	0.75	1.07	2.13	5.91
7	Number of fingers.	8.4544	3.4310**	0.1931	0.25	0.35	0.71	5.19
8	Finger length(cm)	9.1937	12.820**	0.4578	0.38	0.55	1.09	7.35
9	Thousandgrain weight (g)	2.7070	0.2959**	0.0177	0.07	0.10	0.21	4.91
10	Grain yield(g)	46.101	522.46**	9.8792	1.79	2.56	5.09	6.81

Genotypes degrees of freedom = 49

Replication degrees of freedom = 2

Error degrees of freedom = 98

* Significant at 5% level

** Significant at 1 %level

Table 8. Mean performance of fifty genotypes of finger millet

S.No	Genotypes	Days to 50% flowering	Plant height (cm)	Culm thickness (cm)	No. of product. tillers	No. of leaves	Peduncle length (cm)	No. of fingers.	Finger length (cm)	1000 grain weight (g)	Grain yield (g)
1	CO 9	71.00	91.66	3.54	7.17	14.63	21.11	8.25	6.99	2.14	32.62
2	CO 10	66.66	92.49	2.85	6.88	15.28	21.93	7.26	7.27	3.21	27.88
3	CO 11	77.33	122.27	3.35	7.88	16.58	21.99	7.33	7.68	2.49	62.76
4	CO 12	87.00	123.88	3.45	6.66	18.03	22.16	7.44	7.63	3.04	38.95
5	CO 13	67.00	111.05	3.18	5.95	15.62	23.38	9.11	8.88	2.88	45.71
6	TNAU 1	64.00	97.05	2.90	8.77	15.22	23.33	8.27	8.99	3.28	41.04
7	TNAU 3	67.00	122.88	3.50	9.93	15.99	22.66	7.77	11.66	2.92	51.65
8	TNAU 4	67.00	113.22	3.90	9.05	16.52	21.72	8.44	13.66	2.66	56.60
9	TNAU 5	71.00	109.05	3.34	5.55	14.03	22.49	9.01	11.54	3.21	37.16
10	TRY 1	68.66	113.61	3.54	8.99	16.38	25.49	8.55	12.38	3.43	61.20
11	TNAU 8	63.33	112.11	3.73	7.46	15.52	24.66	9.04	12.77	2.96	53.86
12	TNAU 896	74.66	118.38	3.41	4.55	15.31	25.53	10.55	11.27	3.27	28.03
13	TNAU 915	61.33	106.98	3.45	8.77	15.03	22.77	9.22	11.22	2.72	45.35
14	TNAU 946	86.00	110.88	3.74	8.99	17.41	25.99	7.77	6.77	3.13	47.63
15	TNAU 972	75.33	95.44	3.52	5.77	18.51	21.83	9.88	9.94	2.39	46.22
16	AF 260	64.33	92.32	3.32	7.72	11.23	22.49	8.00	7.66	3.07	24.93
17	AF 261	86.66	98.66	4.10	6.28	19.58	17.66	8.77	11.22	2.47	59.16
18	AF 262	75.00	94.10	3.45	6.50	16.97	17.88	11.27	9.10	2.37	50.66
19	AF 263	87.00	108.18	3.48	4.55	19.22	20.33	8.33	6.49	2.22	33.99
20	AF 265	61.33	110.94	3.74	7.85	13.41	23.05	8.96	9.44	2.77	36.51
21	AF 266	75.33	93.72	3.60	8.77	13.36	23.33	8.44	7.00	2.58	62.36
22	AF 267	78.00	126.33	3.37	9.55	16.41	22.33	8.99	11.49	2.41	48.46
23	AF 268	79.00	130.77	3.48	9.08	18.52	26.52	9.11	9.74	2.81	62.51
24	GE 1989	71.33	98.05	3.43	5.66	16.46	20.60	9.41	9.87	2.67	36.07
25	GE 1914	63.00	98.44	3.58	6.34	14.34	21.99	6.55	6.81	3.04	36.42
26	GE 15	67.00	99.44	2.87	9.33	12.96	23.22	6.70	7.20	2.91	34.81
27	GE 1824	79.66	116.16	3.81	8.99	15.05	25.27	8.21	9.10	2.30	71.86
28	GE 1323	75.00	111.16	3.66	6.22	16.62	21.55	6.27	5.79	2.81	33.70
29	GE 1462	67.00	104.99	3.60	12.11	15.44	19.88	9.66	8.88	2.50	47.64
30	GE 1622	67.00	108.77	3.03	8.71	16.40	23.49	8.62	8.09	2.29	49.42
31	GE 1823	62.66	89.88	3.46	10.66	16.79	23.75	7.99	8.40	2.37	47.18
32	GE 1524	71.33	114.05	3.56	7.86	17.42	22.52	9.38	10.05	2.43	54.78
33	MS 3019	79.00	87.38	3.63	7.60	14.37	17.23	9.49	5.10	2.54	42.39
34	MS 899	71.00	104.16	3.51	7.41	14.86	22.99	7.55	9.72	2.85	36.12
35	MS 3015	79.00	118.33	3.50	11.66	19.16	21.38	7.88	8.44	2.88	84.55
36	MS 3221	67.00	86.72	3.61	15.01	11.10	20.60	8.52	7.57	2.51	85.02
37	MS 870	86.66	134.00	3.48	11.83	17.34	24.57	7.77	10.32	2.10	56.24
38	MS 3236	71.00	84.10	3.40	7.05	14.35	26.40	7.66	7.55	2.71	32.53
39	MS 3016	82.00	127.27	3.63	8.16	18.33	21.63	8.10	7.94	2.96	50.03
40	VL 149	75.00	111.77	3.51	8.66	14.23	24.00	7.99	7.66	2.86	33.89
41	PES 400	71.00	103.66	3.56	8.99	15.02	21.33	6.66	8.22	2.63	41.70
42	DPI 1894	74.00	115.44	3.04	8.41	14.57	23.44	11.32	7.92	2.38	34.75
43	HR 374	73.00	104.21	3.26	8.33	16.02	22.33	8.77	9.01	2.81	41.79
44	Indaf 11	83.66	122.33	3.42	7.81	21.70	22.44	9.88	9.66	2.71	58.27
45	PES 110	79.00	107.66	3.61	5.44	15.16	16.77	7.99	11.16	2.46	39.79
46	RAU 8	78.00	106.54	3.58	4.77	16.73	19.44	7.99	10.17	2.48	34.92
47	PY 1	75.00	136.88	3.12	5.66	19.42	23.16	8.04	12.99	2.54	43.95
48	L 211	78.00	109.60	3.22	7.89	19.98	22.66	7.87	9.31	2.55	43.69
49	OUAT 2	71.00	91.38	3.42	7.66	15.98	21.10	7.66	7.57	2.72	35.03
50	PR 202	80.00	104.22	3.43	4.99	20.021	17.77	8.88	14.22	2.75	43.14
	Mean	73.43	107.85	3.46	7.92	16.17	22.24	8.45	9.19	2.70	46.10
	S.E	0.19	1.54	0.06	0.47	0.11	0.75	0.25	0.38	0.07	1.79
	C.D	0.56	4.37	0.17	1.33	0.33	2.13	0.71	1.09	0.21	5.09

4.1.3. Culm thickness

The maximum culm thickness was recorded in the genotype AF 261 (4.10 cm) and minimum culm thickness was observed in the genotype CO 10 (2.85 cm). The general mean was 3.46 cm. Seven genotypes exceeded the general mean significantly.

4.1.4. Number of productive tillers

The maximum number of productive tillers was observed in the genotype MS 3221 (15.01) followed by MS 870 (11.83), MS 3015 (11.66), GE 1823 (10.66) and TNAU 3 (9.93). The general mean was 7.92. Eight genotypes exceeded the general mean significantly.

4.1.5. Number of leaves

The maximum number of leaves was observed in the genotype Indaf 11 followed by PR 202 (20.02) and L. 211 (19.78). Twenty genotypes significantly exceeded the general mean value.

4.1.6. Peduncle length

The peduncle length at the time of harvest ranged from 16.77 cm (PES 110) to 26.52 cm (AF 268). The general mean was 22.24 cm. Eight genotypes significantly exceeded the general mean value.

4.1.7. Number of fingers

The maximum number of fingers was recorded in the genotype DPI 1894 (11.32) followed by AF 262 (11.27), TNAU 896 (10.55), TNAU 972 (9.88), Indaf 11 (9.88) and GE 1462 (9.66). The general mean was 8.45. Ten genotypes exceeded the general mean significantly.

4.1.8. Finger length

The finger length ranged from 5.10 cm (MS 3019) to 14.22 cm (PR 202). The general mean was 9.19 cm. Thirteen genotypes significantly exceeded the general mean value.

4.1.9. Thousand grain weight

Thousand grain weight ranged from 2.10 g (MS 870) to 3.43 g (TRY 1). Values significantly higher than the general mean of 2.91 g were observed in twelve genotypes.

4.1.10. Grain yield

The maximum grain yield was recorded in the genotype MS 3221 (85.02 g) followed by MS 3015 (84.55 g), GE 1824 (71.86 g), CO 11 (62.76 g), AF 266 (62.36 g) and Indaf 11 (58.27g). Values significantly higher than the general mean of 46.10 g were observed in fourteen genotypes.

4.2. Variability studies

The estimates of genotypic and phenotypic coefficients of variation for ten characters are presented in Table 9.

4.2.1. Phenotypic and genotypic coefficients of variation

Since the phenotypic and genotypic variances are associated with units, the coefficients of variation were worked out for valid comparison between characters. In general, for all the traits studied, the phenotypic coefficient of variation was higher than the genotypic coefficient of variation. The phenotypic coefficient of variation was maximum (28.62) for grain yield. Apart from grain yield the PCV estimates were high for number of productive tillers (26.18) and finger length (22.48). Moderate values were observed for number of leaves (13.55), number of fingers (12.64), plant height (11.86), 1000 grain weight (11.60) and peduncle length (10.16). Low PCV was observed for days to 50 per cent flowering (9.81) and culm thickness (7.08).

The maximum GCV of 28.35 per cent was obtained for grain yield followed by number of productive tillers (25.48) and finger length (22.08). Moderate GCV values were recorded for four characters. Low GCV was recorded for culm thickness (6.84) peduncle length (9.57) and days to fifty per cent flowering (9.81).

Table 9. Estimates of variability and genetic parameters of fifty genotypes of finger millet

Sl. No	Characters	Mean	Range	PCV%	GCV%	Heritability %	GA as % of mean
1	Days to fifty per cent flowering	73.433	61.33-87.0	9.81	9.81	99.76	20.18
2	Plant height (cm)	107.85	84.10-136.88	11.86	11.77	95.67	23.93
3	Culm thickness (cm)	3.4603	2.85-4.10	7.08	6.84	82.62	12.81
4	Number of productive tillers	7.9211	4.55-15.01	26.18	25.48	85.73	48.60
5	Number of leaves	16.174	11.10-21.70	13.55	13.53	99.09	27.75
6	Peduncle length (cm)	22.246	16.77-26.52	10.16	9.57	72.35	16.77
7	Number of fingers	8.4544	6.27-11.32	12.64	12.28	84.82	23.31
8	Finger length (cm)	9.1937	5.10-14.22	22.48	22.08	90.00	43.15
9	Thousand grain weight (g)	2.7070	2.10-3.43	11.60	11.25	83.96	21.23
10	Grain yield(g)	46.101	24.93-85.02	28.62	28.35	94.53	56.78

4.2.2. Heritability and genetic advance

Estimates of heritability (broad sense), genetic advance and genetic advance as percentage of mean are furnished in Table 9. The heritability (broad sense) and genetic advance as percentage of mean along with GCV are presented graphically in Fig.1.

The genotypes under study showed high heritability values for all the characters. Days to fifty per cent flowering recorded the highest heritability (99.76 per cent) followed by number of leaves (99.09 per cent), plant height (95.67 per cent), grain yield (94.53 per cent), finger length (90.00 per cent), number of productive tillers (85.73 per cent), number of fingers (84.82 per cent), 1000 grain weight (83.96 per cent), culm thickness (82.62 per cent) and peduncle length (72.35 per cent).

The genetic advance as percentage of mean ranged from 12.81 to 56.78. Grain yield recorded the highest genetic advance as percentage of mean (56.78 per cent). The genetic advance as percentage of mean was high for number of productive tillers (48.60 per cent), finger length (43.15 per cent), number of leaves (27.75 per cent), plant height (23.73 per cent), number of fingers (23.31 per cent), 1000 grain weight (21.23 per cent) and days to fifty per cent flowering (20.18 per cent). Moderate genetic advance as percentage of mean was recorded for peduncle length (16.77 per cent) and culm thickness (12.81 per cent).

Among the characters studied, high heritability and high genetic advance as percentage of mean was obtained for eight characters viz., days to fifty per cent flowering, plant height, number of productive tillers, number of leaves, number of fingers, finger length, 1000 grain weight and grain yield.

4.3. Correlation studies

The nature and extent of association that existed between grain yield and its component characters were studied and the phenotypic and genotypic correlation coefficients were worked out. The results are presented in Table 10 and 11.

