

“GENETIC DIVERSITY STUDIES IN FINGER MILLET
[*Eleusine coracana* (L.) Gaertn]”

BY

VIDHATE NILESH MAHADEO

B.Sc. (Agri.)

DEPARTMENT OF AGRICULTURAL BOTANY

(GENETICS AND PLANT BREEDING)

COLLEGE OF AGRICULTURE, BADNAPUR, DIST. JALNA

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PARBHANI 431 402 (M.S.), INDIA**

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**“GENETIC DIVERSITY STUDIES IN FINGER MILLET
[*Eleusine coracana* (L.) Gaertn]”**

DISSERTATION

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*Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
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IN

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PARBHANI – 431 402 (M.S.), INDIA**

2018

CANDIDATE'S DECLARATION

*I hereby declare that this dissertation
Or part thereof has not been
Previously submitted by me
For a degree of any
University or
Institute*

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CERTIFICATE - I

This is to certify that the dissertation entitled “**Genetic Diversity Studies in Finger Millet [*Eleusine coracana* (L.) Gaertn]**” submitted by Shri. **VIDHATE NILESH MAHADEO** to the College of Agriculture, Badnapur in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **GENETICS AND PLANT BREEDING (AGRICULTURAL BOTANY)** is record of original and bonafide research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree

I also certify that the dissertation or part thereof has not been previously submitted for a degree of any university. The assistance and help rendered during the course of investigation and sources of literature have been duly acknowledged.

Place: BADNAPUR

Date: / 05 /2018

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CERTIFICATE – II

This is to certify that the dissertation entitled “**Genetic Diversity Studies in Finger Millet [*Eleusine coracana* (L.) Gaertn]**” submitted by Shri. **VIDHATE NILESH MAHADEO** to the College of Agriculture, Badnapur in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **GENETICS AND PLANT BREEDING (AGRICULTURE BOTANY)** has been approved by the student’s advisory committee after viva-voce examination in collaboration with the external examiner.

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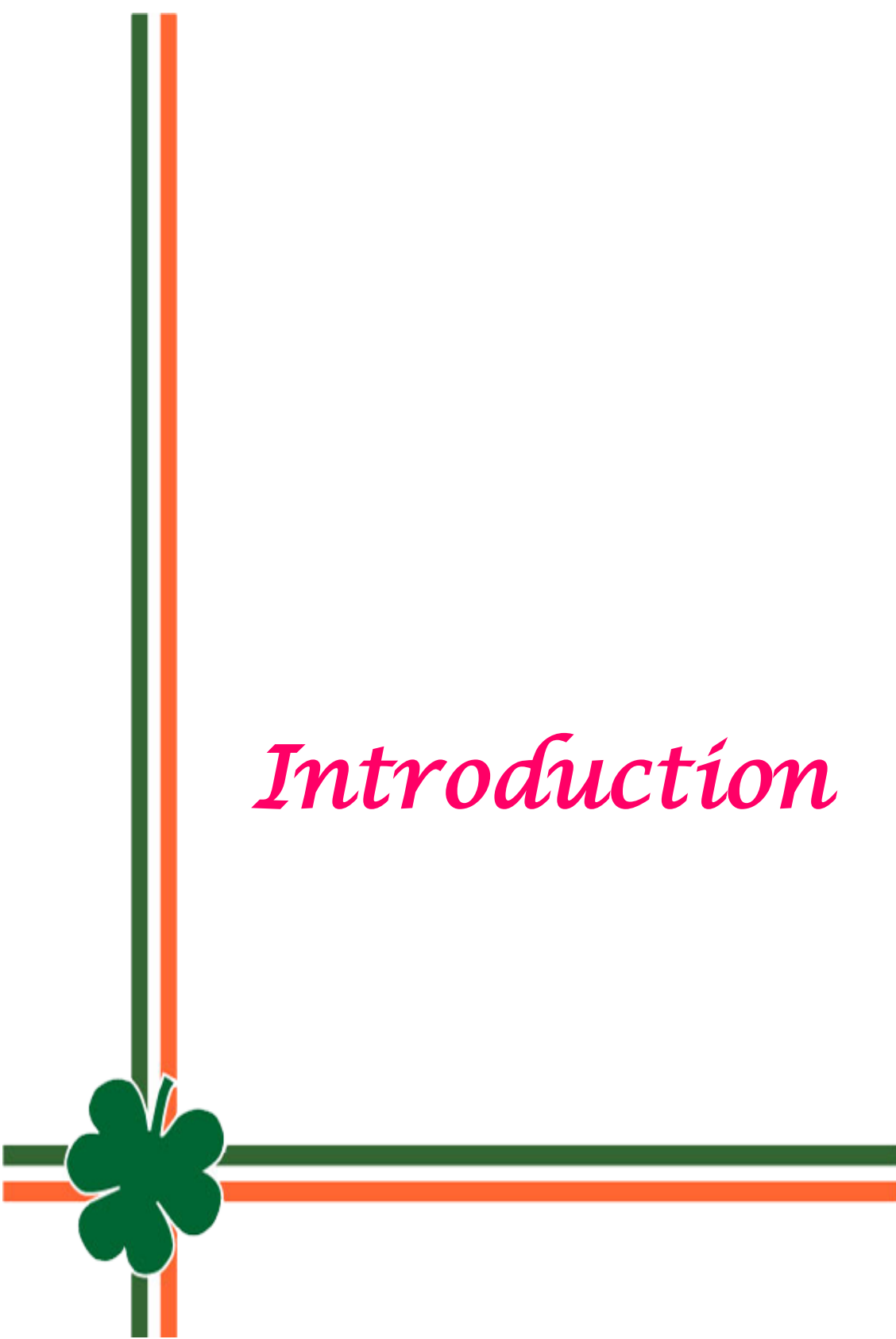
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Abbreviations

/	- Per
bs (h ²)	- Broad sense
C.D.	- Critical differences
cm	- Centimeter
d. f.	- Degree of freedom
e.g.	- Exempli gratia (For example)
EDTA	- Ethylene diamine tetra acetic acid
et al.	- Et alia (and others)
etc.	- Et cetra
Fig.	- Figure
g	- gram
GCV	- Genotypic coefficient of variation
HClO ₄	- Perchloric Acid
HNO ₃	- Nitric Acid
i.e.	- That is
J.	- Journal
Kg	- Kilogram
mm	- Milimeter
M	- Million
M / ha	- Million per hectare
m ²	- Square meter
mg	- miligram
MS	- Mean square
MSe	- Error mean squares
MT	- Metric Tonnes
PCV	- Phenotypic coefficient of variation
q/ha	- Quintals per hectare
Sci.	- Science
SE	- Standard Error
SE(d)	- Standard error of difference
SE(m) ±	- Stanadard error of mean
Sr. No.	- Serial number
Unpub.	- Unpublished
Viz.,	- Videlicet (namely)
vs	- Versus
Wt	- Weight
%	- Per cent
Σ	- Standard deviation
Σ	- Summation



Introduction

CHAPTER-I

INTRODUCTION

Finger millet [*Eleusine coracana* (L.) Gaertn.] also known as African millet or *Ragi* belongs to family Graminae or Poaceae and common name 'Finger millet' is derived from the finger-like branching of the panicle. It is a self pollinated, tetraploid ($2n = 36$) crop. The crop is native to the Ethiopian highlands of Central Africa and was introduced into Indian sub continent approximately 3000 years ago. The long history of cultivation of finger millet in India under diverse agro-climatic conditions and the associated human and natural selection has resulted in generation of large variability giving India the status of secondary centre of diversity. The first advance estimation area, production and productivity in Maharashtra *kharif* 2017-2018 total area 0.864 lakh ha, production 0.932 lakh tones and productivity 1078 kg/ha (Directorate of Agriculture, Government of Maharashtra).

In India, finger millet is cultivated over a wide range of agro climatic conditions almost in all states like Karanataka, Maharastra, Uttarakhand, Tamil Nadu, Andhra Pradesh, Gujarat, Jharkhand, Bihar and Orisa. In India, fingermillet cultivated since ancient time and is serving as a food for working class.

The first advance estimation area, production and productivity under finger millet occupied by different division in Maharashtra during *kharif* 2017-2018 , area in ha Kokan (0.305 lakh ha), Nashik (0.267 lakh ha), Pune (0.36 lakh ha) and Kolhapur (0.262 lakh ha). Production in tonnes under Finger millet occupied by different division in Maharashtra during 2017-2018 is Kokan (0.330 lakh tn), Nashik (0.207 lakh tn), Pune (0.24 lakh tn), and kolhapur (0.371 lakh tn). As regards productivity of finger millet in Maharashtra division in kg/ha during *kharif* 2017-2018, it is Kokan (1083 kg/ha), Nashik (775 kg/ha), Pune (820 kg/ha) and kolhapur (1412 kg/ha), (Directorate of Agriculture, Government of Maharashtra). Finger millet is favorite crop of the Konkan region. It is mainly cultivated in Thane, Raigad, Ratnagiri, Sindhudurg. Dhule, Jalgaon, Nasik, Ahemadnager, Pune, Satara and Kolhapur districts. The largest area of finger millet is found in Konkan region.

In Konkan, finger millet plays as an important role in agriculture with an area. It is taken as major *kharif* crop next to rice. It is also taken as *rabi* crop

where irrigation facilities are available. Finger millet being one of the hardiest crops is best suited to cultivation and requires minimum care and labour. It is mainly grown on hilly slopes and rough and stone high lands having thin coarse soil with high drainage where cultivation of rice is not possible.

In India the crop is grown in an area of 1.2 M ha with a production of 2.1Mt and productivity of 1.7 lakh tn per ha (Anonymous 2015). It contributes nearly fifty percent of small millets produced in India and occupying an area of 1208.00 thousand hectares (Ministry of Agriculture 2015). In India, the finger millet area has decreased from 2.5 million hectare in 1980s to 1.2 million ha during 2015. The finger millet area is being replaced by other comparable and competing crops such as maize and soybean. Considering the increased demand for finger millet for food purposes and decreasing area under this crop due to competing crops, there is an immediate need for genetic enhancement of finger millet productivity.

Finger millet is an important staple food in India. It can be an ideal crop in dry areas, because it can lie dormant for weeks. The grain is resistant to rot and insects and keeps well in storage, making it an important staple when no other food is available. If kept dry, it can store for as long as five years. Finger millet is highly nutritious, non-glutinous and like buckwheat and quinoa, is not an acid forming food hence easy to digest. In fact, it is considered one of the least allergenic and most digestible grains available and it is a warming grain so will help to heat the body in the cold or rainy seasons. It is very useful to persons suffering from diabetes. Finger millet is tasty, with a mildly sweet, nut-like flavor and contains a myriad of beneficial nutrients. It contains protein, high amounts of fiber, B- complex vitamins including niacin, thiamin and riboflavin, the essential amino acid methionine, lecithin and some vitamin E. It is particularly high in the minerals calcium, iron, magnesium, phosphorous and potassium.

The seeds are also rich in phytochemicals, including phytic acid, believed to lower cholesterol and phytate, which is associated with reduced cancer. It is traditionally used or mixed with sorghum to make nutritious porridges, breads, pasta and fermented beverages such as traditional beer. It is an excellent source of dietary calcium and fiber for people suffering from calcium deficiencies. Also good for teeth and bones. It is consumed in the form of unleavened bread and soup, locally called *ambil* which is prepared by boiling the flour with water. The finger millet

straw is also nutritive and serve as excellent fodder for cattle which can be fed green or as hay. Obviously, finger millet occupies a significant position in the economy of large number of people of low income group and thus in agriculture economy. Considering the importance of this crop, it is necessary to pay attention to this crop to raise its per hectare yields, which are measurably low, and to bring about significant increase in its production.

The achievement in plant breeding programme largely depend upon the genetic variability available in breeding population and the efficiency of selection technique. The importance of genetic diversity in plant breeding is obvious from results obtained in different crops. The recognition and measurement of such diversity, its nature and magnitude are beneficial, perhaps crucial to any breeding programme. This is particularly important in a crop like finger millet where hybridization is difficult, there being limited scope for making large number of crosses by random mating and hence, the information regarding the nature of genetic diversity of the parents to be used in the hybridization, is of per amount importance to finger millet breeder.

The D^2 statistic is useful tool to assess the genetic divergence among population. It also provides a quantitative measure of association between geographic and genetic diversity based on generalized distance (Mahalanobis, 1936). Analysis and utilization of available genetic diversity is a short-term strategy for developing improved cultivars for meeting immediate requirement of the farmers and the end users. The present study was undertaken with the following objectives to identify diverse genotypes with good yield potential.

The original concept of correlation was given by Galton (1889). Path analysis is done with the main purpose of understanding the direct and indirect contribution of different characters towards grain yield. The direct contribution of each component to the yield and the indirect effects and its association with other characters cannot be differentiated by simple correlations. It was first developed and described by Wright (1921) as a tool in genetic analysis for deriving the direct and indirect effects of any set of variables themselves related to one another. Later it was employed for crop improvement by Dewey and Lu, (1959).

Even though finger millet is not a traditional crop of Marathwada region efforts were made to grow important minor millet. Which is known as 'nutricereal' crop in this region.

Keeping the above aspects in consideration the present investigation entitled “**Genetic diversity studies in finger millet [*Eleusine coracana* (L.) Gaertn]**” was undertaken during *Kharif* 2017 on the experimental field of Department of Agriculture Botany, College of Agriculture, Badnapur with following objective.

1. To study the genetic variability in finger millet.
2. To study the correlation and path analysis in finger millet.

*Review
of
Literature*

CHAPTER-II

REVIEW OF LITERATURE

A comprehensive review of literature is an essential part of any scientific investigation. Review of literature is always necessary to compare the present findings with the previous studies undertaken by the research workers.

The literature pertaining to the present investigation entitled “Genetic diversity studies in finger millet [*Eleusine coracana* (L.) Gaertn]” has been reviewed under following different aspects.

- 1) To study the genetic variability in finger millet.
- 2) Genetic divergence in finger millet.
- 3) To study the correlation and path analysis in finger millet.

1) To study the genetic variability in finger millet.

Bedi *et al.*, (2006) reported genetic variability in 37 finger millet genotypes. The estimate of genotypic and phenotypic variance showed maximum genetic variability for days to flowering, days to maturity, plant height, number of fingers per ear and grain yield. The phenotypic coefficient of variation was highest for fodder yield, number of productive tillers per plant and grain yield. The highest heritability was observed for grain yield, plant height, days to flowering and fodder yield.

John (2006) reported that high genotypic and phenotypic coefficient of variation was observed for number of productive tillers per plant, number of fingers per ear and total dry matter production moderate to high estimates of heritability was obtained for almost all the characters studied. Number of productive tillers per plant, number of fingers per ear, test weight, total dry matters production and harvest index possessed high heritability coupled with high estimate of genetic advance, it can be suggested that additive gene effect for these characters are present, hence selection at phenotypic level for these traits would be more effective. High heritability estimates accompanied by low genetic advance as observed for days to 50% flowering may due to non-fixable gene effect.

Kebere *et al.*,(2006) evaluated a total of 66 finger millet accessions constituted of 64 landraces and two standard varieties. The mean squares of genotypes were highly significant for all characters. Relatively, grain yield per plant exhibiting the highest range (4.87-21.21g) and days to maturity showed the lowest range (143-200 days). For all characters, the phenotypic and genotypic coefficients of variations varied in the orders of 8.05-31.23% and 6.52- 24.21% respectively in both cases for days to maturity and grain yield per plant, respectively.

Satish *et al.*,(2007) reported genetic variability in 178 genotypes of finger millet for fifteen quantitative characters. Significant difference among the genotypes was recorded for all the characters. The estimate of genotypic variances showed a considerable range of variation for most of characters. High heritability coupled with high genetic advance as per cent of mean was observed for number of tillers, productive tillers, days to 50% per cent flowering, finger number per ear, length of ear head, length of finger, florets number per spikelet, spikelet density, ear weight, test weight, straw yield and grain yield indicating the presence of additive genetic effect for the manifestation of these characters. Plant height, days to maturity exhibited high heritability with moderate genetic advance which indicates the presence of both additive and non additive genetic effect for these characters.

Kadam *et al.*,(2009) revealed that highly significant genotypic and phenotypic variability exist in the crop with respect to characters days to 50% flowering, plant height, basal number of tillers, flag leaf length, flag leaf sheath length, peduncle length, exertion length inflorescence length, longest finger length, peduncle branch number, 1000 grain weight and per plant yield. The highest heritability and genetic advance observed in case of yield and plant height indicated that the character might be under control of additive genes. The higher heritability was also observed in respect of number of basal tillers, plant height and flag leaf sheath length of finger therefore, weightage should be given on these traits in selection programme of genotypes for substantial yield improvement of finger millet.

Krishnappa *et al.*, (2009) the results revealed involvement of both additive and dominance genetic variation with a preponderance of the latter in the expression of time to 50% flower, plant height and dry fodder weight per plant while only dominance genetic variation was operative in the expression of number of tillers, number of fingers ear and grain weight. These results are discussed in relation to the

adoption of suitable breeding and selection strategy for genetic enhancement of economic traits in finger millet.

Shet *et al.*, (2010) showed the interspecific hybrids between cultivated species *Eleusine coracana* involving two different popular varieties viz., HR 911 and PR 202 with *E. africana* for assessing genetic variability, path and correlations among yield and yield components in segregation population. Results indicated that the hybrid showed intermediate reaction for productive tillers, finger length, finger number and days to 50 % flowering and exhibited reduced pollen fertility. The F₂ populations of two crosses registered high PCV and GCV values were observed for grain yield per plant and finger width and low for plant height and days to 50 % flowering, whereas low to moderate for all other characters. Plant height, finger length, test weight and grain yield per plant reported high broad sense heritability accompanied with high genetic advance. The correlation studies of these crosses showed grain yield per plant exhibited highly significant positive association with finger width and test weight. The path analysis in F₂ populations indicates that productive tillers per plant had the highest positive direct effect followed by finger width and test weight on grain yield in these two crosses, while finger number exerted low positive direct effect on grain yield

Dhamdhare *et al.*, (2011) concluded that genotypic coefficient of variation was the major component of total variation. However, PCV was invariably higher than GCV for most of the characters studied. Crude fiber content showed high PCV followed by ear weight, iron content, straw weight and grain yield, while plant height showed lowest PCV. Ear weight, straw weight and total biomass showed high heritability and high genetic advance, while grain yield exhibited moderate heritability and high genetic advance.

Ganapathy *et al.* (2011) studied two hundred and forty finger millet germplasm accessions. The coefficient of variation at phenotypic (PCV) and genotypic (GCV) levels were high for productive tillers per plant and moderate for the traits viz., days to 50 % flowering, plant height, finger numbers per ear, finger length and grain yield per plant. Low PCV and GCV were observed in the trait days to maturity. From the results, high heritability coupled with high genetic advance

observed in days to 50 % flowering, plant height, productive tillers per plant, finger numbers per ear, finger length and seed yield per plant.

Priyadharshini *et al.* (2011) observed values of phenotypic coefficients of variability were greater than genotypic coefficients of variability for all the traits studied. High PCV and GCV were recorded for number of productive tillers per plant and moderate PCV and GCV for longest finger length, seed protein content and harvest index indicated large extent of genetic variability for these traits in the material. High heritability along with high genetic advance (% of mean) observed for plant height, number of productive tillers per plant, number of fingers per ear head, longest finger length, seed protein content, harvest index and single plant grain yield.

Ulaganathan *et al.*, (2011) reported phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the characters studied. High values for phenotypic and genotypic coefficients were recorded for single plant grain yield and productive tillers per plant, indicating that more variability is present in the genotypes for these characters. All the characters recorded high heritability in the present study indicated that these characters were relatively less influenced by environmental factors and phenotypic selection would be effective for the improvement of these characters. All the characters recorded high heritability coupled with high genetic advance except days to 50 per cent flowering, finger width and days to maturity which indicated that these characters were governed by additive genes and selection would be effective for improvement of such characters. Since there is significant variability observed in all the finger millet genotypes, this could be used for genetic improvement through selection and hybridization.