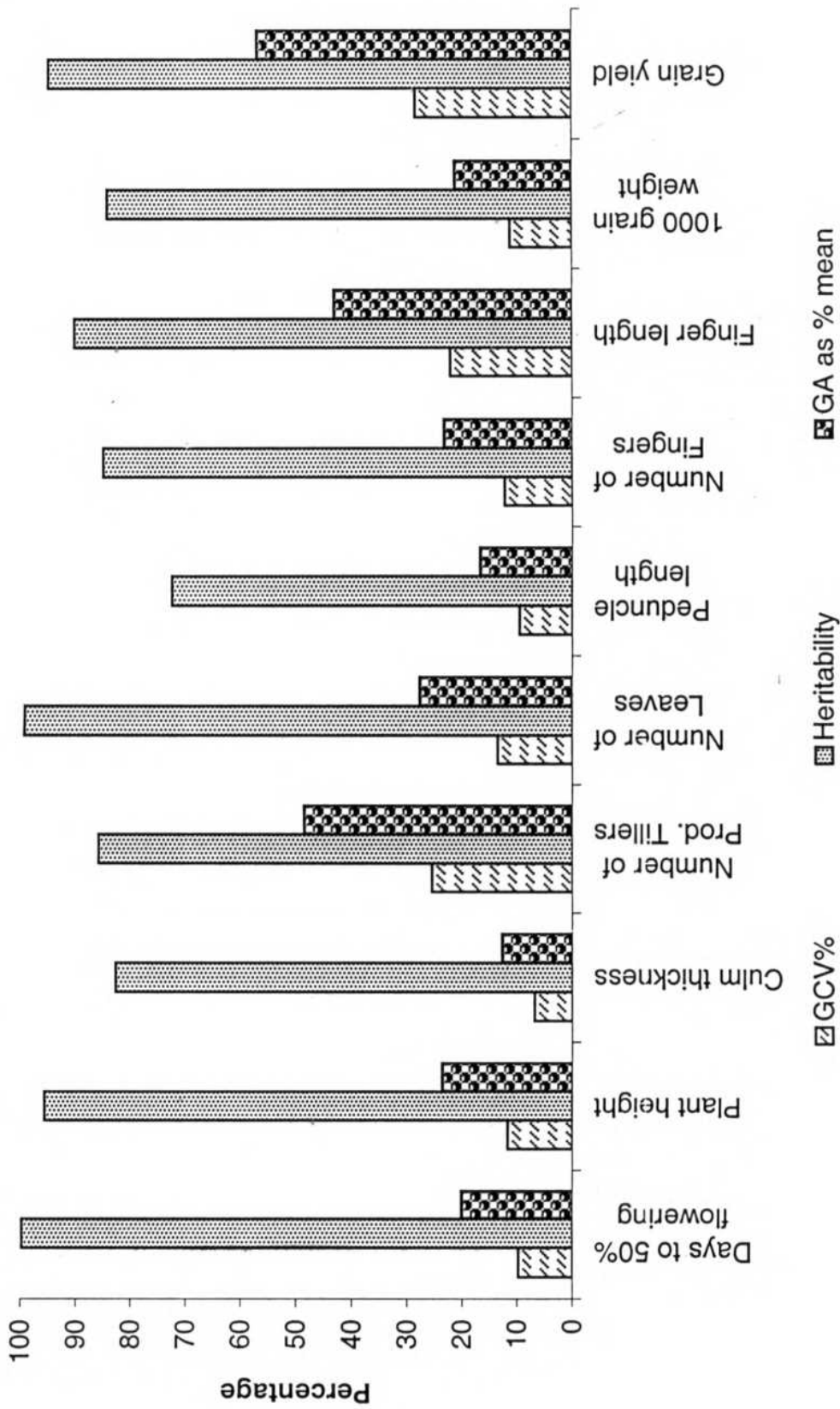


Fig. 1. Comparison of GCV (%), Heritability and GA as % of mean for ten characters in finger millet genotypes

Table 10. Phenotypic correlation co-efficient among the ten characters in finger millet genotypes

Character	Days to 50% flowering	Plant height	Culm Thickness	No. of productive tillers	No. of leaves	Peduncle length	No. of fingers	Finger length	1000 grain weight	Grain yield
Days to 50% flowering	1.000	0.391**	0.242	-0.184	0.611**	-0.170	0.031	-0.063	-0.257	0.182
Plant height		1.000	0.021	0.040	0.465**	0.308*	0.023	0.388**	0.036	0.250
Culm thickness			1.000	0.048	0.089	-0.157	0.014	0.145	-0.152	0.327*
No. of productive tillers				1.000	-0.237	0.228	-0.093	-0.106	-0.121	0.587**
No. of leaves					1.000	-0.112	0.105	0.298*	-0.166	0.210
Peduncle length						1.000	-0.084	0.013	0.309*	0.069
No. of fingers							1.000	0.288*	-0.170	0.095
Finger length								1.000	0.068	0.168
1000 grain weight									1.000	-0.187
Grain yield										1.000

* Significant at 5% level

** Significant at 1% level

Table 11. Genotypic correlation co-efficient among the ten characters in finger millet genotypes

Character	Days to 50% flowering	Plant height	Culm thickness	No. of productive tillers	No. of leaves	Peduncle length	No. of fingers	Finger length	1000 grain weight	Grain yield
Days to 50% flowering	1.000	0.400**	0.265	-0.200	0.614**	-0.197	0.033	-0.066	-0.277	0.188
Plant height		1.000	0.023	0.038	0.480**	0.334*	0.034	0.406**	0.025	0.257
Culm thickness			1.000	0.057	0.098	-0.234	0.008	0.148	-0.205	0.367**
No. of productive tillers				1.000	-0.257	0.238	-0.100	-0.158	-0.115	0.617**
No. of leaves					1.000	-0.133	0.121	0.314*	-0.182	0.222
Peduncle length						1.000	-0.108	-0.001	0.339*	0.042
No. of fingers							1.000	0.311*	-0.197	0.102
Finger length								1.000	0.088	0.180
1000 grain weight									1.000	-0.212
Grain yield										1.000

* Significant at 5% level

** Significant at 1% level

The analysis of character association at genotypic level indicated that among the nine yield components studied, culm thickness and number of productive tillers were significantly and positively correlated with grain yield, the coefficients being 0.367 and 0.617 respectively.

The trait 1000 grain weight was negatively correlated with yield, but with non-significant values. The other traits failed to show any association. The study of correlation at phenotypic level revealed significant positive association of culm thickness (0.327) and number of productive tillers (0.587) with grain yield.

The inter relationship between the components indicated that days to 50 per cent flowering was positively and significantly correlated with plant height (0.400) and number of leaves (0.614).

Plant height was positively and significantly correlated with days to fifty per cent flowering number of leaves (0.480), peduncle length (0.334) and finger length (0.406).

Number of leaves was positively and significantly correlated with days to fifty per cent flowering (0.614), plant height (0.480) and finger length (0.314). Peduncle length was positively and significantly correlated with plant height (0.334) and 1000 grain weight (0.339). Number of fingers was positively and significantly correlated with finger length (0.311). Finger length was positively and significantly correlated with plant height (0.406), number of leaves (0.314) and number of fingers (0.311). Thousand grain weight was positively and significantly correlated with peduncle length (0.339). The rest of the associations between the components were not significant.

4.4. Path coefficient analysis

The direct and indirect contributions of the nine component traits to grain yield are presented in Table 12 and 13. The path diagram showing the relationship between the yield components and grain yield is depicted in Fig. 2.

Table 12. Phenotypic path analysis showing direct (diagonal) and indirect effect of nine characters on grain yield of finger millet

Character	Days to 50% flowering	Plant height	Culm thickness	No. of product tillers	No. of leaves	Peduncle length	No. of fingers	Finger length	1000grain weight	Genotypic 'r' with grain yield
Days to 50% flowering	0.096	0.013	0.057	-0.123	0.143	0.002	0.003	-0.006	-0.001	0.182
Plant height	0.037	0.034	0.005	0.027	0.109	-0.003	0.002	0.039	0.000	0.250
Culm thickness	0.023	0.001	0.233	0.032	0.021	0.001	0.001	0.014	-0.001	0.327*
No. of productive tillers	-0.018	0.001	0.011	0.670	-0.055	-0.002	-0.009	-0.011	-0.001	0.587**
No. of leaves	0.059	0.016	0.021	-0.159	0.234	0.001	0.010	0.030	-0.001	0.210
Peduncle length	-0.016	0.010	-0.037	0.153	-0.026	-0.009	-0.008	0.001	0.001	0.069
No. of fingers	0.003	0.001	0.003	-0.062	0.025	0.001	0.097	0.029	-0.001	0.095
Finger length	-0.006	0.013	0.034	-0.071	0.70	0.000	0.088	0.100	0.000	0.168
1000 grain weight	-0.025	0.001	-0.036	-0.081	-0.039	-0.003	-0.017	0.007	0.004	-0.187

Correlation coefficient

Residual effect = 0.3465

* Significant at 5% level

** Significant at 1% level

Table 13. Genotypic path analysis showing direct (diagonal) and indirect effect of nine characters on grain yield of finger millet

Character	Days to 50% flowering	Plant height	Culm thickness	No. of productive tillers	No. of leaves	Peduncle length	No. of fingers	Finger length	1000 grain weight	Genotypic 'r' with grain yield
Days to 50% flowering	0.136	-0.009	0.064	-0.146	0.154	0.000	0.003	-0.011	-0.022	0.188
Plant height	0.054	-0.023	0.005	0.028	0.120	-0.001	0.003	0.070	0.000	0.257
Culm thickness	0.036	-0.001	0.241	0.042	0.025	0.000	0.001	0.026	-0.002	0.367**
No. of productive tillers	-0.027	-0.001	0.014	0.733	-0.064	0.000	-0.009	-0.027	-0.001	0.617**
No. of Leaves	0.084	-0.001	0.024	-0.188	0.251	0.000	0.011	0.054	-0.002	0.222
Peduncle length	-0.027	-0.008	-0.056	0.174	-0.033	-0.002	-0.009	0.000	0.003	0.042
No. of fingers	0.005	-0.001	0.002	-0.073	0.030	0.000	0.087	0.054	-0.002	0.102
Finger length	-0.009	-0.009	0.036	-0.116	0.079	0.000	0.027	0.172	0.001	0.180
1000 grain weight	-0.038	-0.001	-0.049	-0.084	-0.046	-0.001	-0.017	0.015	0.008	-0.212

Correlation coefficient

Residual effect = 0.3465

* Significant at 5% level

** Significant at 1% level

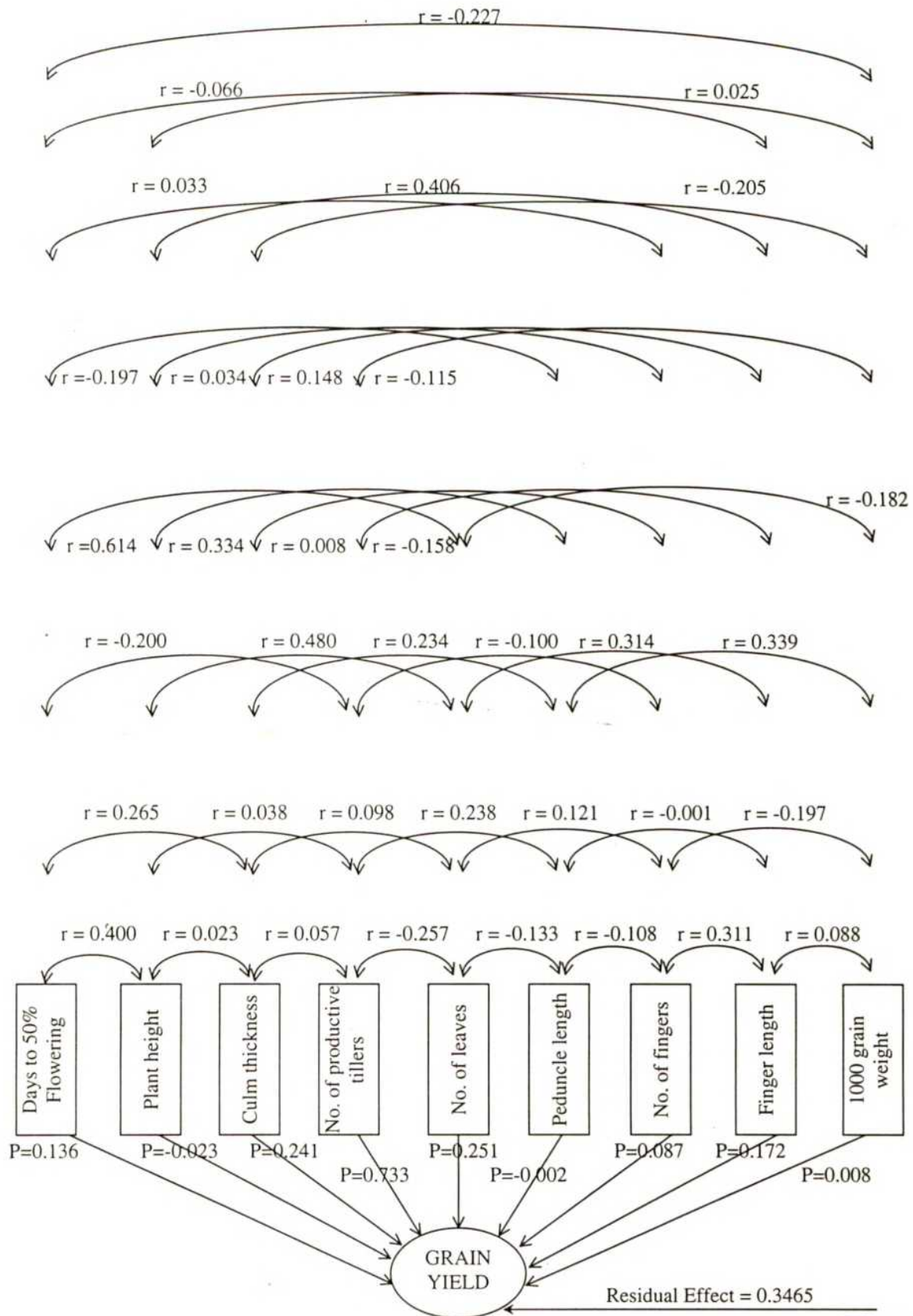


Fig. 2. Genotypic path diagram on grain yield



a) Direct effects

The study of path coefficient revealed the presence of high positive direct contribution (0.733) by number of productive tillers to grain yield. It was followed by number of leaves (0.251), culm thickness (0.241), finger length (0.172), days to fifty per cent flowering (0.136), number of fingers (0.087) and 1000 grain weight (0.008). Plant height (-0.023) and peduncle length (-0.002) showed negative direct effects.

b) Indirect effects

Regarding the indirect effect of component traits on grain yield, finger length had high indirect effect on grain yield through number of leaves and days to fifty per cent flowering. The indirect effect of all the other traits were either low or negligible.