Upadhyaya *et al.* (2011) found that finger millet core collection for grain nutrients and agronomic traits revealed a substantial genetic variability for grain Fe, Zn, calcium (Ca) and protein contents. Accessions rich in Zn content have significantly higher grain yield potential than those rich in Fe and protein content.

Haradari *et al.*, (2012) a study was conducted study to assess the genetic variability in base germplasm (1000 accessions) of finger millet for eleven quantitative characters including grain yield per plant. Highly significant differences were observed among all the finger millet genotypes for different characters. Close

relationship found between GCV and PCV for most of the characters. High heritability was expressed by plant height, finger length and days to 50 per cent flowering. Genetic advance as per cent of mean was observed maximum for finger length, number of productive tillers per plant, grain yield per plant, ear weight per plant and plant height.

Lule *et al.*, (2012) studied 144 finger millet landraces were collected from different regions and reported PCV was higher than the corresponding GCV and genotype by environment coefficient of variations for all traits. This implies, beside the genetic factors, environmental factors have high contributions for the variations observed. The higher heritability coupled with higher genetic advance noted for finger length (41.94%), thousand grain weights (28.88) g and grain yield per plant (26.34) g indicated that the ease of phenotype based selection for the improvement of those traits.

Reddy *et al.*, (2013) noticed that analysis of variance revealed that there were significant differences among the entries for all the traits studied. A wide range of variation was recorded for days to 50% flowering, plant height, ear head length, chlorophyll content, grain yield and straw yield. The phenotypic coefficient of variation was greater than genotypic coefficient of variation for all the characters studied which shows the influence of the environmental effect on the characters. High values for phenotypic coefficient and genotypic coefficient was recorded for number of fingers per ear head. High heritability and high genetic advance was recorded for ear head yield, ear head length and number of fingers per ear head indicating that these characters were controlled by additive gene effects. Selection based on these characters would be effective for future finger millet crop improvement program. Moderate heritability coupled with moderate genetic advance was observed for grain yield and straw yield. Threshing percentage showed low heritability as well as low genetic advance.

Srilakshmi *et al.*, (2013) estimates the heritability and genetic advance as per cent of mean were high for the characters viz, seed calcium content, protein content, finger length and seed yield per plant. High heritability coupled with high genetic advance as per cent of mean was observed for the characters viz, number of fingers per ear and plant height.

Wolie (2013) recorded high GCV for number of tillers per plant (71.93 %), number of ears per plant (96.55 %), number of fingers per ear (85.48 %), finger length (94.48 %), biomass yield (87.67 %), and grain yield (78.17 %) and high PCV was similarly recorded for number tillers per plant (30.42 %), number of ears per plant (45.55 %), number of fingers per ear (24.88 %), finger length (26.18 %), biomass yield (85.56 %), and grain yield (29.87 %). High heritability coupled with high expected genetic advance as percent of mean was obtained for number of ears per plant (96.55, 90.59 %), number of fingers per ear (85.48, 43.81 %), finger length (94.48, 50.95%), biomass yield (87.67, 154.52 %) and 1000 kernel weight (93.69, 37.70 %) indicating that the presence of more additive gene effects for potential crop improvement and so these characters could be improved through selection.

Karad and Patil (2013) showed analysis of variance exhibited significant difference among the genotypes for all the characters indicating substantial degree of variability. The estimates for GCV were lower than the PCV for all the characters. The days to maturity exhibited the lowest GCV (7.37 %) as well as PCV (7.36 %) where as, the iron percent had highest GCV and PCV (55.33 and 53.46 % respectively). The highest difference between GCV and PCV values was observed for number of productive tiller per plant (3.84 %), whereas, iron content (0.13 %) showed the lowest difference between the GCV and PCV values. Heritability (broad sense) of all the characters in present investigation, was categorized as high to very high ranging from 61.52 to 99.52 %. The genetic advance was found ranging from 0.58 to 23.38. High heritability coupled with high genetic advance observed for the fodder yield per plant, days to 50 per cent flowering, days to maturity and plant height advocated high genetic progress for them.

Suryanarayana *et al.*, (2014) revealed that GCV and PCV levels were high for seed yield per plant, productive tillers per plant and ear length. High heritability coupled with high genetic advance observed for seed yield per plant and ear length.

Malambane *et al.*, (2014) evaluated thirty-five finger millet accessions. Combined analysis showed significant differences among seasons, genotype and genotype by season interactions for yield per plot, 1000 seed weight, finger length, plant height and days to flowering. Season contributed to a large proportion of variations on yield per plot (97.4 %), 1000-seed weight (93.5 %), finger length

(62.8%), plant height (94.6%) and days to flowering (78%). However, variations due to genotype were (38.5%) for finger number, finger width (41.8%) and days to flowering (16.8%). Accession IE 3618 showed low variation in yield for the two seasons while IE 4565 had the highest variations when evaluated in the two seasons for yield per plot. Because of high yield and low variation, IE 3618 is promising for production in both the dry season and the rainy season.

Ulaganathan and Nirmalakumari (2014) revealed that total of 105 finger millet genotypes constituted of 100 germplasm accessions and five standard varieties were evaluated for 13 quantitative traits in randomized complete block design with three replications. The objectives were to assess the variability and association of characters. High values for phenotypic and genotypic coefficients were recorded for grain yield per plant (29.48 and 28.93 %) and productive tillers per plant (23.96 and 22.74 %) indicating that more variability is present in the germplasm accessions. All the characters recorded high heritability in the present study ranged from 63.95 to 96.27 % indicated that these characters were relatively less influenced by environmental factors and phenotypic selection would be effective for the improvement of these characters. The higher heritability coupled with higher genetic advance noted for grain yield per plant are significant and positively correlated with grain yield per plant. Overall observations on variability and correlation studies for grain yield and its attributes in finger millet germplasm accessions indicated presence of ample variability for most of the traits.

Goswami *et al.*, (2015) conducted the experiment at the research block of Crop Improvement, GBPUAT, Hill Campus, Ranichauri using randomized block design (RBD) to characterize finger millet germplasm for morphological characters viz., plant height, number of tiller plant, number of finger ear, ear length and grain yield plant. Among all germplasms, number of finger ear and grain yield plant (g) had recorded highest in VL 149 which were 9.96, 150.66, 2.63 g respectively. The germplasm GEC 1406 attained lowest plant height (75.89 cm), GEC 268 had recorded maximum number of tiller per Plant (3.30), GEC 199 had recorded higher ear length (9.20 cm) among all germplasm of finger millet.

Kumari and Singh (2015) an experiment with thirty five genotypes of finger millet carried out to study the nature and magnitude of divergence using

Mahalanobis D² statistics, in randomized block design with three replication. The data for eleven important quantitative traits recorded from the genotypes raised. The variability study indicated high to moderate phenotypic and genotypic coefficient of variation accompanied by high heritability and genetic advance as per cent of mean for traits, grain yield per plant, harvest index, grain weight of main panicle, number of tillers per plant, flag leaf area, 1000 grain weight, number of fingers per panicle, panicle length and days to fifty per cent flowering, indicating their importance in selection for yield improvement. The 35 genotypes of finger millet were grouped into six clusters using Tocher's method. Days to fifty per cent flowering and grain yield per plant contributed maximum towards genetic divergence.

Umar and Kwon-Ndung (2014) conducted experiment to characterize the morphological diversity of 10 germplasm accessions of finger millet (*Eleusine coracana*(L) Gaertn) collected from diverse locations spread across the geographic Northern Nigeria during the 2008, 2009 and 2010 cropping seasons. The seeds of the accessions were planted in a randomized complete block design (RCBD) with three replications in each of two locations-Keffi and Gwagwalada, during the three cropping seasons. The field studies for the three seasons in the two locations followed uniform agricultural practices. Field data was collected on morphological traits such as plant height, leaf length, leaf diameter, finger length, finger width, number of fingers and 1000 seed weight were recorded in accordance with standard finger millet descriptors.

Jyothsna *et al.*, (2016) noticed that genotypic coefficients of variation for all the characters studied were lesser than the phenotypic coefficients of variation indicating the interaction of genotypes with environment. High heritability coupled with high genetic advance was observed for grain yield per plot and straw yield per plot indicating the importance of additive gene action in governing the inheritance of these traits. Hence, simple selection is effective to improve the respected trait.

Anuradha *et al.*, (2017) studied the genetic variability, heritability and correlation of grain yield and yield related traits. Analysis of Variance of 25 finger millet advanced breeding lines revealed significant variation for all the traits studied. The mean grain yield was 31.50 q/ha, with a minimum of 29.22 and maximum of 39.74 q/ha. Grain yield recorded genotypic coefficient of variation of 12.86, while

phenotypic coefficient of variation was 18.06 . Heritability ranged from 0.35 (number of finger per ear) to 0.88 (days to 50% flowering), while heritability for yield was 0.51. Number of tillers per plant and number of fingers per ear were observed to be highly associated with yield. The present findings implies the presence of larger variability for yield and other related traits which can be exploited in finger millet improvement.

Mahanthasha *et al.*, (2017) revealed significant differences among genotypes for all the characters. Studies of genetic variability revealed high phenotypic and genotypic coefficients of variation, heritability and genetic advance as per cent of mean for the traits viz., number of basal tillers per plant, number of productive tillers per plant, main ear width, grain yield per plant and grain yield per plot indicating simple selection can be practiced for improvement of these characters. The genotypic coefficient of variation for all the characters studied was lesser than the phenotypic coefficient of variation indicating the effect of environment. High GCV and PCV values were observed for grain yield per plot followed by grain yield per plant, number of basal tillers per plant, productive tillers per plant, main ear width and finger length. High heritability coupled with high genetic advance as per cent of mean was observed for plant height, number of basal tillers per plant, number of productive tillers per plant, main ear length, main ear width, finger length, grain yield per plant and grain yield per plot. Thus, these traits are predominantly under the control of additive gene action and hence these characters can be improved by selection.

2) Genetic divergence in finger millet

The sum total of genes present in the genotypes is called germplasm. The study of genotype diversity and the information of core subsets are important activities in the conservation, evaluation and utilization of genetic resources (Brown, 1989).