4.4. Genetic divergence

The genetic divergence both within the genotypes and the characters was tested by Wilk's criterion and was found to be significant. Thus the analysis of genetic divergence among the genotypes taken for the study was considered to be relevant.

4.4.1. D^2 analysis

By the application of clustering technique, the fifty genotypes grouped into fourteen clusters (Table 14 and Fig. 3). Cluster I consisted of seventeen genotypes, cluster III ten genotypes, cluster V six genotypes, cluster VI seven genotypes, cluster II, cluster IV and clusters VII to XIV consisted of one genotype each.

4.4.2. Intra and inter cluster distances

The intra and inter cluster D^2 values among the fourteen clusters are furnished in Table 15.

Cluster I had the highest intra cluster generalized distance of 17.01. There were clusters II, IV and VII to XIV possessing single entries with no cluster distance. Among the inter cluster distances, it was the highest between cluster XI and XIII (79.21)

Table 14. Constitution of D² cluster of fifty genotypes of finger millet

Clusters number	Number of genotypes	Name of the genotypes
1	17	MS 899, PES 400, OUAT2, CO9, MS 3236, GE 1789, HR 374, TNAU 5, VL 149, DPI 1894, GE1323, TNAU 896, AF 266, AF262, GE 1524, TRY 1, CO13
2	1	GE1622
3	10	TNAU 3, TNAU4, GE 1462, TNAU 8, TNAU 1, TNAU 915, GE 1823, GE 1914, CO 10, AF 265.
4	1	TNAU 972
5	6	CO 12, TNAU 946, AF 263, MS 870, MS 3016, AF 261.
6	7	PES 110, RAU 8, AF 267 ,CO11, GE 1824, AF 268, MS 3019.
7	1	L211
8	1	MS 3015
9	1	GE 15
10	1	PR 202
11	1	AF 260
12	1	PY 1
13	1	Indaf 11
14	1	MS 3221

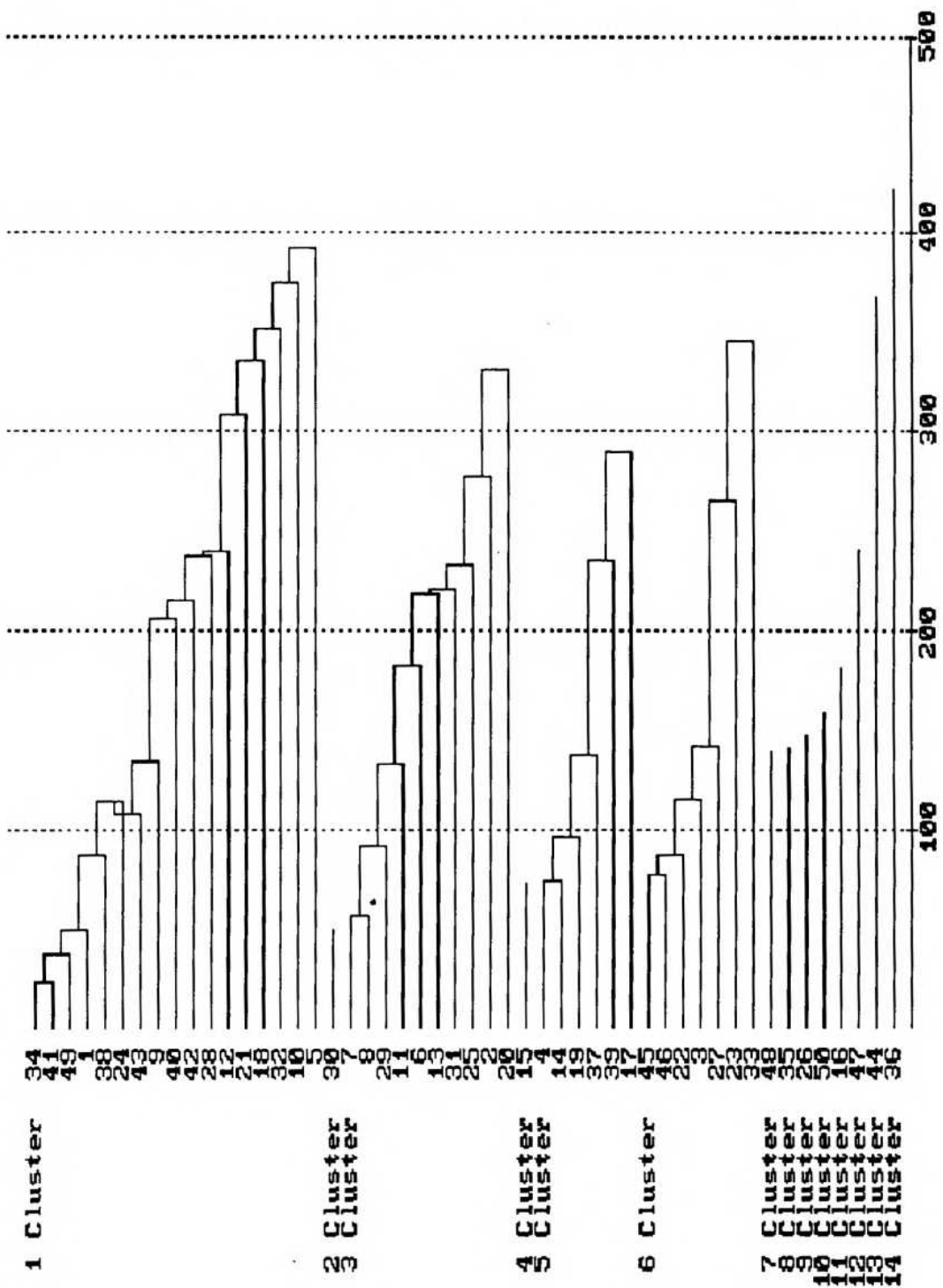


Fig. 3. Clustering for fifty genotypes in finger millet based on ten characters

Table 15. Average intra (in bold) and inter cluster D^2 distances

Cl. No	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	17.01	21.69	28.29	22.32	45.44	25.24	30.46	35.07	24.00	35.89	34.08	28.84	48.75	31.79
2	21.69	0.00	16.02	28.07	57.76	36.51	36.71	41.27	21.59	44.54	31.29	30.64	56.23	30.40
3	28.29	16.02	16.52	37.90	66.44	44.71	46.96	50.96	21.33	53.42	26.42	40.90	66.25	28.80
4	22.32	28.07	37.90	0.00	34.07	20.03	12.96	20.99	38.98	18.42	49.99	17.52	31.48	45.19
5	45.44	57.76	66.44	34.07	15.96	28.13	27.19	27.14	62.45	24.66	73.39	36.71	23.28	67.15
6	25.24	36.51	44.71	20.03	28.13	16.20	21.78	23.56	40.23	24.23	50.98	25.35	34.25	44.98
7	30.46	36.71	46.96	12.96	27.19	21.78	0.00	15.25	47.60	12.62	59.59	15.48	21.07	54.90
8	35.07	41.27	50.96	20.99	27.14	23.56	15.25	0.00	51.94	18.65	65.93	22.26	20.69	54.37
9	24.00	21.59	21.33	38.98	62.45	40.23	47.60	51.94	0.00	53.81	13.47	44.14	67.40	20.53
10	35.89	44.54	53.42	18.42	24.66	24.23	12.62	18.65	53.81	0.00	65.05	21.08	19.13	59.88
11	34.08	31.29	26.42	49.99	73.39	50.98	59.59	63.93	13.47	65.05	0.00	55.71	79.21	22.49
12	28.84	30.64	40.90	17.52	36.71	25.35	15.48	22.26	44.14	21.08	55.71	0.00	30.19	52.76
13	48.75	56.23	66.25	31.48	23.28	34.25	21.07	20.69	67.40	19.13	79.21	30.19	0.00	72.59
14	31.97	30.40	28.80	45.19	67.15	44.98	54.90	54.37	20.5	59.88	22.49	52.76	72.59	0.00

followed by the inter cluster distance between cluster V and XI (73.39), XIII and XIV (72.59), IX and XIII (67.40), V and XIV (67.15), VIII and XI (65.93) and it was least between cluster VII and X (12.62).

4.4.3. Cluster mean values of characters

The cluster mean values for different characters are presented in Table 16. Perceptible differences were observed in cluster mean values for all characters under consideration.

Among the fourteen clusters, cluster XII showed the highest mean value for plant height (136.88 cm). Cluster V showed the highest mean values for days to fifty per cent flowering (85.88) and culm thickness (3.65 cm); cluster IV for number of fingers (9.88); Cluster X for finger length (14.22 cm), cluster XI thousand grain weight (3.07 g), cluster XIII for number of leaves (21.70) and number of fingers (9.88) and cluster XIV for number of productive tillers (15.01) and grain yield (85.02 g).

Cluster II recorded the lowest mean value for thousand grain weight (2.29 g). Cluster IX recorded the lowest mean values for culm thickness (2.87 cm), number of fingers (6.07) and finger length (7.20 cm), cluster X had the lowest mean values for number of productive tillers (4.99) and peduncle length (19.77 cm), cluster XI recorded the lowest mean values for days to fifty per cent flowering (64.33) and grain yield (24.93 g) and cluster XIV recorded the lowest mean values for plant height (86.72) and number of leaves (11.10). The accessions of cluster XI were earlier in flowering (64.33) and that of cluster V was late (85.88).

4.4.4. Contribution of characters to genetic divergence

The relative contribution made by each character to genetic divergence is presented in Table 17 and Fig. 4.

Table 16. Cluster mean values for ten characters of fifty genotypes of finger millet

Cl. No	Days to 50% flowering	Plant height (cm)	Culm thickness (cm)	No. of product. tillers	No. of leaves	Peduncle length (cm)	No. of fingers	Finger length	1000 grain weight (g)	Grain yield (g)
1	72.13	104.09	3.43	7.28	15.40	22.67	8.70	8.85	2.75	41.06
2	67.0	108.97	3.03	8.71	16.40	23.49	8.62	8.09	2.29	47.42
3	64.36	104.90	3.47	8.78	15.35	22.57	8.31	9.91	2.84	44.41
4	75.33	95.44	3.52	5.77	18.51	21.83	9.88	9.94	2.39	46.22
5	85.88	117.14	3.65	7.50	18.32	22.06	8.03	8.39	2.65	49.66
6	78.57	113.87	3.55	7.62	16.12	21.36	8.44	9.21	2.50	51.81
7	78.0	109.60	3.22	7.89	19.98	22.66	7.87	9.31	2.55	43.69
8	79.0	118.33	3.50	11.66	19.16	21.38	7.88	8.44	2.88	84.55
9	67.0	99.44	2.87	9.33	12.96	23.22	6.70	7.20	2.91	34.81
10	80.0	104.22	3.43	4.99	20.02	17.77	8.88	14.22	2.75	43.14
11	64.33	92.32	3.32	7.72	11.23	22.49	8.0	7.66	3.07	24.93
12	75.0	136.88	3.12	5.66	19.42	23.16	8.04	12.99	2.54	43.95
13	83.66	127.33	3.42	7.81	21.70	22.44	9.88	9.66	2.71	58.27
14	67.0	86.72	3.61	15.01	11.10	20.60	8.52	7.57	2.51	85.02

Table 17. Relative contribution of characters towards divergence in finger millet.

S/No	Characters	Number of first ranks.	Percentage of contribution towards divergence.
1	Days to fifty per cent flowering	877	71.59
2	Plant height	38	3.10
3	Culm thickness	8	0.65
4	Number of productive tillers	2	0.16
5	Number of leaves	229	18.69
6	Peduncle length	1	0.08
7	Number of fingers	15	1.22
8	Finger length	10	0.82
9	Thousand grain weight	11	0.90
10	Grain yield	34	2.78

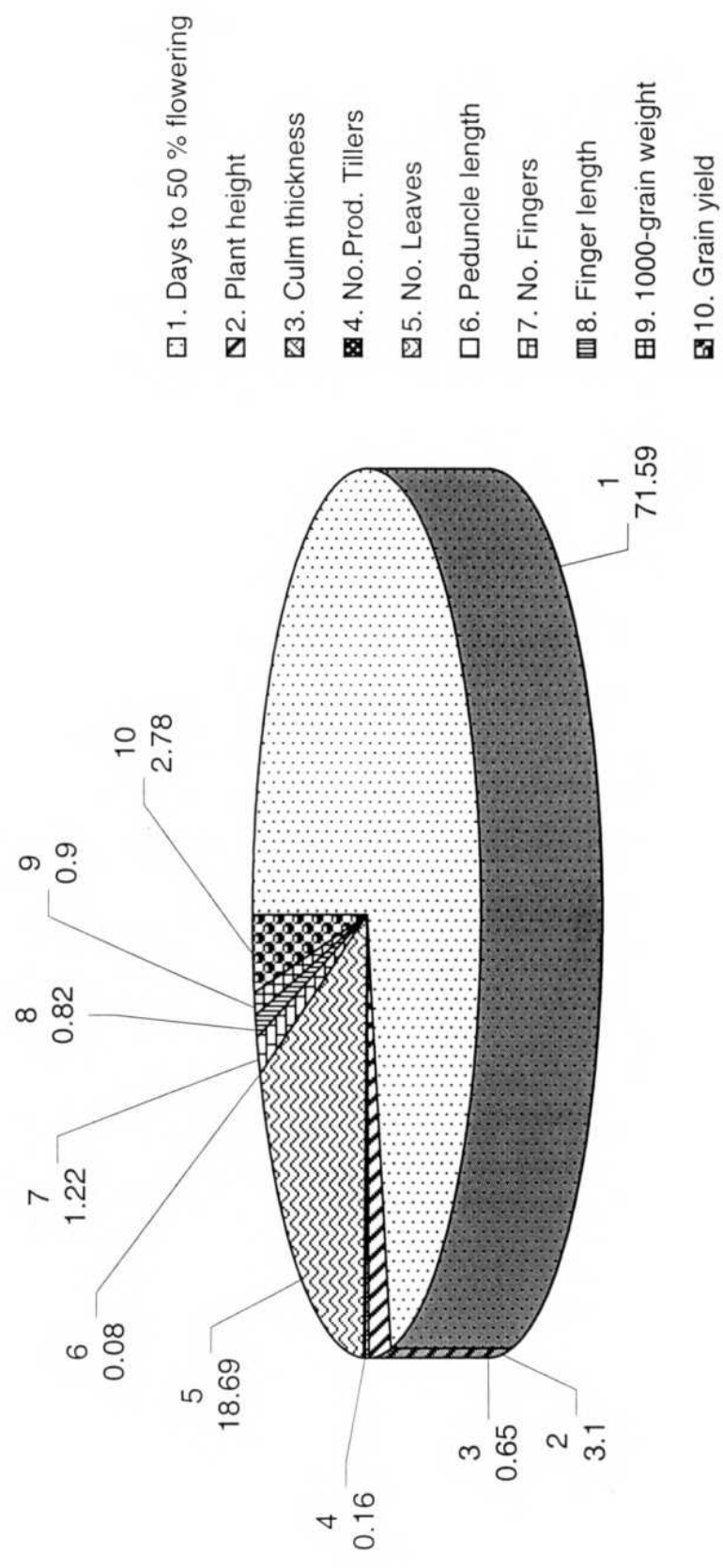


Fig. 4. Contribution of different characters towards genetic divergence

Maximum contribution to genetic divergence was made by days to fifty per cent flowering (71.59%) followed by number of leaves (18.69%), plant height (3.10%), grain yield (2.78%), number of fingers (1.22%), 1000 grain weight (0.90%), finger length (0.82%), culm thickness (0.65%), number of productive tillers 0.16 and the lowest contribution was recorded for peduncle length (0.08%).

4.5. Salinity tolerance studies

(i) Germination percentage

There was significant differences among the genotypes for germination at different salinity levels. The interaction of the genotypes with different salinity levels was also found to be significant. The germination percentage was found to reduce with the increase in salinity level in all the genotypes studied (Table 18).

The mean germination percentage of the genotypes under four levels viz. 4, 8, 12 and 16 dSm⁻¹ ranged from 8.33 per cent (CO 9) to 69.99 per cent (PY 1). The second ranking genotype for tolerance was TRY 1 (69.16%) followed by MS 870 (58.33%), CO 12 (56.66%) and TNAU 915 (55.83). Among these high ranking genotypes PY 1 and TRY 1 gave 63.33 per cent and 60.0 per cent germination at 12 dSm⁻¹ respectively and 50.0 per cent and 53.33 per cent at 16 dSm⁻¹ respectively. The genotypes, MS 870, CO 12 and TNAU 915, gave 43.33 per cent, 53.33 per cent and 56.66 per cent at 12 dSm⁻¹ respectively and 13.33 per cent, 46.66 per cent and 21.33 per cent at 16 dSm⁻¹ respectively (Table).

The lowest tolerance for germination was shown by CO 9 (8.33%) followed by OUAT 2 (9.16%), L 211 (13.33%) and DPI 1894 (13.33%).

(ii) Seedling root length

Seedling root length of the genotypes differed significantly at different salinity levels. The increase in salt concentration reduced seedling root length. The seedling root length of each genotype at control and at four salinity levels is given in Table 19.

Table 18. Germination (%) of fifty genotypes of finger millet against salinity stress at four levels

Sl. No	Genotypes	Control	Salinity stress level				Mean
			4 dSm ⁻¹	8 dSm ⁻¹	12 dSm ⁻¹	16 dSm ⁻¹	
1.	CO9	86.66 (68.86)	20.00(26.57)	13.33(21.14)	0.00(0.00)	0.00(0.00)	8.33(23.31)
2.	CO10	90.00(75.00)	66.66(54.78)	50.00(45.00)	33.33(35.21)	0.00(0.00)	37.49(42.00)
3.	CO11	93.33(77.71)	60.00(51.14)	33.33(35.21)	16.66(26.57)	3.33(6.14)	28.33(39.35)
4.	CO12	73.33(75.00)	66.66(54.78)	60.00(50.77)	53.33(46.92)	48.66(43.07)	56.66(54.13)
5.	CO13	93.33(81.14)	73.33(59.00)	53.33(46.92)	26.66(30.99)	23.33(28.78)	44.16(49.37)
6.	TNAU1	86.66(72.29)	56.66(48.84)	20.00(26.57)	6.66(12.28)	0.00(0.00)	20.83(31.99)
7.	TNAU3	93.33(77.71)	66.66(54.78)	43.33(41.15)	26.66(30.99)	10.00(18.43)	36.66(44.61)
8.	TNAU4	86.66(72.29)	66.66(54.78)	36.66(37.22)	13.33(21.14)	0.00(0.00)	29.16(37.08)
9.	TNAU5	83.33(66.14)	46.66(43.07)	26.66(30.99)	10.00(18.44)	0.00(0.00)	20.23(31.73)
10.	TNAU8	83.33(66.14)	46.66(43.07)	33.33(35.01)	0.00(0.00)	0.00(0.00)	19.99(28.84)
11.	TNAU896	83.33(66.14)	46.66(43.07)	23.33(30.99)	3.33(6.14)	0.00(0.00)	18.33(29.27)
12.	TNAU915	93.33(81.14)	80.00(63.43)	63.33(52.77)	56.66(48.8)	23.33(26.57)	55.83(54.55)
13.	TNAU946	86.66(68.86)	50.00(45.00)	36.66(37.22)	13.33(21.14)	0.00(0.00)	24.99(34.44)
14.	TNAU972	86.66(72.29)	60.00(50.77)	30.00(33.21)	13.33(21.14)	10.00(18.43)	28.33(39.16)
15.	AF260	80.00(63.43)	63.33(52.77)	26.66(30.99)	13.33(21.14)	10.00(18.43)	28.33(37.35)
16.	AF261	86.66(68.86)	53.33(46.92)	36.66(37.22)	20.00(26.57)	6.66(12.28)	29.16(38.37)
17.	AF262	93.33(81.14)	46.66(43.07)	16.66(23.85)	16.66(23.85)	0.00(0.00)	19.99(34.38)
18.	AF263	96.66(83.86)	76.66(61.21)	26.66(30.99)	16.66(23.85)	6.66(12.28)	31.66(42.44)
19.	AF265	100.00(90.00)	63.33(52.77)	53.33(46.92)	16.66(23.85)	10.00(18.44)	35.83(46.40)
20.	AF266	86.66(72.29)	80.00(63.43)	30.00(36.21)	20.00(26.53)	6.66(12.28)	34.16(41.55)
21.	AF267	86.66(72.29)	53.33(46.92)	20.00(26.57)	10.00(18.43)	3.33(6.17)	21.66(34.07)
22.	AF268	93.33(77.71)	76.66(61.21)	53.33(46.92)	2.00(26.57)	3.33(6.07)	33.33(43.70)
23.	GEI789	83.33(66.14)	60.00(50.77)	36.66(37.22)	6.66(12.28)	3.33(6.14)	26.66(34.51)
24.	GEI914	96.66(83.86)	80.00(63.43)	56.66(48.84)	40.00(39.23)	16.66(23.85)	48.33(51.84)
25.	GE15	93.33(81.14)	63.66(52.77)	43.33(41.15)	20.00(26.57)	6.66(12.30)	33.41(42.78)
26.	GEI824	90.00(71.57)	76.66(61.21)	46.66(43.07)	36.66(37.22)	23.33(28.78)	45.82(48.37)
27.	GEI323	93.33(81.14)	66.66(54.78)	43.33(41.15)	20.00(26.57)	10.00(18.43)	34.99(44.41)
28.	GEI622	90.00(75.00)	53.33(46.92)	50.00(45.00)	36.66(37.22)	6.66(23.85)	36.66(45.60)
29.	GEI462	100.00(90.00)	76.66(61.21)	26.66(30.99)	16.66(23.85)	0.00(0.00)	29.99(41.21)
30.	GEI823	86.66(72.29)	43.33(41.15)	26.66(30.99)	16.66(23.85)	10.00(18.47)	24.16(37.35)

(Contd..)

Table 18. (Contd..)

Sl. No	Genotypes	Control	Salinity stress level				Mean
			4 dSm ⁻¹	8 dSm ⁻¹	12 dSm ⁻¹	16 dSm ⁻¹	
31.	GEI524	93.33(81.14)	53.33(46.92)	36.66(37.22)	20.00(26.57)	6.66(12.30)	29.16(40.83)
32.	MS3019	100.00(90.00)	83.33(66.14)	26.66(30.99)	10.00(18.43)	3.33(6.14)	30.83(42.34)
33.	MS899	93.33(77.71)	50.00(45.00)	16.66(23.85)	10.00(18.43)	0.00(0.00)	19.16(33.00)
34.	MS3015	83.33(72.29)	60.00(50.77)	43.33(41.15)	20.00(26.57)	10.00(18.43)	33.33(41.84)
35.	MS3221	100.00(90.00)	73.33(59.00)	43.33(41.15)	20.00(26.57)	6.66(12.28)	35.83(45.80)
36.	MS870	96.66(83.86)	93.33(77.71)	83.33(66.14)	43.33(41.15)	13.33(21.14)	58.33(58.00)
37.	MS3236	80.00(63.43)	46.66(43.07)	26.66(30.99)	6.66(12.28)	0.00(0.00)	19.99(29.95)
38.	MS3016	96.96(83.86)	63.33(52.77)	40.00(39.23)	23.33(28.78)	10.00(18.43)	34.16(44.61)
39.	VL149	100.00(90.00)	73.33(59.00)	43.33(41.15)	26.66(30.99)	20.00(26.57)	40.83(49.54)
40.	PES400	100.00(90.00)	83.33(66.14)	23.33(28.78)	13.33(21.14)	6.66(12.28)	31.66(43.67)
41.	DPI894	80.00(63.43)	40.00(39.23)	13.33(21.14)	0.00(0.00)	0.00(0.00)	13.33(24.76)
42.	HR374	96.66(83.86)	73.33(59.00)	46.66(43.07)	26.66(30.99)	20.00(26.57)	41.66(48.70)
43.	Indaf11	63.33(52.67)	43.33(41.15)	33.33(35.21)	6.66(12.28)	0.00(0.00)	20.83(28.26)
44.	PES110	80.00(63.43)	46.66(43.07)	23.33(28.78)	10.00(18.43)	3.33(6.14)	20.83(31.97)
45.	RAU8	86.66(72.29)	43.33(41.15)	23.33(28.78)	0.00(0.00)	0.00(0.00)	16.66(28.44)
46.	PY1	96.66(83.86)	86.66(68.85)	80.00(63.43)	63.33(52.77)	50.00(45.00)	69.99(62.78)
47.	L211	63.33(52.71)	40.00(39.23)	13.33(21.14)	0.00(0.00)	0.00(0.00)	16.66(22.61)
48.	OUAT2	86.66(72.29)	23.33(28.78)	10.00(18.43)	3.33(6.07)	0.00(0.00)	9.16(25.11)
49.	PR202	93.33(77.71)	66.66(54.78)	46.66(43.07)	16.66(23.85)	10.00(18.43)	34.99(43.57)
50.	TRY1	100.00(90.00)	86.66(72.28)	76.66(61.21)	60.00(50.77)	53.33(46.92)	69.16(64.23)
	Mean	89.32	60.80	37.32	19.24	9.06	43.14

* Transformed values are given within parenthesis

	SED	CD (0.05)	CD(0.01)
Genotypes	2.145	4.215	5.548
Salinity stress level	0.678	1.333	1.754
Geno x salinity stress	4.797	9.425	12.406

Table 19. Seedling root length (cm) of fifty genotypes of finger millet against salinity stress at four levels

Sl. No	Genotypes	Salinity stress level					Mean
		Control	4dSm ⁻¹	8dSm ⁻¹	12dSm ⁻¹	16dSm ⁻¹	
1	CO 9	3.03	2.03	1.10	0.00	0.00	0.78
2	CO10	6.63	4.36	2.46	1.50	0.00	2.08
3	CO11	7.16	4.36	1.50	1.26	0.33	1.86
4	CO12	5.20	4.46	2.93	2.43	1.96	2.94
5	CO13	6.96	5.36	2.86	2.30	0.40	2.73
6	TNAU1	3.06	1.30	0.46	0.10	0.00	0.46
7	TNAU3	2.20	2.06	0.40	0.13	0.10	0.67
8	TNAU4	3.60	2.53	1.46	1.20	0.00	1.28
9	TNAU5	4.26	2.46	0.40	0.30	0.10	0.72
10	TNAU8	3.36	2.30	0.60	0.00	0.00	0.70
11	TNAU896	3.13	1.76	0.96	0.10	0.00	0.70
12	TNAU915	2.63	1.30	0.96	0.30	0.13	0.67
13	TNAU946	3.46	2.03	0.80	0.40	0.00	0.80
14	TNAU972	4.96	2.20	1.56	0.56	0.16	1.12
15	AF260	2.56	1.10	0.53	0.26	0.16	0.51
16	AF261	2.50	1.23	1.03	0.56	0.20	0.75
17	AF262	4.46	2.63	0.86	0.33	0.00	0.95
18	AF263	2.40	0.76	0.43	0.26	0.10	0.38
19	AF265	2.36	0.93	0.56	0.43	0.16	0.52
20	AF266	3.30	2.23	0.53	0.23	0.06	0.76
21	AF267	4.10	1.43	0.83	0.43	0.00	0.67
22	AF268	3.00	2.43	1.93	1.50	0.33	1.54
23	GE1789	4.16	1.36	0.83	0.16	0.06	0.60
24	GE1914	4.53	2.20	1.06	0.56	0.33	1.03
25	GE15	2.30	0.86	0.46	0.23	0.10	0.41
26	GE1824	3.83	2.10	0.80	0.43	0.30	0.90
27	GE1323	2.50	1.50	1.16	0.50	0.23	0.84
28	GE1622	3.40	1.10	0.50	0.30	0.16	0.51
29	GE1462	2.53	1.30	0.83	0.40	0.06	0.64
30	GE1823	3.10	1.06	0.70	0.23	0.10	0.52
31	GE1524	3.00	1.46	1.16	0.76	0.26	0.91
32	MS3019	3.36	2.10	1.06	0.30	0.06	0.88
33	MS899	3.06	1.53	1.06	0.36	0.00	0.73
34	MS3015	3.23	0.76	0.53	0.43	0.20	0.48
35	MS3221	2.76	1.06	0.66	0.43	0.30	0.61
36	MS870	2.90	2.60	2.03	1.66	0.20	1.62
37	MS3236	2.90	1.33	0.43	0.16	0.00	0.48
38	MS3016	3.46	2.40	0.96	0.33	0.20	0.97
39	VL149	3.06	2.63	1.96	1.53	1.10	1.80
40	PES400	5.93	3.73	1.73	1.40	0.76	1.90
41	DPI1894	1.76	1.16	0.43	0.00	0.00	0.39
42	HR374	5.70	4.63	2.80	2.26	2.03	2.93
43	Indaf11	5.90	4.53	2.33	0.13	0.00	1.74
44	PES110	2.86	1.46	0.30	0.23	0.13	0.53
45	RAU8	3.03	2.26	1.70	0.00	0.00	0.99
46	PY1	6.13	5.10	3.06	1.96	0.30	2.60
47	L211	2.36	1.33	0.70	0.00	0.00	0.50
48	OUAT2	2.36	1.06	0.70	0.20	0.00	0.49
49	PR202	5.06	3.93	2.36	0.80	0.36	1.86
50	TRY1	7.86	4.10	3.63	1.96	1.66	2.83
	Mean	3.74	2.24	1.22	0.64	0.26	1.62