Morphological similarity, eco-geographic diversity, phylogenetical relationship, Mahalanobis D^2 statistics etc were the few earlier methods used for discriminating divergent populations, which are reinforced by more scientific and advanced biometric techniques viz., multivariate analysis based on principal component analysis, agglomerative cluster analysis.

Sheriff (1992) conducted study on nine metric traits in twenty ragi varieties grown under rainfed and irrigated conditions using Mahalanobis D^2 statistic. They were grouped into four clusters under rainfed and eleven under irrigated conditions. Genetic diversity is not related to geographic diversity. Days to flowering,

days to maturity, plant height, ear length, ear weight and grain weight contributed maximum to genetic diversity in both environments.

Suryakumar *et al.*, (1998) studied forty nine finger millet genotypes grouped into 10 clusters. Cluster analysis revealed that geographical diversity was not related to genetic diversity. The genotypes from the clusters II, X, V and VII having moderate to high genetic divergence coupled with high mean performance may be selected for yield and its important components such as productive tillers and straw yield for better recombination.

Vadivoo *et al.*, (1998) grouped thirty six genotypes into eight clusters. Based on inter cluster distances of the genotypes MS 1168, MS 174 and CO 13 were found to be suitable for use as parents in a hybridization program for improving yield.

Bedis *et al.*, (2007) conducted an experiment on thirty seven finger millet strains to study the nature and magnitude of genetic divergence for seed yield and its components. D^2 values corresponding to the pairs of comparison between thirty seven cultivars indicated a considerable amount of genetic diversity among the strains studied. The thirty seven strains were grouped into seven clusters, the cluster means revealed that days to flowering, days to maturity, plant height, number of productive tillers per plant, main ear length, number of fingers per ear, and fodder and grain yield per plant are important characters towards maximum divergence.

Satish *et al.* (2007) conducted a study on finger millet to assess extent of genetic diversity involving 178 genotypes of finger millet for productivity traits. Study revealed that the genetic diversity did not relate to geographic origin. All the genotypes were grouped into ten different clusters. The inter cluster distance revealed that cluster 2 and 5 were found to be highly divergent. Florets number per spikelet contributed maximum to the divergence. Among all the clusters, cluster 7 showed highest cluster mean across the fifteen traits followed by cluster 5, 8 and 4 indicating presence of most promising genotypes in them. Selection of parents for hybridization to get desirable recombinants has been suggested.

Anantharaju and Meenakshiganesan (2008) conducted an experiment on fifty genotypes of finger millet for genetic divergence using cluster analysis for ten quantitative traits. The genotypes were grouped into fourteen clusters. Among the characters they studied, days to 50% flowering followed by number of leaves contributed more towards the total divergence.

Kadam (2008) grouped seventy genotypes in 8 clusters. The higher inter cluster distance was observed between cluster VIII and V followed by that between cluster VI and II, suggesting more variability in genetic makeup of genotypes included in these clusters. Cluster III had the highest mean values for grain yield/plant, 1000 grain weight, panicle branch number and flag leaf blade width. Cluster VIII was the second highest for grain yield per plant (g) and for exertion peduncle length and basal tiller, plant height and days to 50% flowering followed by flag leaf blade length contributed maximum towards the total divergence. There were 4 solitary clusters and in the remaining clusters the genotypes varied from 2 to 4 numbers. Parallelism was observed between geographical diversity and genetic diversity.

Prabhu *et al.*, (2008) grouped one hundred fifty finger millet germplasm into 18 cluster based on genetic distance. Fourteen solitary clusters were superior viz., II, III, V, VI, VIII, X, XI, XII, XIII, XIV, XV, XVI, XVII and XVIII. Intercrossing between genotypes of these diverse clusters would generate a broad spectrum of variability for effective selection in the segregating generations for the development of high yielding cultivars.

Kumar *et al.*, (2010) grouped one hundred and forty diverse genotypes of finger millet into ten non-overlapping clusters. The inter-cluster distance varied from 16.85 between clusters X and I to 1.94 between clusters III and VIII. Genetic diversity was observed to be independent of the geographical origin of the genotypes.

Lule *et al.* (2012) concluded that the trend of quantitative trait diversity revealed that the highest genetic diversity were observed at the lowest level (among landrace populations) followed among the regions or countries of origin and least among altitude classes. This leads to suggest, taking more samples within a locality or population would be a better approach to capture the range of variation in finger millet population.

Sahu and Pradhan (2012) grouped thirty finger millet genotypes into 12 clusters out of which, cluster 1 had six genotypes, cluster II seven genotypes, clusters III and V three genotypes each, clusters IV, VI and VII two genotypes each and clusters VIII to XIII consisted of one genotype each. The inter cluster distance was highest between cluster IV and VII followed by cluster IV and XII. The highest means for grain yield were observed in cluster X (OEB 71) and cluster VI and for number of productive tillers/plant were observed in cluster VIII. Custer XII (VL 149)

had the highest mean for plant height, fingers/ear and ear length. The genotypes of these superior clusters can be effectively used in breeding programs. Among the characters, days to maturity followed by days to flowering and plant height contributed more towards the total divergence.

Mahanthasha *et al.* (2017) studied Genetic diversity in finger millet with 11 characters viz., grain yield per plant, main ear width, total number of basal tillers per plant, total number of fingers on the main ear, finger width, main ear length, plant height, number of leaves on the main tiller, total productive tillers per plant, finger length and grain yield per plot, which partitioned the 48 germplasm lines into eight clusters.

Patel *et al.* (2017) conducted experiment during kharif, 2016 with 65 germplasm accessions of finger millet to study genetic diversity for yield and yield contributing traits at Hill Millet Research Station, Waghai, Dangs, Gujarat in a randomize block design. The observations for eight morphological characters were recorded.

Negi *et al.*, (2017) carried out investigation to study the genetic divergence among 35 finger millet genotypes for fourteen morphological characters using Mahalanobis D^2 statistics during *kharif*, 2014. D^2 statistics indicated that the genotypes studied were genetically diverse. The 35 genotypes of finger millet were grouped into 6 clusters irrespective of geographical diversity, indicating no parallelism between geographic and genetic diversity.

3) To study the correlation and path analysis in finger millet.

John (2006) investigated correlation analysis for total dry matter production showed a positive and highly significant association with test weight, total dry matter production and harvest index. Hence grain yield could be improved through these characters. Significant positive regression coefficient was observed between grain yield and dry matter production.

Kebera *et al.*, (2006) revealed that genotypic correlation and path-coefficient analysis showed 1000 grain weight, finger number and productive tillers as a major contributor to grain yield per plant. Hence, this is a potential character of interest which could be used in the genetic improvement of finger millet through hybridization and/or selection.

Kadam *et al.*, (2009) revealed from the correlation analysis that there were highly significant positive association with yield and almost all the growth and yield contributing characters except flag leaf blade width and exertion. Path analysis that indirect effect of yield had masked the direct or indirect effect in almost all the characters except inflorescence width. The traits like yield, flag leaf blade length, flag leaf sheath length, inflorescence length, inflorescence width and 1000 grain weight be given due emphasis in selection programme of genotypes for substantial high yield improvement of finger millet.

Shet *et al.* (2010) showed the interspecific hybrids between cultivated species *Eleusine coracana* involving two different popular varieties viz., HR 911 and PR 202 with *E. africana* for assessing genetic variability, path and correlations among yield and yield components in segregation population. Results indicated that the hybrid showed intermediate for productive tillers, finger length, finger number and days to 50 % flowering and exhibited reduced pollen fertility. The F₂ populations of two crosses registered high PCV and GCV values were observed for grain yield per plant and finger width and low for plant height and days to 50 % flowering whereas low to moderate for all other characters. Plant height, finger length, test weight and grain yield per plant reported high broad sense heritability accompanied with high genetic advance. The correlation studies of these crosses showed grain yield per plant exhibited highly significant positive association with finger width and test weight. The path analysis in F₂ populations indicates that productive tillers per plant had the highest positive direct effect followed by finger width and test weight on grain yield in these two crosses while finger number exerted low positive direct effect on grain yield.

Nandini *et al.*, (2010) indicated the grain yield has strong positive correlation with weight of main ear, 1000 seed weight and total tillers per plant. Productive tillers and plant height exhibited moderate positive correlation. Weight of main ear, 1000 seed weight showed positive direct effect on grain yield of main ear.

Dhamdhare *et al.*, (2011) concluded that genotypic coefficient of variation was the major component of total variation. However, PCV was invariably higher than GCV for most of the characters studied. Crude fiber content showed high PCV followed by ear weight, iron content, straw weight and grain yield while plant

height showed lowest PCV. The character ear weight, straw weight and total biomass showed high heritability and high genetic advance while grain yield exhibited moderate heritability and high genetic advance.

Wolie and Dessalegn (2011) observed that correlations among the traits and grain yield was significantly correlated with its component characters like plant height, number of ears per plant, number of fingers per ear, finger length, biomass yield, harvest index and thousand kernel weight.

Ganapathy *et al.*, (2011) studied correlation and path analysis revealed that, the traits viz., productive tillers per plant and finger length are the important yield contributing traits and due critical emphasis needs be given to productive tillers per plant and finger length while selecting for grain yield improvement in finger millet. Since these traits had significant positive correlation with grain yield and positive inter correlation also themselves.

Priyadarshani *et al.*, (2011) reported grain yield had positive correlation with number of productive tillers, finger length and harvest index. On the basis of path analysis, harvest index had high positive direct effect on grain yield and number of productive tillers and finger length had moderate direct effect and revealed true relationship of these traits with grain yield.

Haradari *et al.*, (2012) revealed that, grain yield per plant had highly positive and significant association with plant height, days to 50 per cent flowering, days to maturity and ear weight per plant. Path analysis revealed that number of productive tillers per plant, days to maturity and ear weight per plant had direct positive effect on grain yield.

Lule., (2012) recorded the higher and positive direct effect of productive tillers per plant (0.356) and thousand grain weight (0.285) and the positive direct effect of finger length, finger number on grain yield indicated that any genetic improvement on those traits has positive contribution to improve productivity of finger millet.

Muduli *et al.* (2012) performed correlation analysis in forty four micromutant lines of each of the two finger millet varieties VR 708 and GPU 26. Significant positive association of tillers per plant, fingers per ear and ear weight per

plant with grain yield per plant and among themselves was observed in both sets of mutant lines.