	SED	CD (0.05)	CD(0.01)
Genotypes	0.076	0.150	0.197
Salinity stress level	0.024	0.047	0.062
Geno x Salinity stress	0.170	0.335	0.441

The mean seedling root length of the genotypes under four levels ranged from 0.38 cm (AF 263) to 2.94 cm (CO 12). The second ranking genotype for seedling root length was HR 374 (2.93 cm) followed by TRY 1 (2.83 cm), CO 13 (2.73 cm), PY 1 (2.60 cm) and CO 10 (2.08 cm). At 12 dSm⁻¹, the order of the genotypes showing high root length were CO 12 (2.43 cm), CO 13 (2.30 cm) and HR 374 (2.26 cm) and at 16 dSm⁻¹ these genotypes had seedling root length of 1.96 cm, 0.40 cm and 2.03 cm respectively. The genotypes PY 1, TRY 1 and MS 870 gave 1.96 cm, 1.96 cm and 1.66 cm at 12 dSm⁻¹ respectively and 0.30 cm, 1.66 cm and 0.20 cm at 16 dSm⁻¹ respectively.

The lowest salinity root length was observed in AF 263 (0.38 cm) followed by DPI 1894 (0.39 cm) and GE 15 (0.41 cm).

(iii) Seedling shoot length

The shoot length significantly decreased with the increase in salinity level in all the genotypes. The interaction of the genotypes with the different salinity levels was found to be significant.

The seedling shoot length of the fifty genotypes under each salinity level is presented in Table 20. The mean seedling shoot length of the genotypes under four salinity levels ranged from 0.33 cm (L 211) to 2.46 cm (PY 1). The other genotypes having higher root length were TRY 1 (2.31 cm), HR 374 (2.16 cm), PES 400 (1.96 cm) and CO 12 (1.83 cm). Among these genotypes, the maximum seedling shoot length at 12 dSm⁻¹ was recorded in HR 374 (2.23 cm) followed by PY 1 (2.16 cm) and PES 400 (1.96 cm) and at 16 dSm⁻¹ the genotypes showing maximum shoot length in order were TRY 1 (1.40 cm), CO 12 (1.40 cm), HR 374 (1.16 cm). The genotypes PY 1 and PES 400 at 16 dSm⁻¹ had 0.56 cm and 0.80 cm respectively. The genotypes TRY 1 and CO 12 had lesser shoot length at 12 dSm⁻¹ 1.56 cm and 1.80 cm respectively.

Table 20. Seedling shoot length (cm) of fifty genotypes of finger millet against salinity stress at four levels

Sl.No	Genotypes	Control	Salinity stress level				Mean
			4 dSm ⁻¹	8 dSm ⁻¹	12 dSm ⁻¹	16 dSm ⁻¹	
1	CO 9	3.66	2.10	0.50	0.00	0.00	0.65
2	CO10	3.63	2.53	2.13	1.16	0.00	1.45
3	CO11	5.20	2.46	2.03	1.23	0.30	1.50
4	CO12	3.33	2.16	1.96	1.80	1.40	1.83
5	CO13	3.16	2.26	2.10	1.93	0.26	1.63
6	TNAU1	2.26	2.03	1.53	0.30	0.00	0.96
7	TNAU3	1.76	1.13	0.80	0.36	0.23	0.63
8	TNAU4	2.70	2.10	1.46	0.73	0.00	1.07
9	TNAU5	2.16	1.33	1.10	0.30	0.13	0.71
10	TNAU8	2.70	2.16	1.00	0.00	0.00	0.79
11	TNAU896	2.26	2.06	1.03	0.16	0.00	0.81
12	TNAU915	2.16	1.20	0.90	0.16	0.10	0.59
13	TNAU946	1.73	1.03	0.89	0.73	0.00	0.66
14	TNAU972	2.53	1.36	1.20	0.40	0.13	0.77
15	AF260	2.26	1.53	1.03	0.60	0.20	0.84
16	AF261	2.60	1.36	1.13	0.33	0.10	0.73
17	AF262	2.33	2.03	0.83	0.20	0.00	0.76
18	AF263	2.20	2.03	0.96	0.40	0.10	0.87
19	AF265	2.93	1.56	1.23	1.06	0.23	1.02
20	AF266	2.46	2.06	0.96	0.40	0.10	0.88
21	AF267	2.66	1.76	1.00	0.43	0.00	0.79
22	AF268	2.40	2.06	1.50	0.66	0.06	1.07
23	GE1789	2.23	1.96	0.90	0.36	0.06	0.82
24	GE1914	3.26	2.30	1.46	1.16	0.30	1.30
25	GE15	2.00	1.56	1.23	1.00	0.10	0.97
26	GE1824	2.36	1.46	1.06	0.733	0.16	0.85
27	GE1323	2.86	1.53	1.13	0.70	0.26	0.90
28	GE1622	2.76	2.06	1.50	1.03	0.50	1.27
29	GE1462	2.23	2.00	0.86	0.33	0.03	0.80
30	GE1823	3.16	1.86	1.20	0.46	0.20	0.93
31	GE1524	2.33	1.96	1.50	0.46	0.10	1.00
32	MS3019	2.66	1.86	1.13	0.20	0.03	0.80
33	MS899	2.46	1.16	0.43	0.16	0.00	0.43
34	MS3015	3.16	1.46	1.33	0.93	0.23	0.98
35	MS3221	3.13	2.16	1.33	0.70	0.30	1.12
36	MS870	2.53	2.30	2.06	1.46	0.30	1.53
37	MS3236	2.26	1.53	0.66	0.26	0.00	0.61
38	MS3016	2.26	1.83	1.03	0.56	0.13	0.88
39	VL149	2.53	1.83	1.30	1.03	0.83	1.24
40	PES400	4.23	2.86	2.23	1.96	0.80	1.96
41	DPI1894	2.13	1.36	0.73	0.00	0.00	0.52
42	HR374	3.83	2.73	2.53	2.23	1.16	2.16
43	Indaf11	2.20	1.80	1.40	0.10	0.00	0.82
44	PES110	3.03	2.03	0.33	0.23	0.13	0.68
45	RAU8	2.26	2.10	1.50	0.00	0.00	0.9
46	PY1	4.90	4.03	3.10	2.16	0.56	2.46
47	L211	1.40	0.96	0.36	0.00	0.00	0.33
48	OUAT2	3.33	2.06	0.60	0.13	0.00	0.69
49	PR202	2.86	2.70	2.40	0.66	0.30	1.51
50	TRY1	4.10	3.23	3.06	1.56	1.40	2.31
	Mean	2.75	1.94	1.31	0.68	0.22	1.38

	SED	CD (0.05)	CD (0.01)
Genotypes	0.067	0.132	0.174
Salinity stress level	0.021	0.041	0.055
Geno x Salinity stress	0.150	0.296	0.390

The lowest seedling shoot length was recorded in L 211 (0.33 cm) followed by MS 899 (0.43 cm) and DPI 1894 (0.52 cm) and CO 9 (0.65 cm).

(iv) Mean seedling length

The increase in salinity level significantly influenced the mean seedling length. There was a progressive reduction in the mean seedling length with increased salinity (Table 21).

The highest mean value for seedling length was recorded in TRY 1 (5.51cm) followed by HR 374 (5.09 cm), PY 1 (5.07 cm), CO 12 (4.69 cm) and CO 13 (4.37 cm). The order of the mean seedling length of these genotypes at 12 dSm⁻¹ was HR 374 (4.50cm), CO 13 (4.23 cm), CO 12 (4.20 cm) PY 1 (4.13 cm) and TRY 1 (3.53 cm). At 16 dSm⁻¹, the highest ranking genotype for mean seedling length was HR 374 (3.20 cm) followed by TRY 1 (3.06 cm), CO12 (3.03 cm), VL 149 (1.03 cm) and PES 400 (1.56 cm). The two genotypes CO 13 and PY 1 which had high ranks at 12 dSm⁻¹ showed lesser shoot lengths at 16 dSm⁻¹ (0.66 cm and 0.86 cm respectively) compared to their high ranking counterparts at 12 dSm⁻¹.

The minimum mean seedling length was observed in L 211 (0.85 cm) followed by DPI 1894 (0.92 cm) OUAT 2 (1.19 cm) MS 3236 (1.06 cm) and PES 110 (1.23 cm).

(v) Seedling vigour index

The vigour index in terms of germination percentage and mean seedling length, showed a gradual decrease with increasing salinity (Table 22).

The mean vigour index of the genotypes observed under four levels ranged from 22 (OUAT 2) to 397 (PY 1). The maximum mean value was recorded in PY 1 (397) followed by TRY 1 (396), CO 12 (275), HR 374 (243) and CO 13 (238). Among these high ranking genotypes. TRY 1, PY 1 and CO 12 gave 268, 260 and 226 at 12 dSm⁻¹

Table 21. Mean Seedling length (cm) of fifty genotypes of finger millet against salinity stress at four levels

Sl.No	Genotypes	Salinity stress level					Mean
		Control	4dSm ⁻¹	8dSm ⁻¹	12dSm ⁻¹	16dSm ⁻¹	
1	CO 9	6.70	4.13	1.60	0.00	0.00	1.43
2	CO10	10.26	6.90	4.60	2.66	0.00	3.54
3	CO11	12.36	6.83	3.53	2.50	0.63	3.37
4	CO12	8.33	6.63	4.90	4.23	3.03	4.69
5	CO13	10.13	7.63	4.96	4.23	0.66	4.37
6	TNAU1	5.33	3.33	1.93	0.40	0.00	1.41
7	TNAU3	3.96	3.20	1.20	0.50	0.33	1.30
8	TNAU4	6.30	4.66	2.93	1.93	0.00	2.38
9	TNAU5	6.43	3.80	1.50	0.60	0.23	1.53
10	TNAU8	6.06	4.46	1.60	0.00	0.00	1.51
11	TNAU896	5.40	3.83	1.70	0.26	0.00	1.44
12	TNAU915	4.80	2.50	1.86	0.46	0.23	1.26
13	TNAU946	5.20	3.06	1.60	1.20	0.00	1.46
14	TNAU972	7.50	3.56	2.76	0.96	0.30	1.89
15	AF260	4.83	2.63	1.56	0.86	0.36	1.35
16	AF261	5.10	2.60	2.16	0.90	0.30	1.49
17	AF262	6.53	4.66	1.70	0.53	0.00	1.72
18	AF263	4.60	2.80	1.40	0.66	0.20	1.26
19	AF265	5.30	2.50	1.80	1.50	0.46	1.56
20	AF266	5.76	4.30	1.50	0.63	0.20	1.65
21	AF267	7.10	3.10	1.83	0.86	0.00	1.44
22	AF268	5.40	4.50	3.43	2.00	0.46	2.59
23	GE1789	6.40	3.33	1.13	0.50	0.00	1.24
24	GE1914	7.80	4.50	2.53	1.73	0.63	2.34
25	GE15	4.30	2.13	1.63	1.23	0.20	1.29
26	GE1824	6.20	3.56	1.86	1.16	0.46	1.76
27	GE1323	5.36	3.03	2.30	1.16	0.50	1.74
28	GE1622	5.16	3.16	2.00	1.33	0.66	1.78
29	GE1462	4.76	3.30	1.70	0.76	0.10	1.46
30	GE1823	6.26	2.93	1.90	0.70	0.30	1.45
31	GE1524	5.33	3.43	2.66	1.23	0.36	1.92
32	MS3019	6.03	3.96	2.20	0.50	0.10	1.69
33	MS899	5.53	2.70	1.50	0.53	0.00	1.81
34	MS3015	6.40	2.23	1.86	1.06	0.43	1.39
35	MS3221	5.90	3.23	2.00	1.13	0.60	1.74
36	MS870	5.43	4.90	4.10	3.13	0.50	3.15
37	MS3236	5.16	2.86	1.10	0.43	0.00	1.09
38	MS3016	5.73	4.23	2.00	0.90	0.33	1.86
39	VL149	5.60	4.46	3.26	2.56	1.93	3.05
40	PES400	10.16	6.60	3.96	3.36	1.56	3.87
41	DPI1894	3.90	2.53	1.16	0.00	0.00	0.92
42	HR374	9.53	7.36	5.33	4.50	3.20	5.09
43	Indaf11	8.10	6.33	3.73	0.23	0.00	2.57
44	PES110	5.90	53.50	0.63	0.53	0.26	1.23
45	RAU8	5.30	4.36	3.20	0.00	0.00	1.89
46	PY1	11.03	9.13	6.16	4.13	0.86	5.07
47	L211	3.76	2.30	1.10	0.00	0.00	0.85
48	OUAT2	5.70	3.13	1.30	0.33	0.00	1.19
49	PR202	7.93	6.63	4.76	1.50	0.66	3.38
50	TRY	11.96	7.33	6.70	3.53	3.06	5.51
	Mean	6.48	4.17	2.51	1.32	0.48	2.99