Anuradha *et al.*, (2013) studied association and effect of yield attributing traits on seed yield have been studied to identify a set of characters for effective selection during breeding programs. Days to maturity, number of fingers per ear showed positive significant at genotypic level. Path analysis revealed days to maturity and number of finger per ear exhibited positive association and positive direct effect towards seed yield.

Bhanu *et al.* (2013) showed the association and effect and effect of yield attributing traits on seed yield in finger millet Days to maturity, number of fingers per ear showed positive significance at genotypic level. Path analysis revealed days to maturity and number of fingers per ear exhibited positive association and positive direct effect towards seed yield.

Dhamdhere *et al.* (2013) conducted experiment to find phenotypic, genotypic and environmental correlation between various characters under study and to estimate direct and indirect effect of various component characters on yield for 29 elite genotypes. The results revealed that finger length, straw weight and total biomass showed highly significant positive correlation with yield. Grain yield was found positively associated with days to 50% flowering, days to maturity, thousand grain weight, ear weight and harvest index. Days to 50% flowering showed highly significant positive correlation with days to maturity, ear weight, straw weight and total biomass. All the nutritional characters were found negatively correlated with yield. Total biomass, harvest index, number of tillers per plant, flag leaf area and days to 50% flowering showed positive direct effect on yield while thousand grain weight showed positive indirect effect on yield through ear weight. It can be concluded that selection for reduced plant height, more number of tillers per plant, increased ear weight, higher total biomass, greater harvest index and longer maturity duration would be in favour of achieving higher yield in the finger millet.

Das. (2013) conducted a field experiment to carry out yield component analysis through correlation and path analysis. From correlation studies it was observed that grain yield per plant has exhibited significant positive association with total number of basal tillers per plant, productive tillers per plant, total fingers on the

main ear, finger length and finger width. Path analysis revealed that maximum positive direct effect on grain yield per plant was exhibited productive tillers per plant followed by finger length, finger width. Therefore, it is emphasized to pay attention on traits like productive tillers per plant followed by finger length, finger width while selecting for improvement in grain yield of finger millet.

Srilakshmi *et al.*, (2013) revealed that genotypic correlation in the traits, finger per ear, test weight, finger length possess significant positive association with seed yield at both genotypic and phenotypic level. Further path analysis revealed that productive tillers per plant, test weight, also got high positive direct effect on seed yield along with the strong significant positive association.

Bothikar *et al.*, (2014) recorded genotypic and phenotypic correlation of grain yield per hectare was significant and positive with number of tillers per plant, length of finger, harvest index, grain yield per plot and straw yield per plot. The character plant height, number of finger per ear, number of tillers per plant, length of finger, harvest index, protein content and iron content had positive direct effect on grain yield per hectare. Whereas, the calcium content, straw yield, grain yield per plant, grain yield per plot showed negative direct effect on grain yield per hectare.

Kumar *et al.* (2014) showed that the data on 10 quantitative traits viz. days to 50 % flowering, days to maturity, plant height, number of tillers/plant, productive tillers/plant, number of fingers/ plant, total fingers/plant, biological yield, grain yield and harvest index were collected from a random sample of 10 plants for each genotype. The analysis of variance exhibited significant difference among the genotypes for all the characters indicating substantial degree of variability. Path coefficient analysis indicated that positive genotypic and phenotypic direct effects were observed for productive tillers/plant, biological yield, harvest index and number of fingers/ear had higher positive direct effect on grain yield. These traits having a positive direct effect on grain yield can be considered as a suitable selection criterion for evolving high yielding finger millet genotypes.

Jadhav *et al.*, (2015) carried out an investigation to assess the character association and the magnitude of direct and indirect effects of yield component traits on grain yield of finger millet for 11 characters viz., days to 50% flowering, days to maturity, plant height (cm), number of productive tillers per plant, number of fingers

per ear, finger length (cm), 1000 seed weight (g), seed protein content (%), seed calcium content (mg/100gm). Character association studies revealed that, traits like 1000 seed weight, number of fingers per ear, finger length, days to maturity, productive tillers per plant, days to 50% flowering and plant height were found to possess significant positive association with seed yield per plant at both genotypic and phenotypic levels. Further, path analysis studies revealed that 1000 seed weight, number of fingers per ear, days to maturity, finger length and days to 50% flowering showed true relationship with seed yield per plant by establishing significant positive association and high positive direct effect.

Gani *et al.*, (2016) recorded the correlation analysis for grain yield was positively and significantly associated with all the growth and yield characters evaluated but negatively correlated with the weed components. The highest correlation coefficients were found between grain yield and productive tillers per plant and between grain yield and harvest index. The partitioning of the total correlation into direct and indirect contribution showed that productive tillers per plant made greatest individual contribution to yield while productive tillers per plant via harvest index made the highest indirect percent contributions to grain yield of finger millet. Correlation and path analysis revealed that, productive tillers per plant and harvest index are the important yield contributing traits and due critical emphasis needs be given to these traits while selecting for grain yield improvement in finger millet.

Jyothsna *et al.*, (2016) revealed that, plant height and main ear length shows positive correlation with grain yield per plot at genotypic and phenotypic levels and days to 50% flowering, days to maturity, number of fingers per ear shows positive correlation with grain yield per plot at phenotypic level. Path analysis studies revealed that plant height and main ear length showed true relationship by establishing positive association and direct effect on grain yield per plant both at genotypic and phenotypic levels and number of productive tillers per plant, days to 50% flowering and number of fingers per ear at genotypic level and days to maturity at phenotypic level.

Manayasa *et al.*, (2016) determine the association and heritability for 19 quantitative traits. There were inherent strong genetic relationships among most traits as evidenced by the higher genotypic than phenotypic correlations. Grain yield had high, positive correlations. These traits could be considered for grain yield

selection. Path coefficient analysis revealed that productive tillers per plant (0.473) and 1000 grain mass (0.136) had positive, direct effects on grain yield. Due consideration should be placed on these traits when selecting for grain yield improvement in finger millet. There were also strong, positive indirect effects contributed to grain yield by finger width, peduncle length, It will be necessary to simultaneously select for these traits together with those with strong positive, direct effects on grain yield in order to improve grain yield in finger millet. High broad sense heritability estimates were recorded for fingers per panicle, flag leaf blade length, 1000 grain weight, productive tillers per plant, finger length indicating the potential for their improvement through selection.



Materials and Methods

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled “Genetic diversity studies in finger millet [*Eleusine coracana* (L.) Gaertn]” was undertaken during *Kharif*, 2017 in randomized block design with 158 genotypes were sown at section of Agricultural Botany, College of Agriculture, Badnapur. The details of material and methods used for this investigation are given below.

3.1 Materials

3.1.1 Experimental field

The field experiment was conducted on the field of section of Agricultural Botany, College of Agriculture, Badnapur. Experimental material comprises of 150 germplasm lines received from NBPGR, Akola and 8 checks grown in two replication with randomized block design during *Kharif*, 2017. The genotypes used for study are mentioned in following table 3.1. Recommended agronomic practice followed as per the requirement of crop. Plant protection measures were taken as per requirement. The details of material given below,

Table-3.1 List of finger millet germplasm lines and checks.

SN	Acc. Nos.	SN	Acc. Nos.	SN	Acc. Nos.	SN	Acc. Nos.
1	IC43276-A	41	IC49995-A	81	IC71381	121	IC87517
2	IC44032-A	42	IC49998-A	82	IC71382-B	122	IC87518
3	IC44840	43	IC49999	83	IC71395	123	IC87519
4	IC45841-A	44	IC49999-A	84	IC71395-A	124	IC87519-B
5	IC45844	45	IC49999-B	85	IC71399	125	IC87522
6	IC45844-A	46	IC50000	86	IC71400-A	126	IC87526
7	IC45845-A	47	IC50000-B	87	IC71408	127	IC87529-A
8	IC45847	48	IC50001	88	IC71410	128	IC87530
9	IC45850	49	IC50002	89	IC71411-A	129	IC87565-B
10	IC45852	50	IC50004	90	IC71411-B	130	IC203961
11	IC45859	51	IC50006	91	IC71413	131	IC203970
12	IC45861	52	IC50009	92	IC71413-A	132	IC203975
13	IC45862	53	IC50011	93	IC71418-A	133	IC203978
14	IC45863	54	IC50012-A	94	IC71418-B	134	IC204141
15	IC45863-A	55	IC50013	95	IC71419-A	135	IC204143
16	IC45864	56	IC50013-B	96	IC71420	136	IC206167
17	IC45865	57	IC50015-A	97	IC71420-A	137	IC206171
18	IC45866	58	IC50019	98	IC71581	138	IC340116
19	IC45867	59	IC51458	99	IC73541-A	139	IC340136
20	IC45868	60	IC65559	100	IC87458-A	140	IC340138
21	IC45876	61	IC65558-B	101	IC87469	141	IC340142
22	IC45878-A	62	IC65595	102	IC87470	142	IC361118
23	IC49940	63	IC65632-A	103	IC87471	143	IGPM-14-3
24	IC49942	64	IC65696-B	104	IC87472	144	IGPM-20-3
25	IC49944-B	65	IC66048-A	105	IC87476	145	IC395842
26	IC49946-A	66	IC66172	106	IC87478	146	12-3
27	IC49947	67	IC66235	107	IC87483	147	14-3
28	IC49947-A	68	IC66255	108	IC87485	148	17-3
29	IC49949-A	69	IC66337	109	IC87486	149	LS-5L
30	IC49953	70	IC66588	110	IC87487	150	RDV-10
31	IC49956	71	IC69596-A	111	IC87488	151	GPU-28 (check)
32	IC49965	72	IC69598	112	IC87490	152	VL-149 (check)
33	IC49979-B	73	IC71330-A	113	IC87494-A	153	HR-374 (check)
34	IC49981-A	74	IC71340	114	IC87494-B	154	JK-439 (check)
35	IC49983	75	IC71342	115	IC87497-A	155	BR-708 (check)
36	IC49985	76	IC71377-C	116	IC87498	156	Phule Nachani (check)
37	IC49988	77	IC71378-B	117	IC87500	157	GPU67 (check)
38	IC49990-B	78	IC71378-C	118	IC87502	158	GPU45 (check)
39	IC49992	79	IC71379-A	119	IC87504		
40	IC49992-A	80	IC71380	120	IC87514-A		

3.2 Experimental Methods

3.2.1 Experimental details

One hundred fifty eight genotypes of finger millet including eight checks were sown during *Kharif*, 2017 in randomized block design with two replications at experimental field of section of Agricultural Botany. College of Agriculture, Badnapur. The experimental details were as below

- | | |
|--------------------------|-------------------------------------|
| 1) Design | : RBD. |
| 2) Number of Replication | : Two. |
| 3) Treatments | : 158 (150 genotypes + 8 checks) |
| 4) Plot size | : One row of 3 mt length |
| 5) Spacing | : 30 x 10 cm ² |
| 6) Fertilizer dose | : 50:40:25 NPK (kg/ha). |
| 7) Season | : <i>Kharif</i> 2017-18 |
| 8) Locations | : College of Agriculture, Badnapur. |

3.3 Observations recorded

Random plants from each line in each replication were selected for recording observations. The selected plants were tagged at the age of 35 days. The following observations were recorded on the plants from each genotype at different growth stages of crop and average values per plant were worked out.