	SED	CD(0.05)	CD(0.01)
Genotypes	0.118	0.232	0.306
Salinity stress level	0.037	0.073	0.096
Geno.x salinity stress	0.264	0.520	0.684

Table 22. Seedling vigour index of fifty genotypes of finger millet against salinity stress at four levels

Sl. No	Genotypes	Control	Salinity stress level				Mean
			4dSm ⁻¹	8dSm ⁻¹	12dSm ⁻¹	16dSm ⁻¹	
1	CO 9	583.00	82.66	21.66	0.000	0.000	26.08
2	CO10	924.33	461.66	230.00	89.33	0.000	195.24
3	CO11	1155.33	425.66	118.33	42.66	6.33	148.24
4	CO12	751.00	442.33	294.00	226.66	140.00	275.74
5	CO13	945.33	560.00	264.00	113.66	16.00	238.41
6	TNAU1	462.66	188.66	38.66	4.00	0.000	57.83
7	TNAU3	370.33	231.00	51.66	14.00	3.33	70.49
8	TNAU4	479.33	311.00	107.33	27.00	0.000	111.33
9	TNAU5	535.33	176.66	40.33	6.00	0.000	55.74
10	TNAU8	506.66	209.33	54.66	0.000	0.000	65.99
11	TNAU896	450.00	179.00	43.66	2.66	0.000	56.33
12	TNAU915	480.00	200.00	114.00	27.00	6.33	86.83
13	TNAU946	450.00	153.33	59.66	15.66	0.000	57.16
14	TNAU972	650.00	214.00	83.00	13.00	3.00	78.25
15	AF260	370.66	166.66	42.00	11.33	3.66	55.91
16	AF261	442.00	121.00	80.00	18.00	3.00	55.5
17	AF262	608.00	218.00	28.33	8.66	0.000	63.74
18	AF263	445.00	181.33	37.00	11.66	2.00	57.99
19	AF265	530.00	158.00	96.66	25.66	4.33	71.32
20	AF266	501.33	344.00	45.00	12.66	2.00	100.91
21	AF267	615.33	169.00	36.66	8.66	0.000	53.58
22	AF268	503.00	345.33	182.66	40.00	0.66	142.16
23	GE1789	533.33	200.00	51.66	5.33	1.33	64.58
24	GE1914	754.00	360.00	142.33	69.33	10.66	145.58
25	GE15	402.66	135.00	70.00	24.66	2.00	57.91
26	GE1824	558.00	273.33	86.33	43.00	11.00	103.41
27	GE1323	500.66	202.00	100.00	23.33	5.000	82.58
28	GE1622	464.00	169.33	100.00	49.33	11.33	82.49
29	GE1462	476.66	253.33	45.33	12.33	0.000	77.74
30	GE1823	542.66	127.66	51.66	12.00	3.00	48.58
31	GE1524	499.33	183.33	99.33	24.66	3.66	77.74
32	MS3019	603.33	330.66	59.00	5.00	1.00	98.91
33	MS899	515.66	135.00	25.66	5.33	0.000	41.49
34	MS3015	555.33	134.00	81.33	21.33	4.33	60.24
35	MS3221	590.00	237.00	86.66	22.66	4.66	87.74
36	MS870	525.66	457.66	340.33	142.33	7.33	236.91
37	MS3236	413.33	134.33	29.00	4.33	0.000	41.91
38	MS3016	554.33	267.00	80.00	21.00	3.33	92.83
39	VL149	560.00	329.33	110.00	68.00	38.66	143.99
40	PES400	1016.66	554.33	92.00	45.33	15.66	176.83
41	DPI1894	312.00	101.33	15.66	0.000	0.000	29.24
42	HR374	923.00	540.33	249.33	121.33	64.00	243.74
43	Indaf11	516.00	275.66	122.66	1.66	0.000	99.99
44	PES110	472.00	163.66	14.66	5.33	1.00	46.16
45	RAU8	458.00	190.00	64.00	0.00	0.000	63.5
46	PY1	1069.66	791.66	493.33	260.33	43.33	397.16
47	L211	238.00	92.00	14.33	0.00	0.000	26.58
48	OUAT2	474.66	73.33	13.00	3.33	0.000	22.24
49	PR202	743.33	442.00	212.33	24.00	6.66	171.24
50	TRY1	1196.66	639.33	514.33	268.00	162.66	396.00
	Mean	584.55	266.28	109.27	40.03	11.82	202.39

	SED	CD(0.05)	CD(0.01)
Genotypes	13.36	26.25	34.55
Salinity stress level	4.225	8.301	10.92
Geno. x salinity stress	29.87	58.70	77.25

respectively and 162, 43 and 140 at 16 dSm⁻¹ respectively. The genotypes HR 374, MS 870 and CO 13 showed the vigour index of 121, 142 and 113 at 12 dSm⁻¹ respectively and 64, 7 and 16 at 16 dSm⁻¹ respectively.

The lowest tolerance for vigour index was expressed by OUAT 2 (22) followed by L 211 (26), CO 9 (26) and DPI 1894 (29).

DISCUSSION

CHAPTER V

DISCUSSION

Genetic and genotypic diversity in crop species is the gift of nature. With the advent of scientific principles over the past decades, the plant breeders have been increasingly cognizant of the importance of genetic diversity in crop plants. An insight into the extent and magnitude of variability present in the crop species is of utmost importance as it forms the basis of selection and thus enables execution of any effective crop improvement programme. Besides, its quantitative estimation would indicate the potentiality of the germplasm from where the selection of desirable types with desirable traits can be done, for maximizing the yield level. The yield and yield components of a breeding population are highly influenced by the environment which renders it difficult to conclude, whether the observed variability is heritable or not. It, therefore becomes essential to partition the observed variability into heritable and non-heritable components, by a study of the genotypic as well as phenotypic variations existing among the genotypes.

The results obtained in the present investigation are discussed in detail under the following heads.

- 5.1. *Per se* performance of genotypes
- 5.2. Genetic variability
- 5.3. Correlation studies
- 5.4. Path analysis
- 5.5. Genetic divergence
- 5.6. Salinity tolerance

5.1. *Per se* performance of genotypes

Finger millet is one of the important small millets. It comes up in a wide range of environment even under adverse conditions. It is grown for either grain and or fodder. Among the fifty genotypes of finger millet studied, as many as fourteen genotypes viz., CO 11, TNAU 3, TNAU 4, TRY 1, TNAU 8, AF 261, AF 266, AF 268, GE 18724, GE 1524, MS 3015, MS 3221, MS 870 and Indaf 11 were outstanding in performance for grain yield.

In addition to high *per se* performance for grain yield, these genotypes showed high *per se* performance for a number of other yield attributes also. As for example, MS 3221, the top ranking genotype for grain yield, had high mean value for number of productive tillers. Similarly, TRY 1 had high mean values for 1000 grain weight, number of fingers and finger length. Indaf 11 had high mean values for number of leaves, days to 50 per cent flowering, plant height, number of fingers and finger length. All these fourteen genotypes with high *per se* performance for grain yield and a number of other characters related to yield would deserve consideration for use in crop improvement work.

Eight genotypes viz., TNAU 915, AF 265, GE 1823, GE 1914, AF 260, TNAU 8, TNAU 1 and CO 10 could be identified as early ones to come to fifty per cent flowering and these would be useful in hybridization programme to induce earliness in the resultant hybrids and hybrid derivatives.

When parents with high *per se* performance are involved in hybridization work, the resultant hybrids or hybrid derivatives are generally found with the expression of high heterosis or good recombination potential (Gilbert, 1958). A consideration to the effect that the genotypes with high *per se* performance would be useful in breeding work and would lead to the identification of a good number of potential genotypes. They are as summarized below.

Sl. No	Characters	Genotypes
1.	Days to 50 per cent flowering	Longer duration – CO 12, AF 263, TNAU 946, AF 261, AF 268. Shorter duration – TNAU 915, AF 265, GE 1823, GE 1914, AF 260.
2.	Plant height	PY 1, Indaf 11, MS 870, MS 3016, AF 268
3.	Culm thickness	AF 261, TNAU 4, GE 1824, TNAU 8, AF 265
4.	Number of productive tillers	MS 3221, GE 1462, MS 870, MS 3015, GE 1824
5.	Number of leaves	Indaf 11, PR 202, L211, AF 261, PY1
6.	Peduncle length	AF 268, TRY 1, MS 3236, TNAU 896, TNAU 946
7.	Number of fingers	DPI 1894, AF 262, TNAU 896, TNAU 972, Indaf 11
8.	Finger length	PR 202, TNAU 4, PY 1, TNAU 8, TRY 1
9.	Thousand grain weight	TRY 1, TNAU 1, TNAU 896, TNAU5, TNAU 946, CO 10
10.	Grain yield	MS 3221, MS 3015, GE 1824, CO 11, AF 268

5.2. Genetic variability

Genetic variability studies provide basic information regarding the genetic properties of the population, based on which, breeding methods are formulated for further improvement of the crop. These studies are also helpful to know about the nature and extent of variability attributable to different causes, sensitive nature of the crop to environmental influences, heritability of the characters and genetic advance that can be realised in practical breeding.

In the present study, the traits days to fifty per cent flowering, plant height, number of leaves, number of fingers, finger length, thousand grain weight and grain yield showed narrow differences between phenotypic and genotypic coefficients of variation indicating the very low effect of environment and greater role of genetic factors on the expression of these traits. Culm thickness, number of productive tillers and peduncle length showed slight differences between phenotypic and genotypic coefficients of variation suggesting their vulnerability to environment.

High GCV estimates were recorded for number of productive tillers, finger length and grain yield. The traits plant height, number of leaves, number of fingers, thousand grain weight had moderate GCV values. High GCV estimates of productive tillers, finger length and grain yield were obtained by Mahudeswaran and Murugesan (1973), Patnaik and Jana (1973), Goud and Lakshmi (1977), Mallanna *et al.* (1978), Shanthappa (1980), Goswami and Asthana (1984), Abraham *et al.* (1989), Tyagi and Koranne (1989), Gontia (1992), Ravikumar and Seetharam (1994), Thakur and Saini (1995), Chunilal *et al.* (1996), Bandyopadhyay (1998) and Mahto *et al.* (2000).

The genotypic and phenotypic coefficients of variation indicated the extent of variability for different traits. For assessing the heritable variation, the magnitude of heritability is the most important aspect in the breeding material which has close bearing on the response to selection with fixable additive gene action. All the ten traits studied in the present investigation recorded high heritability in broad sense indicating high influence of genetic components. Similar results were reported in finger millet by Dhagat *et al.* (1972), Mahudeswaran and Murugesan (1973), Kempanna (1975), Chaudhari *et al.* (1977), Goud and Lakshmi (1977), Shanthappa (1980), Mishra *et al.* (1980a), Goswami and Asthana (1984), Sheriff *et al.* (1986), Ravikumar (1988), Suresh (1988), Verma *et al.* (1989),

Joshi and Mehra (1989), Abraham *et al.* (1989), Tyagi and Koranne (1989), Jayaprakash Naik (1991), Cauvery (1993), Marimuthu (1993), Ramaswamy *et al.* (1994), Thakur and Saini (1995), Suryakumar (1995), Ravi shankar *et al.* (1997) and Bandyopadhyay (1998).

Since heritability is also influenced by environment, the information on heritability alone may not help in pin pointing characters for enforcing selection. Nevertheless, the heritability estimates in conjunction with predicted genetic advance will be more reliable (Johnson *et al.*, 1955). Heritability gives the information on the magnitude of inheritance of quantitative traits, while genetic advance will be helpful in formulating suitable selection procedures.

High heritability along with high genetic advance (as % of mean) was observed for days to fifty per cent flowering, plant height, number of productive tillers, number of leaves, number of fingers, finger length, thousand grain weight and grain yield in the present investigation. Similar results were obtained in finger millet by Mahudeswaran and Murugesan (1973), Goud and Lakshmi (1977), Shanthappa (1980), Mishra *et al.* (1980a), Verma *et al.* (1989), Joshi and Mehra (1989), Abraham *et al.* (1989), Tyagi and Koranne (1989), Ramaswamy *et al.* (1994), Thakur and Saini (1995), Suryakumar (1995) and Bandyopadhyay (1998).

5.3. Correlation studies

Understanding of the interaction of the traits among themselves and with the environment is of great use in plant breeding. Correlation studies provide information on the nature and extent of association between any two metric traits and it would be possible to bring about genetic upgradation in one trait by selection of the other of a pair. An attempt was made to study the association prevailing among the ten metric traits in the fifty genotypes in the present investigation.

In general, the genotypic correlation coefficient values were higher than the phenotypic correlation coefficient values for all the traits, indicating that the strong association between the traits were mainly governed by genetic factors, while the phenotypic values were reduced by the significant interaction of the environment.

In the present study, at genotypic level culm thickness and number of productive tillers were significantly and positively correlated with grain yield. The positive correlation of productive tiller number with grain yield had been reported by several finger millet workers (Dhagat *et al.*, 1972; Michael Raj *et al.*, 1973; Appadurai *et al.*, 1977; Subramaniam *et al.* (1977), Prabhakar and Prasad (1983); Ravikumar (1988), Abraham *et al.* (1989); Basavaraja and Sheriff (1991), Cauvery (1993); Marimuthu (1993); Tamilcovane (1994); Suryakumar (1995); Ravindran *et al.* (1996) and Bandyopadhyay (1998).

From this it could be inferred that selection for high yield would be effective through selection of positively associated characters like culm thickness and number of productive tillers. Besides, these two characters showed high heritability and moderate and high genetic advance respectively and hence selection for these two characters is reliable.

Regarding the inter correlation between yield attributes, days to fifty per cent flowering had significant positive association with plant height and number of leaves. The trait plant height was significantly and positively associated with days to fifty per cent flowering, number of leaves, peduncle length and finger length. Number of leaves was significantly and positively correlated with days to fifty per cent flowering, plant height and finger length. Peduncle length was positively and significantly correlated with plant height and thousand grain weight. Number of fingers was positively and significantly correlated with finger length.

Finger length was significantly and positively correlated with plant height, number of leaves and number of fingers. Thousand grain weight was positively associated with peduncle length. This indicates the possibility of simultaneous improvement of these traits by a single selection programme.

5.4. Path analysis

The correlation measures the relationship existing between pairs of traits. But, a dependent trait is an interaction product of many mutually associated components. The path analysis takes into account the cause and effect relationship between the variables by partitioning the association into direct and indirect effects through other independent variables to yield or any such dependent variable.

In the present study, path analysis on grain yield revealed that number of productive tillers had high positive direct effect and culm thickness and number of leaves had moderate direct effect and this revealed the true relationship of these traits with grain yield and hence direct selection for these traits would be rewarding for yield improvement. Hence, direct selection for the traits could be practised to reduce the undesirable effect of other component traits studied.

Similar finding was reported in finger millet by Prabhakar and Prasad (1983), Ravikumar (1988), Suresh (1988), Chaudhary (1989), Jayaprakash Naik (1991), Cauvery (1993), Marimuthu (1993), Tamilcovane (1994) and Ravindran *et al.* (1996).

Regarding the indirect effect of component traits on grain yield, finger length had high indirect effect on grain yield through number of leaves and days to fifty per cent flowering.

Hence from the results, it could be inferred that the trait number of productive tillers culm thickness and number of leaves have to be accounted for direct selection for yield improvement. The low residual value indicated the adequacy of the characters chosen for path analysis.

5.5. Genetic divergence

In the present study, mahalanobis D^2 analysis was applied.

- (i) to assess the genetic divergence among the genotypes.
- (ii) to identify promising genotypes with more divergence to initiate crossing programme.
- (iii) to assess the contribution of different characters to genetic diversity.

Finger millet is cultivated under varied ecological conditions for both grain and fodder purposes. This crop has accumulated considerable diversity over the years for vegetative, reproductive and physiological characters.

In the present study Wilk's criterion has shown highly significant differences among genotypes for all characters which suggested the existence of considerable divergence. The cluster analysis suggested the resolution of fifty genotypes into fourteen clusters following Tocher's methods of clustering. Several finger millet workers obtained more than 10 clusters in the genotypes studied by them (Hussaini *et al.*, 1977; Xavier, 1979; Swamynath, 1979; Jain *et al.*, 1981; Singh and Singh, 1991; Reddy *et al.*, 1993 and Gupta and Srivastava, 1997).

Cluster I comprising of seventeen genotypes (MS 899, PES 400, OUAT2, CO 9, MS 3236, GE 1789, HR 374, TNAU 5, VL 149, DPI 1894, GE 1323, TNAU 896, AF 266, AA 262, GE 1524, TRY 1, CO 13) had the highest intracluster distance followed by cluster III with 10 genotypes (TNAU 3, TNAU 4, GE 1462, TNAU 8, TNAU 1, TNAU 915, GE 1823, GE 1914). Considering the inter cluster distances, it was the highest between cluster XI and XIII followed by the inter cluster distance of V and XI, XIII and XIV, IX and XIII, V and XIV, VIII and XI. Also, the mean performance of grain yield and other important contributing characters such as number of productive tillers and grain yield was the highest for cluster XIV. Cluster XII had the highest mean value for plant height and cluster XI was the earliest in terms of days to fifty per cent flowering. Keeping this in view, it appears that crosses between the genotypes with high *per se* performance belonging to cluster XIV, XII, V and XI in all possible combinations would exhibit high heterosis as well as high level of production. The following genotypes of outstanding mean performance from the selected clusters may serve as potential genotypes for any breeding programmes.

Cluster	Characters	Genotypes
V	Days to fifty per cent flowering long duration	CO 12, TNAU 946, AF 263
XI	Short duration	AF 260
XII	Plant height	PY 1
V	Culm thickness	AF 261, TNAU 946, MS 3016
XIV	Number of productive tillers	MS 3221
XIII	Number of leaves	Indaf 11
II	Peduncle length	GE 1622
IV and XIII	Number of fingers	TNAU 972, Indaf 11
X	Finger length	PR 202
XI	Thousand grain weight	AF 260
XIV	Grain yield	MS 3221

With regard to the contribution of the different characters towards the genetic divergence, it was found that the maximum contribution to the genetic divergence was accounted by days to fifty per cent flowering followed by number of leaves. The low contribution to genetic divergence by other characters may be due to the fact that selection towards uniformity in these characters could have caused an eroding effect on genetic diversity. Das and Borthakur (1973) showed that genetic variability was reduced in the course of selection. There is possibility of operation of a similar phenomenon in characters showing less contribution towards the genetic divergence in the present investigation.

5.6. Salinity tolerance

Finger millet is one of the cereal crops widely grown in semi arid areas both under rainfed and irrigated conditions. With increased irrigation facilities and poor water management practices, problem of soil salinity is being intensified day by day.

The problem is of much concern under arid and semi arid conditions. For better utilization of saline lands, it is essential to manage the salinity and/or to grow crops and their varieties resistant to salinity. Since reclamation of saline soils is a time taking and costly affair, it is urgently needed to identify crops and their genotypes, which can resist salinity.

It is obvious that even moderately resistant crops can be made fairly tolerant by proper breeding programme. But, before initiating such programme, it would be important to identify the genotypes showing salinity resistance at different stages of growth and also the traits attributing resistance to salinity. Research has shown that some of the drought tolerant crop plants are also moderately resistant to salinity (Fowler *et al.*, 1988). Finger millet being a drought tolerant crop (Hilu and De Wet, 1976; Bhandari, 1974) has been found to tolerate medium levels of salinity (Singaram, 1994).

Seed germination is the most critical and sensitive stage to salinity stress. Poor germination in saline soils leads to poor crop stand and the productivity. Increased salinity levels have been found to reduce germination in several cereals (Sharma, 1993; Ayman, 1995 and Ram, 1996). Considering these aspects in mind, in the present investigation, fifty genotypes of finger millet were evaluated at germination stage at four levels of salinity stress *viz.*, 4, 8, 12 and 16 dSm⁻¹, which were created through the use of combination of salts (NaCl, CaCl₂ and Na₂SO₄ in the ratio of 7:2:1 w/v). These salinity levels, were selected, because they correspond to what is commonly recognized as the low, medium and high salinities for the glycophytes (Richards, 1968).

In the present investigation for testing the level of tolerance of the fifty genotypes of finger millet against salinity stress at germination stage, the genotypes were grown in cups containing neutral sterile sand. Germination percentage and four seedling parameters *viz.*, seedling root length, seedling shoot length, mean seedling length and seedling vigour index were recorded on 7th day after sowing. The results obtained are discussed below.

(i) Germination

At the highest level of salinity stress *viz.*, 16 dSm⁻¹, among the fifty genotypes TRY 1 showed the maximum percentage of germination (53.33%) followed by PY 1 (50.0%). At 12 dSm⁻¹ also they performed well for germination (63.33% by PY 1 and 60.0% by TRY 1). However, the genotype MS 870 behaved differently at 12 dSm⁻¹ and at 16 dSm⁻¹ and its germination was much reduced at 16dSm⁻¹ compared to that of 12 dSm⁻¹.

The differential response of finger millet genotypes for germination at different salinity levels had been reported by Panigarh *et al.* (1978) and Onkware (1993). The drastic effect of higher salinity levels (above 12 dSm⁻¹) on the germination of finger millet had also been reported by Sarma *et al.* (1983) and Uma *et al.* (1995).

(ii) Seedling root length

At the maximum level of salinity stress *viz.*, 16 dSm⁻¹, the genotypes HR 374 and CO 12 ranked top in seedling root length (2.03 cm and 1.96 cm respectively). At 12 dSm⁻¹ also they performed well for root length (2.26 cm by HR 374 and 2.43 cm by CO 12). However, seedling root length of the genotypes PY 1 and CO 13 was greatly reduced at 16 dSm⁻¹ compared to that of 12 dSm⁻¹ (1.96 cm by PY 1 and 2.30 cm in CO13 at 12 dSm⁻¹).

This indicated that HR 374 and CO 12 tolerated salinity at both the highest levels of salinity, while CO 13 and PY 1 were drastically affected at 16 dSm⁻¹. The reduction in seedling root length due to increased salinity had been reported by Panigarh *et al.* (1978) in finger millet and other crops by Pearson *et al.* (1966).

(iii) Seedling shoot length

Similar to root length in the present investigation, shoot length also significantly decreased with the increase in salinity stress in finger millet. Among the genotypes TRY 1 and CO 12 showed the maximum shoot length (1.40 cm and 1.40 cm) at 16 dSm⁻¹.

At 12 dSm⁻¹ also they performed well for shoot length (1.56 cm by TRY 1 and 1.80 cm by CO 12). The genotypes PY 1 and CO 13 behaved differently at 12 dSm⁻¹ and at 16 dSm⁻¹. The shoot length was much reduced at 16 dSm⁻¹ compared to that at 12 dSm⁻¹ in these two varieties. The reduction of shoot length was found to accompany with increased salt stress in several crops (Torres and Echevarria, 1994; Farida Begum *et al.*, 1996; Singh *et al.*, 1998 and Singh and Singh, 1999).

(iv) Mean seedling length

Three genotypes *viz.*, HR 374, TRY 1 and CO 12 occupied one of the three top ranks for mean seedling length at 12 dSm⁻¹ as well as 16 dSm⁻¹. Two genotypes PY 1 and CO 13 which performed well for mean seedling length at 12 dSm⁻¹ was affected seriously at 16 dSm⁻¹. The salinity tolerance of each genotype / crop was found to vary with the level of salinity stress and each genotype / crop has a maximum tolerable limit of its own against salinity stress. The reduction of mean seedling length due to increased salinity had been reported in several crops by Abul-Baki and Anderson (1973) Torres and Echevarria (1994), Singh *et al.* (1998) and Singh and Singh (1999).

(v) Seedling vigour index

The vigour index in terms of germination percentage and mean seedling length showed a gradual decrease under increasing salinity as observed for other seedling characters. The maximum seedling vigour was observed in TRY 1 and CO 12 (162.66 and 140) at 16 dSm⁻¹. At 12 dSm⁻¹ also they performed well for seedling vigour (268 by TRY 1 and 226 by CO 12 respectively). However, the genotypes PY 1 and MS 870 had much reduced seedling vigour index at 16 dSm⁻¹ compared to that at 12 dSm⁻¹.

Reduction of seedling vigour due to salinity crops have been reported by Abul-Baki and Anderson (1973), Farida Begum *et al.* (1996), Powar and Mehta (1997) and Singh and Singh (1999) in different crops.

SUMMARY

CHAPTER VI

SUMMARY

A collection of fifty genotypes of finger millet (*Eleusine coracana* (L.) Gaertn.) was evaluated under randomized block design for yield and yield attributing characters viz. days to fifty per cent flowering, plant height, culm thickness, number of productive tillers, number of leaves, peduncle length, number of fingers, finger length, thousand grain weight and grain yield. The studies were carried out during kharif 2000. The objective of the study was to assess the mean *per se* performance of the genotypes, the extent of variability, association of grain yield and its components, the direct and indirect contribution of component traits to grain yield, the genetic divergence among the genotypes and the level of salinity tolerance of the genotypes. For salinity tolerance studies, the fifty genotypes were evaluated at four levels of salinity stress viz., 4, 8, 12 and 16 dSm⁻¹ by growing them in cups containing sterile neutral sand artificially added with a combination of salts viz., NaCl, CaCl₂ and Na₂SO₄ in the ratio of 7:2:1 w/v. The salient findings of the present investigation are summarized hereunder.

1. A wide range of variability existed for all the traits studied indicating the presence of significant variation among the genotypes.
2. The genotypes MS 3221, MS 3015, GE 1824, CO 11 and AF 268 were the best five with regard to grain yield.
3. The genotypes TNAU 915, AF 265, GE 1823, GE 1914 and AF 260 were identified as early for flowering and CO 12, AF 263, TNAU 946, AF 261 and AF 268 were late for flowering.
4. The genotypes PY 1, Indaf 11, MS 870, MS 3016 and AF 268 were taller than the other genotypes.

5. Regarding productive tillers, MS 3221, GE 1462, MS 870, MS 3015, GE 1824 were found to possess higher number of productive tillers.
6. The top three ranking genotypes for grain yield viz., MS 3221, MS 3015 and GE 1824 also had higher number of productive tillers and they were among the five top ranking genotypes for number of productive tillers.
7. High GCV estimates were recorded for number of productive tillers, finger length and grain yield. The traits plant height, number of leaves, number of fingers, thousand grain weight had moderate GCV values.
8. All the ten characters studied had high heritability indicating the high influence of genetic components.
9. All the characters except culm thickness and peduncle length had high heritability coupled with high genetic advance (per cent) indicating the governance of these eight characters by additive genes and thus these characters could be improved through selection in earlier generations.
10. Culm thickness and number of productive tillers were significantly and positively correlated with grain yield. These two characters also showed high heritability and moderate and high genetic advance (per cent) respectively indicating that the selection for these two characters can be relied upon for increasing yield.
11. Regarding the inter correlation between yield attributes, days to fifty per cent flowering had significant positive association with plant height and number of leaves. The trait plant height was significantly and positively associated with days to fifty per cent flowering, number of leaves, peduncle length and finger length. The number of leaves was significantly and positively correlated with days to fifty per cent flowering, plant height and finger length. Peduncle length

was positively and significantly correlated with plant height and thousand grain weight. Number of fingers was positively and significantly correlated with finger length. Finger length was significantly and positively correlated with plant height, number of leaves and number of fingers. Thousand grain weight was positively associated with peduncle length.