3.3.1 Days to 50 per cent flowering

Plant population was counted in which there was complete opening of florets among 50 per cent population of the each plot and the date on which this condition was observed from date of sowing recorded as days to 50 per cent flowering observation in all two replications.

3.3.2 Plant height (cm)

Plants were randomly selected from each plot and plant height was recorded from base of plant to the basal portion of ear head where neck ring is formed.

3.3.2.3 Productive tillers per plant

This observation was recorded by counting the total number of effective tillers from basal portion of the plant on five randomly selected plants.

3.3.4 Flag leaf sheath length (cm)

Measured from node to ligule of flag top at flowering.

3.3.5 Flag leaf sheath width (cm)

Flag leaf sheath width is measured at the widest point of the flag leaf sheath.

3.3.6 Flag leaf blade length (cm)

Flag leaf blade length is measured from ligule to flag leaf blade tip.

3.3.7 Flag leaf blade width (cm)

Flag leaf blade width is measured at the widest point of the flag leaf.

3.3.8 Finger number per panicle

Number of finger per panicle were counted.

3.3.9 Finger Length (cm)

Length of finger was recorded from the base of the finger to the tip of the finger of ear head in finger of head in centimeter.

3.3.10 Finger width (cm)

Finger width is measured at the widest point of finger.

3.3.11 Days to maturity

Days to maturity was taken from date of sowing to stage when main tillers have mature ears i.e., the ear colour changes from green to brownish.

3.3.12 Thousand grain weight (g)

One thousand grains were counted and took weight in electronic balance

3.3.13 Seed per plant (g)

Random plants from each replication were harvested separately, dried in the sun for fifteen days and then threshed and weight of individual plant were recorded in gram.

3.3.14 Calcium content (mg/100g)

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

0.5g of sample was taken into a digestion tube and added 5 ml of diacid mixture of HNO_3 , and HClO_4 in the ratio of (9:4) and allowed for overnight digestion. Digested samples were cooled and final volume of 50 ml were done by using volumetric flask. A suitable aliquot (5ml) of digested sample was taken and 4-5 drops of 4 N NaOH added in sample to make it alkaline. The aliquot was then titrated

against 0.01 N versenate solution (EDTA) using murexide as an indicator till the colour of the solution changes from pink to violet. Reading on burette were recorded and this reading was used to calculate calcium content of the sample.

The calcium content was calculated by employing the following formula.

$$\text{Calcium content (mg/100g)} = \frac{A \times C \times E \times 100 \times 0.002}{F \times G} \times 1000$$

Where

A	=	volume of EDTA for Ca (ml)
C	=	Normality of EDTA (0.01 N)
E	=	Total volume of sample solution (50ml)
F	=	Volume of sample solution taken for titration (5ml)
G	=	Weight of sample (0.5g)

3.3.15 Iron content (mg/100g)

The seeds were crushed into flour and Iron content was estimated as follows.

0.5g of sample was taken into a digestion tube and added 5 ml of diacid mixture of HNO₃, and HClO₄ in the ratio of (9:4) and allowed for overnight digestion . After that aliquot digested in diacid mixture used for estimation of iron content in sample on Atomic Absorption Spectrometer (Varian A. A.,1475) using following operation condition.

The standards of AAS for estimation of Iron.

Wave length (nm)	248.3
Slit (mm)	0.2
Current (mA)	5.0
Fuel	Acetylene air
Optimum working range (mg/ml)	2.5-10

Blank reading for digested aliquot was 1.0 for calcium estimation as well as for iron estimation. Reading on AAS were recorded and iron content mg/100g were calculated by using following formula.

$$\text{Iron content (mg/100g)} = \frac{A \times 100}{1000} \times 100$$

Where A is the reading obtained on AAS machine after subtracting the blank reading

3.4 Statistical analysis

3.4.1 Assessment of variability

a. Analysis of variance

The data collected on individual characters were subjected to the method of analysis of variance commonly applicable to the randomized block design (Panse and Sukhatme, 1967).

$$Y_{ij} = \mu + G_i + R_j + E_{ij}$$

Where,

$$i = 1, 2, \dots, G$$

$$j = 1, 2, \dots, R$$

$$Y_{ij} = \text{Observation on } i^{\text{th}} \text{ genotype in } j^{\text{th}} \text{ replication}$$

$$\mu = \text{General mean}$$

$$G_i = \text{Effect of } i^{\text{th}} \text{ genotype}$$

$$R_j = \text{Effect of } j^{\text{th}} \text{ replication}$$

$$E_{ij} = \text{Random error associated with } Y_{ij} \text{ observation}$$

ANOVA Table:

Source	Degree of Freedom	Mean of sum	expected Mean sum of squares
Replication	r-1	RMS	$\sigma_e^2 + g\sigma_r^2$
Treatment	g-1	GMS	$\sigma_e^2 + r\sigma_g^2$
Error	(r-1)(g-1)	EMS	σ_e^2

Where,

$$r = \text{Number of replications}$$

$$g = \text{Number of genotypes}$$

$$\sigma_r^2 = \text{Variance due to replications}$$

$$\sigma_g^2 = \text{Variance due to genotypes and}$$

σ_e^2 = Variance due to error

The genotype mean square (GMS) was tested against error mean square (EMS) by 'F' test for $n_1 = (g-1)$ and $n_2 = (r-1)(g-1)$ degrees of freedom, where, g = number of genotypes and r = number of replications. The characters showing significant differences were subjected to further analysis.

Estimation of S.E. and C.D.

$$\text{S.E. of mean (S.E.m)} = \sqrt{\sigma_{e/r}^2}$$

$$\text{C.D.} = t \text{ at error d.f.} \times \text{S.E.m} \sqrt{2}$$

b. Estimation of mean and range

The mean values for each character were worked out by dividing the total by corresponding number of observations:

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$$

Where,

$\bar{X}$ = Mean of character

$\sum X_i$ = Total of all the observations for character

N = Number of observations

The lowest and highest values of mean of each character represented the range.

c. Estimation of components of variation

The phenotypic and genotypic variances were calculated using the respective mean squares from variance table (Johnson *et al.* 1955) as below.

Environmental variance (σ_e^2) = EMS

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

Phenotypic variance (σ_p^2) = $\sigma_g^2 + \sigma_e^2$

Where,

GMS = Genotypic mean sum of square

EMS = Error mean sum of squares

r = Number of replications

d. Estimation of coefficient of variation

The genotypic and phenotypic coefficients of variation were calculated by using following formulae given by Burton, (1952).

i) Genotypic coefficient of variation (GCV)

$$\text{GCV (\%)} = \frac{\sigma_g^2}{\bar{X}} \times 100$$

Where,

σ_g^2 = Genotypic variance and,

$\bar{X}$ = Mean of character

ii) Phenotypic coefficient of variation (PCV)

$$\text{PCV (\%)} = \frac{\sigma_p^2}{\bar{X}} \times 100$$

Where,

σ_p^2 = Phenotypic variance and,

$\bar{X}$ = Mean of character

GCV and PCV estimates were classified as Low : < 10 per cent, Medium: 10 to 20 per cent and High: > 20 per cent.

e. Estimation of heritability (b.s.)

Heritability in broad sense was estimated for various characters as suggested by Hanson *et al.* (1956)

$$h^2 = \frac{\sigma_g^2}{\sigma_p^2} \times 100$$

Where,

h^2 = Heritability

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

The high, medium and low heritability estimates were classified on the basis of values given by Robinson (1966).

Low heritability = < 10 %

Moderate heritability = 10-30 %

High heritability = > 30 %

f. Genetic advance (G.A.)

Genetic advance (at 5 % selection intensity) was calculated using the formula given by Allard (1960).

i) Genetic advance (G.A.)

$$G.A. = k \times \frac{\sigma^2_g}{\sigma^2_p} \times \sqrt{\sigma^2_p}$$

Where,

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

k = Selection differential (at 5 % selection = 2.06)

ii) G.A. as percentage of means (GAM)

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

Where,

G.A. = Genetic advance

$\bar{X}$ = Character mean

GA (As percentage of mean) was classified as

Low : 10 per cent

Medium : 10 to 20 per cent s

High : > 20 per cent

3.4.2 Genetic divergence

D² analysis

The analysis of divergence was carried out by D² statistics proposed by Mahalanobis (1928, 1936) as described by Rao (1952). Analysis of variance for the

individual character was worked out as per randomized block design analysis to test the significances of differences among the genotypes. The characters exhibited significant differences so all were used for further analysis of D^2 statistics. The analysis of covariance for character pair based on plant average was carried out (Cochran and Cox, 1957).

a. Wilk's criteria

After testing differences among populations for characters, a simultaneous test of significance of difference between the mean value of number of correlated variables with regard to pooled effect of nine characters considered together was carried out using Wilk's criteria ' Λ ' (Wilks, 1932) which was estimated using the relationship.