12. Number of productive tillers had high positive direct effect and culm thickness and number of leaves had moderate direct effects on grain yield indicating the true relationship of these traits with grain yield and direct selection for these traits could be practised to reduce the undesirable effect of other component traits studied.
13. Regarding the indirect effect of component traits on grain yield, finger length had high indirect effect on grain yield through number of leaves and days to 50 per cent flowering. The indirect effect of all the other traits were either low or negligible.
14. The fifty genotypes studied resolved into fourteen clusters through Mahalanobis D^2 analysis and the largest cluster consisted of seventeen genotypes (Cluster I).
15. The highest intracluster distance was observed in cluster I followed by cluster III with 10 genotypes.
16. Regarding the intercluster distance, it was the highest between cluster XI and cluster XIII followed by that between cluster V and XI. The lowest inter cluster distance was between the clusters VII and X.
17. Cluster XIV consisting of the sole genotype MS 3221 had the highest mean value for number of productive tillers and grain yield.
18. The maximum contribution to the genetic divergence was accounted by days to fifty per cent flowering followed by number of leaves.

19. Salinity tolerance studies at germination stage revealed significant differences among the genotypes for salinity tolerance at different levels for the seedling characters viz., germination percentage, seedling root length, seedling shoot length, mean seedling length and seedling vigour index.
20. At the highest level of salinity stress viz., 16 dSm⁻¹, TRY 1 showed the maximum percentage of germination followed by PY 1. At 12 dSm⁻¹ also they performed well for germination. However, some of the genotypes which showed tolerance at 12 dSm⁻¹ became susceptible at 16 dSm⁻¹.
21. At 16 dSm⁻¹ and 12 dSm⁻¹, the genotypes HR 374 and CO 12 ranked top in seedling root length. However, the genotype PY 1 and CO 12 had drastically reduced root length at 16 dSm⁻¹ compared that at 12 dSm⁻¹ indicating that HR 374 and CO 12 tolerated salinity at both the highest levels of salinity, while CO 13 and PY 1 were drastically affected at 16 dSm⁻¹.
22. Shoot length also significantly decreased with the increase in salinity stress similar to root length. Among the genotypes TRY 1 and CO 12 had the maximum shoot length at 16 dSm⁻¹ as well as 12 dSm⁻¹. The behaviour of PY 1 and CO 13 for shoot length at the two highest levels of salinity stress applied was similar to that of root length and the shoot length of these two genotypes drastically reduced at 16 dSm⁻¹ compared to that at 12 dSm⁻¹.
23. Three genotypes viz. HR 374, TRY 1 and CO 12 occupied one of the three top ranks for mean seedling length at 12 dSm⁻¹ as well as 16 dSm⁻¹. The two genotypes PY 1 and CO 13 which performed well for mean seedling length at 12 dSm⁻¹ was affected seriously at 16 dSm⁻¹.

24. The seedling vigour index in terms of germination percentage and mean seedling length showed a gradual decrease under increasing salinity as observed for other seedling characters. The maximum seedling vigour was observed in TRY 1 and CO 12 at 16 dSm^{-1} as well as at 12 dSm^{-1} . The seedling vigour of two genotypes PY1 and MS 870 was much reduced at 16 dSm^{-1} compared that at 12 dSm^{-1} . Regarding the grain yield of tolerant genotypes at normal soil, TRY 1 ranked 7th while, CO 12 ranked more than ten indicating its moderate yield level.



Plate 1. Field variation



Plate 2. Screening for salinity tolerance in cups filled with neutral sterile sand

A - Control, B - 4 dSm⁻¹, C - 8 dSm⁻¹, D - 12 dSm⁻¹, E - 16 dSm⁻¹

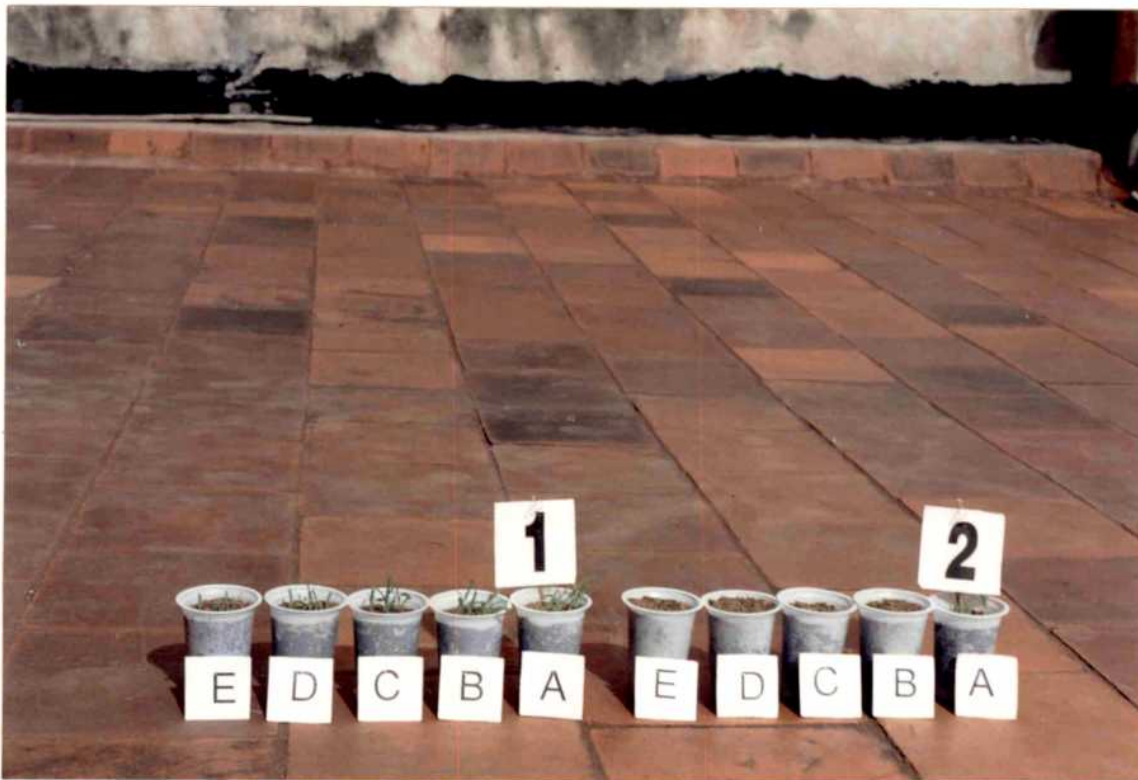


Plate 3. Comparison of tolerant genotype TRY 1 (1) and susceptible genotype CO9 (2) for salinity tolerance
 A - Control, B - 4 dSm^{-1} , C 8 dSm^{-1} , D - 12 dSm^{-1} , E - 16 dSm^{-1}



Plate 4. Performance of tolerant genotypes HR 374 (First row), PY1 (middle row) and TRY 1 (Rear row)

A - Control, B - 4 dSm^{-1} , C - 8 dSm^{-1} , D - 12 dSm^{-1} , E - 16 dSm^{-1}

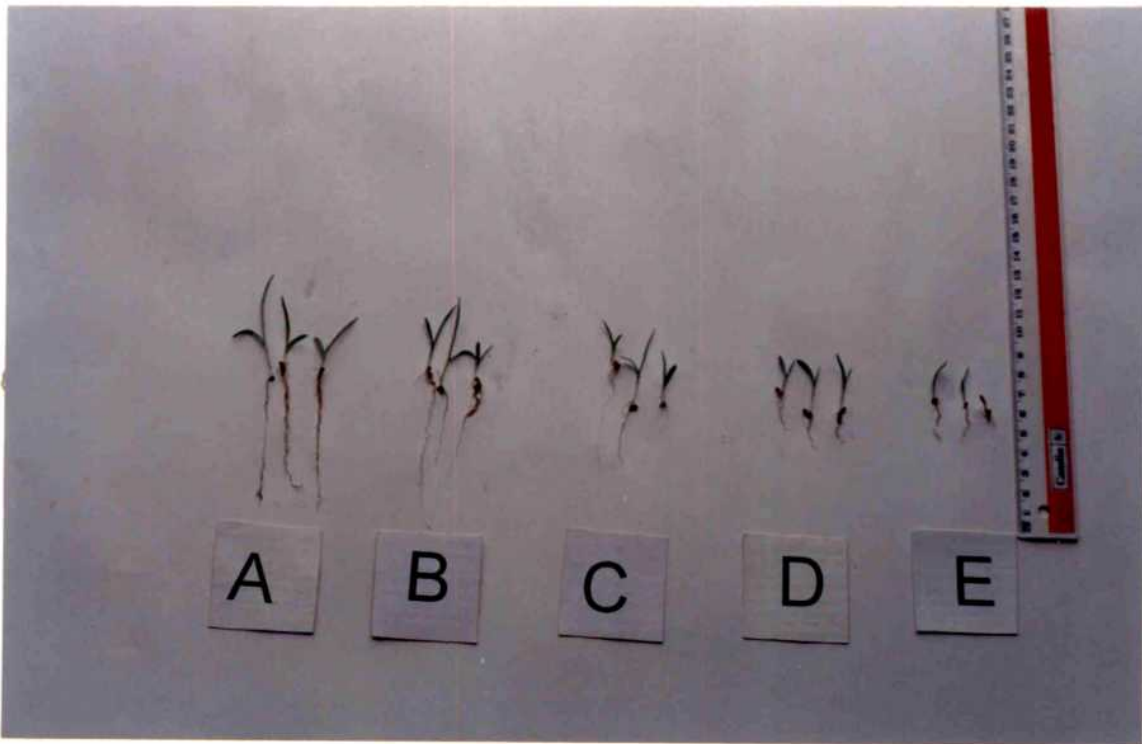


Plate 5. Seedling length variation in TRY 1 grown at different salinity stress levels.
 A - Control, B - 4 dSm⁻¹, C 8dSm⁻¹, D - 12 dSm⁻¹, E - 16 dSm⁻¹

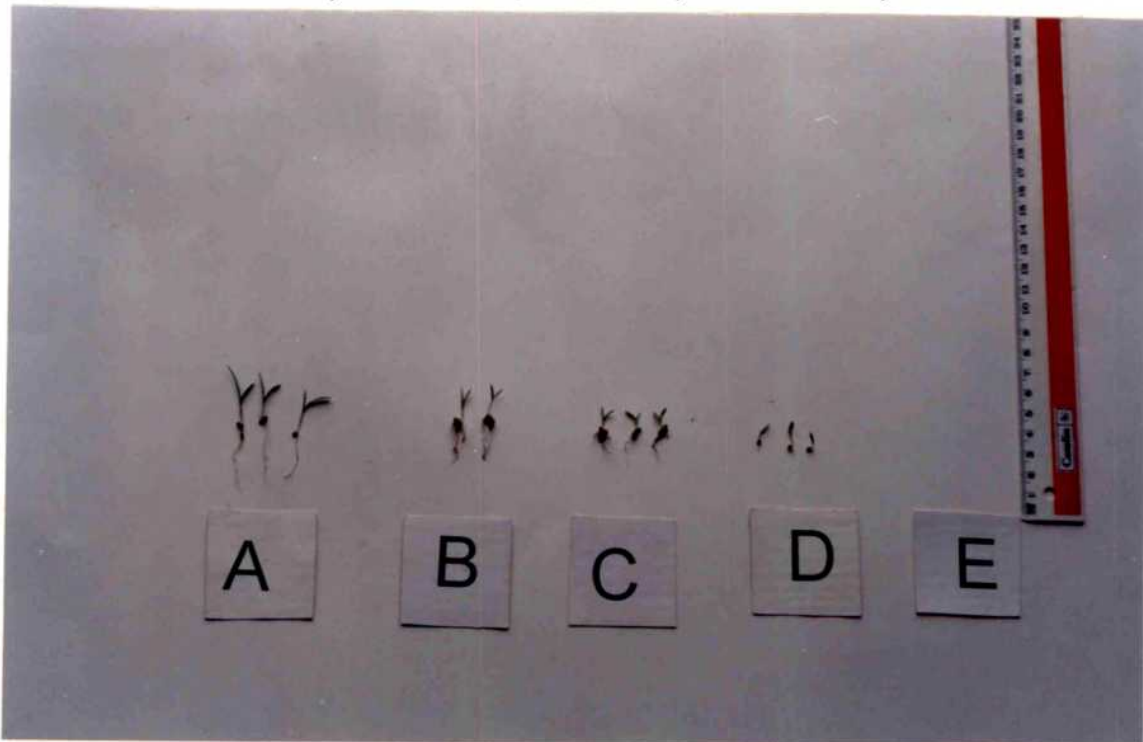
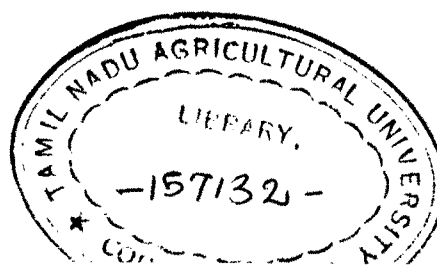


Plate 6. Seedling length variation in CO 9 grown at different salinity stress levels.
 A - Control, B - 4 dSm⁻¹, C 8dSm⁻¹, D - 12 dSm⁻¹, E - 16 dSm⁻¹

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*** Originals not seen**