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

Where,

$|E|$ = The determinant of experimental error sum of squares and sum of products matrix

$|E + V|$ = The determinant of experimental error sum of squares and sum of products plus population sum of squares and product matrix

The significance of Wilk's criteria (Λ) was tested by χ^2 as,

$$\chi^2_{pq} = V = -m \cdot \log_e (\Lambda)$$

Where,

$$m = n - \frac{(p+q+1)}{2}$$

n = $N_1 + \dots + N_{k-1}$ (Total number of observations-1)

p = Number of significant characters

q = $k-1$ (Number of genotypes -1)

K = Number of genotypes

b. Mahalanobis's generalized distance (D^2)

The generalized distance between any two populations is defined as:

$$D^2 = \sum \sum \lambda_{ij} x_i x_j$$

Where,

λ_{ij} = Reciprocal matrix to the common dispersion matrix

$\square_i$ = Difference between mean value of the two populations for the i^{th} character

$\square_j$ = Difference between mean value of the two populations for the j^{th} character.

This quantity is estimated by D^2 statistic (Majumdar and Rao, 1958) as:

$$D^2 = \sum \sum S_{ij} \square_i \square_j$$

Where,

$S_{ij}, \square_i, \square_j$ are the sample estimates of $\lambda_{ij}, \square_i$ and $\square_j$ respectively, since this formula for computation requires inversion of tenth order determinant and then evaluation of 10 (10+1) terms, whose sum is D^2 .

c. Computation of D^2 values

For each combination, D^2 was calculated. Thus total $80(79)/2 = 3160$ number of D^2 values were worked out.

d. Determination of population constellation

No rules can be laid down for the finding the clusters, because cluster is not well defined term. The only criteria appears to be that, any two groups belonging to same cluster should be at least, on an average show a smaller D^2 value than those belonging to two different.

The simple method suggested by Tocher (Rao, 1952) for cluster formation is to start with two closely related groups and find third group which has a smaller average D^2 value from the first two. Similarly, the fourth group is chosen to have smaller average D^2 values from the first three and so on. While proceeding further from cluster formation, it at any stage, the average D^2 value of the group appears to be high than those already listed, then this group does not fit in that format group and taken outside of that cluster.

The genotypes included in first cluster are then omitted and the rest are treated similarly to form next cluster.

e. Average intra-cluster distances

The intra cluster distances were calculated as,

$$\sum D_i^2$$

$$\frac{\sum D_i^2}{n}$$

Where,

$\sum D_i^2$ = Sum of distances between all possible combinations

n = Number of genotypes included in a cluster

f. Average inter-cluster distances

The procedure followed for calculating inter-cluster distances was first to measure the distance between cluster-I and cluster-II, between cluster-I and cluster-III, and between cluster-I and cluster-IV and so on. Likewise the clusters were taken one by one and the distances between other clusters were calculated. The average inter-cluster distances were they calculated as,

$$\frac{\sum D_i^2}{(n_i.n_j)}$$

Where,

n_i = Number of genotypes in cluster 'i'

n_j = Number of genotypes in cluster 'j'

g. Cluster diagram

The intra and inter-cluster distances (D values) were obtained by taking square root of average D^2 values of respective groups.

With the help of D^2 values between the clusters, a diagram showing the relationship between different populations was drawn.

3.4.3 Correlations

Analysis of covariance was carried out by taking two characters at a time. The genotypic co-variance was calculated as per Johnson *et al.* (1955) as below:

Source	Degree of Freedom	Sum of squares	Mean sum of squares	Expectation of mean sum of squares
Replications	(r-1)	RP	RMP	$COVe_{1.2} + gCOV_{r1.2}$
Genotypes	(g-1)	GP	GMP	$COVe_{1.2} + rCOV_{g1.2}$
Error	(r-1) (g-1)	EP	EMP	$COVe_{1.2}$

Environmental covariance ($COV. e_{1.2}$) = EMP

GMP – EMP

$$\text{Genotypic covariance (COV. } g_{1.2}) = \frac{\text{GMP} - \frac{(\sum G)^2}{r}}{r}$$

$$\text{Phenotypic covariance (COV. } p_{1.2}) = (\text{COV. } g_{1.2}) + (\text{COV. } e_{1.2})$$

Where,

GMP = Genotypic mean sum of product

EMP = Error mean sum of product

r = Replication

Appropriate variances and co-variances were used for calculating phenotypic and genotypic correlation coefficients (Johnson *et al.*, 1955).

The phenotypic correlation coefficient (r_p) was calculated as:

$$r_{p1.2} = \frac{\text{COV.}_{p1.2}}{\sqrt{(\sigma^2_{p1}).(\sigma^2_{p2})}}$$

Where,

$r_{p1.2}$ = Phenotypic correlation coefficient between character 1 and 2

$\text{COV.}_{p1.2}$ = Phenotypic covariance between character 1 and 2.

$\sigma^2_{p1}, \sigma^2_{p2}$ = Phenotypic variance of character 1 and 2 respectively.

The significance of the phenotypic correlation coefficient was tested by referring to Fisher and Yates (1943). The genotypic correlation coefficient (r_g) was calculated as:

$$r_{g1.2} = \frac{\text{COV.}_{g1.2}}{\sqrt{(\sigma^2_{g1}).(\sigma^2_{g2})}}$$

Where,

$r_{g1.2}$ = Genotypic correlation coefficient between character 1 and 2

$\text{COV.}_{g1.2}$ = Genotypic covariance between character 1 and 2

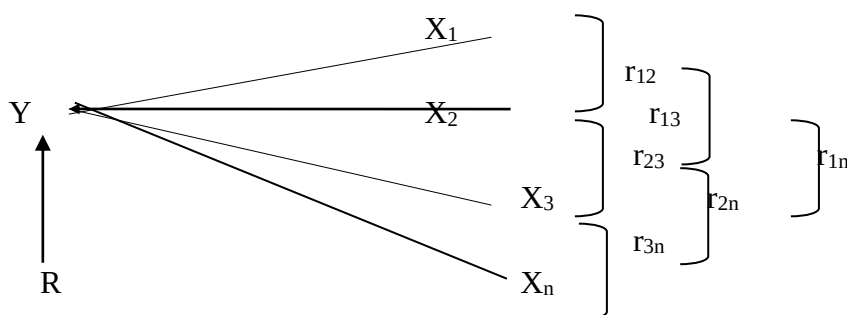
$\sigma^2_{g1}, \sigma^2_{g2}$ = Genotypic variance of character 1 and 2 respectively.

The significance of correlation coefficients was tested from the statistical table of correlation coefficient at 1 and 5 per cent level of significance (Snedcor and Cochran, 1967).

3.4.4 Path coefficient analysis

To establish a cause and effect relationship the first step used was to partition genotypic and phenotypic correlation coefficient into direct and indirect effects by path analysis as suggested by Dewey and Lu (1959) and developed by Wright (1921).

The second step in path analysis is to prepare path diagram based on cause and effect relationship. In the present study, path diagram was prepared by taking yield as the effect i.e. function of various components like X_1 , X_2 , X_3 and these component showed following type of association with each other.



In path diagram the yield is the result of X_1 , X_2 , X_3 X_n and some other undefined factors designated by R. The double arrow lines indicated mutual association as measured by correlation coefficient. The single arrow represents direct influence as measured by path coefficient P_{ij} .

Path coefficients were obtained by solving a set of simultaneous equation of the form as per Dewey and Lu (1959).

$$r_{ny} = P_{ny} + r_{n2} P_{2y} + r_{n3} P_{3y} + \dots$$

Where,

r_{ny} = represents the correlation between one component and yield

P_{ny} = represents path coefficient between that character and yield

r_{n2} = represents correlation between that character and each of the other components in turn.

$$\begin{matrix} \text{Matrix A} \\ \begin{pmatrix} r_{1y} \\ r_{2y} \\ r_{ny} \end{pmatrix} \end{matrix} = \begin{matrix} \text{Matrix B} \\ \begin{pmatrix} r_{11} & r_{12} & r_{13} & \dots & r_{1n} \\ r_{21} & r_{22} & r_{23} & \dots & r_{2n} \\ r_{n1} & r_{n2} & r_{n3} & \dots & 1 \end{pmatrix} \end{matrix} \begin{matrix} \text{C} \\ \begin{pmatrix} P_{1y} \\ P_{2y} \\ P_{ny} \end{pmatrix} \end{matrix} \begin{pmatrix} \\ \\ \end{pmatrix}$$

Where,

r_{12} = r_{21} and so on

r_{1y} = Correlation between one component character and seed yield

The 'B' matrix was inverted $[B]^{-1}$ and path coefficients (P_{ij}) were obtained as,

i.e. $P_{ij} = (B)^{-1}.A$

The indirect effects of a particular character through other characters were obtained by multiplication of direct paths and particular correlation between these characters separately.

$$\text{Indirect effects} = r_{ij} \times p_{iy}$$

Where,

i = 1 to 9

j = 1 to 9

P_{iy} = $P_{1y}, P_{2y}, \dots, P_{ny}$

Path coefficient (P_{ij}), correlation coefficient (r_{ij}) and residual factors (R) were diagrammatically presented. The residual factor i.e. variation in yield unaccounted for by these associations was calculated with the following formula:

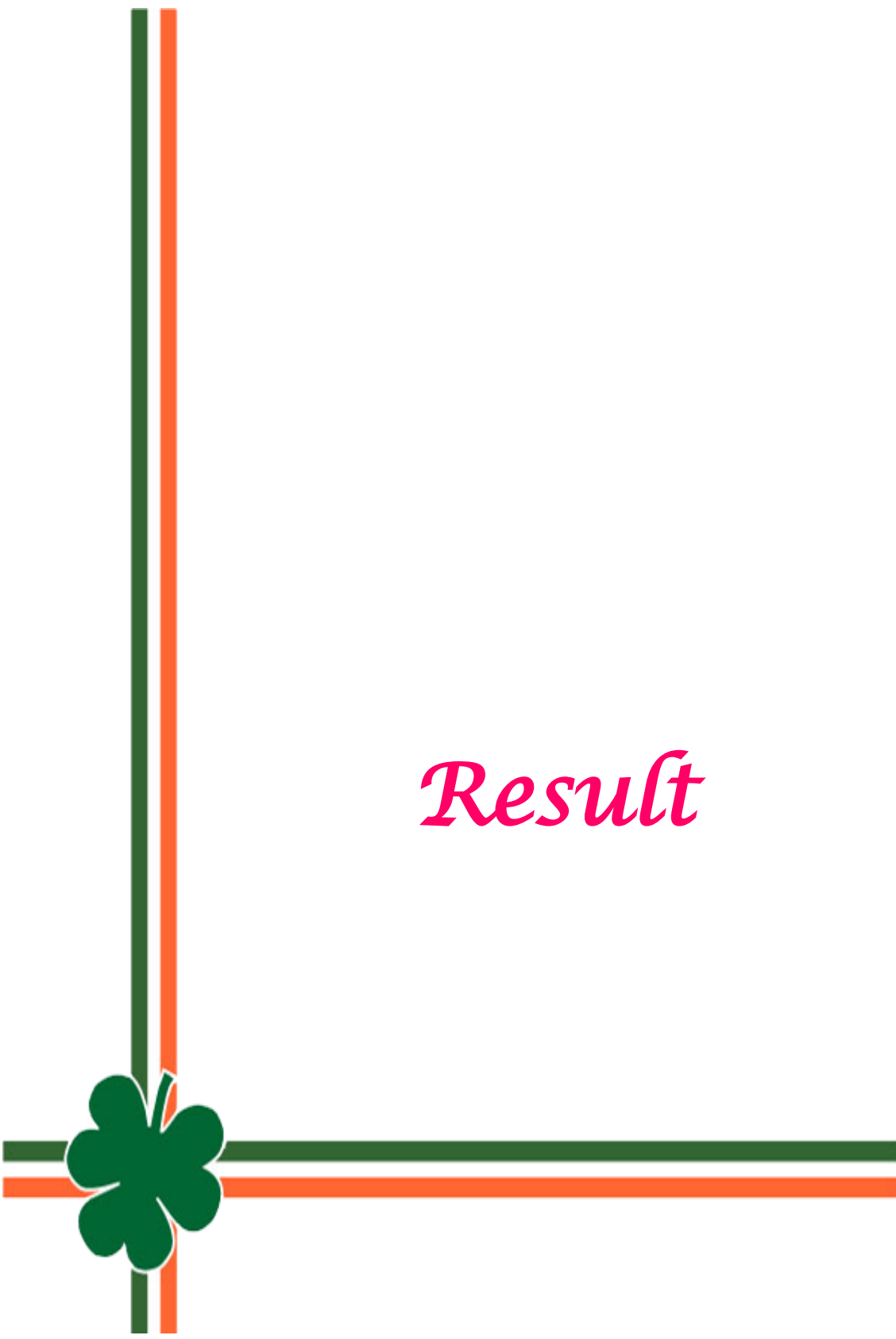
$$\text{Residual factor (R)} = (1 - R^2)$$

Where,

$$R^2 = P_{1y} r_{1y} + P_{2y} r_{2y} + \dots + P_{ny} r_{ny}$$

$P_{1y}, P_{2y}, \dots, P_{ny}$ = Direct path values

r_{1y}, r_{2y}, r_{ny} = Correlation coefficient.



Result

CHAPTER - IV

RESULTS

The present investigation was undertaken with 150 germplasm lines and eight checks of finger millet [*Eleusine coracana* (L.) Gaertn]”. The objective of experiment was to study genetic variability, genetic diversity, correlation and path analysis for fifteen traits in finger millet.

Fifteen characters studied were subjected analysis for various quantitative characters have been presented under the following major heading

4.1 Analysis of variance

4.2 Mean performance

4.3 Genetic variability

4.4 Genetic diversity

4.5 Correlation

4.6 Path analysis

4.1 Analysis of variance

The variation among genotypes were highly significant for day to 50 % flowering, plant height, productive tillers per plant, flag leaf sheath length, flag leaf sheath width, flag leaf blade length, flag leaf blade width, finger number per panicle, finger length, finger width, days to maturity, thousand grain weight, seed yield per plant (gm), calcium content and iron content mg/100gm (Table No 4.1)

Table. 4.1. Analysis of variance for fifteen characters in finger millet.

Sr. No.	Characters	Mean sum of squares		
		Replication (d.f. 1)	Genotype (d.f. 157)	Error (d.f. 157)
1	Days to 50% flowering	2.84	68.90**	0.97
2	Plant height (cm)	10.63	158.96**	85.90
3	Productive tillers per plant	0.55	0.95**	0.17
4	Flag leaf sheath length (cm)	0.77	3.14**	0.39
5	Flag leaf sheath width (cm)	0.003	0.02**	0.001
6	Flag leaf blade length (cm)	8.86	35.55**	2.89
7	Flag leaf blade width (cm)	0.081	0.02**	0.001
8	Finger number per panicle	0.13	4.32**	0.16
9	Finger length (cm)	0.25	2.82**	0.16
10	Finger width (cm)	0.004	0.02**	0.004
11	Days to maturity	1.39	68.53**	0.48
12	Thousand grain weight (g)	0.04	0.40**	0.03
13	Seed yield per plant (g)	0.008	2.55**	0.08
14	Calcium content (mg/100g)	29.16	8624.38**	13.59
15	Iron content mg (mg/100g)	1.84	460.62**	0.55

* -Significant at 5 % level of significance

** - Significant at 1 % level of significance

Table 4.2. Mean performance of fifteen quantitative characters in one hundred 158 genotypes of finger millet.

SN	Name of Germplasm/ Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
1	IC43276-A	85	123.5	2.5	11.71	0.75	25.72	0.82	4.6	6.39	0.92	117	2.70	4.63	264.00	13.20
2	IC44032-A	84	118.1	3.1	9.74	0.80	27.74	0.78	5.9	5.31	0.68	118	1.80	2.80	236.00	52.57
3	IC44840	81	134.6	1.6	9.24	0.80	30.10	0.95	6.4	5.36	0.83	112	2.35	2.27	275.50	18.02
4	IC45841-A	81	128.8	3.5	10.53	0.87	31.32	0.75	5.8	6.45	0.73	115	2.00	2.39	291.50	23.28
5	IC45844	80	144.3	2.6	10.48	0.82	27.33	0.85	6.6	4.55	0.67	115	3.30	3.32	348.00	19.21
6	IC45844-A	82	116.2	3.1	8.97	0.73	28.28	0.83	6.1	4.38	0.83	111	2.25	2.75	213.00	23.15
7	IC45845-A	87	126.7	4.3	10.22	0.84	38.21	0.94	6.9	6.05	0.93	120	1.70	2.17	246.00	15.25
8	IC45847	86	115.5	3.3	7.83	0.73	25.14	0.73	6.7	6.06	0.73	118	1.80	2.11	215.00	17.47
9	IC45850	85	114.4	4.3	9.00	0.84	30.15	0.83	6.7	4.84	0.86	119	2.45	2.59	250.50	15.07
10	IC45852	77	112.2	3.0	12.89	1.11	33.37	1.13	6.3	6.64	1.15	108	2.20	4.12	209.50	3.83

Table 4.2. contd.....

SN	Name of Germplasm/ Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
11	IC45859	80	103.2	3.3	12.17	0.72	23.80	0.83	5.6	4.97	0.85	114	2.40	4.08	309.50	9.39
12	IC45861	54	102.7	4.1	10.31	0.77	30.15	0.73	5.5	5.99	0.95	87	2.50	3.57	297.50	5.77
13	IC45862	80	115.6	3.7	8.01	0.81	25.10	0.81	4.6	4.98	0.91	112	1.60	3.33	361.00	6.85
14	IC45863	84	117.5	4.7	8.79	0.76	25.15	0.87	5.7	6.39	0.72	114	2.50	2.99	227.50	53.48
15	IC45863-A	84	129.3	4.7	10.07	0.85	27.42	0.87	5.6	6.89	0.96	113	2.30	2.11	245.50	11.92
16	IC45864	80	140.4	3.1	8.17	0.77	27.93	0.90	6.7	5.39	0.91	115	1.65	4.13	235.50	23.81
17	IC45865	81	135.9	3.9	12.23	0.74	28.08	1.05	5.2	5.30	0.84	114	2.50	2.72	218.50	7.83
18	IC45866	80	133.5	3.9	9.61	0.79	26.78	0.93	6.5	4.55	0.85	113	2.40	3.40	214.50	6.00
19	IC45867	87	126.3	4.1	9.48	0.82	25.96	0.87	5.4	6.06	0.77	118	1.95	2.50	208.00	25.23
20	IC45868	82	130.3	4.8	11.30	0.77	29.16	0.88	6.7	6.00	0.80	115	1.55	2.73	251.00	1.315

Table 4.2. contd.....

SN	Name of Germplasm/ Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
21	IC45876	84	123.0	3.9	8.32	0.74	30.35	0.87	5.1	4.99	1.01	116	2.80	3.99	289.50	16.83
22	IC45878-A	74	111.3	4.3	10.86	0.79	33.40	0.85	5.6	5.99	0.92	107	2.55	3.55	217.00	44.26
23	IC49940	77	122.3	4.8	11.27	0.79	24.56	0.98	4.9	5.71	0.87	108	2.45	3.01	211.00	7.73
24	IC49942	79	110.5	5.1	8.62	0.75	31.29	0.84	5.7	5.49	0.87	113	2.00	3.10	236.50	31.91
25	IC49944-B	61	115.6	4.0	9.73	0.76	24.74	0.85	4.2	6.16	0.88	97	2.40	2.42	389.00	27.39
26	IC49946-A	70	121.7	5.1	8.97	0.77	24.80	0.75	5.5	5.70	0.91	99	2.75	4.07	297.50	39.06
27	IC49947	74	133.5	5.3	11.72	0.73	30.02	0.97	5.8	5.98	0.91	106	2.35	3.80	354.50	12.02
28	IC49947-A	74	131.4	3.9	10.03	0.81	32.38	0.90	6.1	5.62	0.75	107	2.05	2.46	295.00	28.88
29	IC49949-A	73	143.4	4.3	11.38	0.64	28.80	0.87	6.7	5.70	0.85	106	2.10	3.41	379.00	21.36
30	IC49953	73	133.8	3.1	10.83	0.80	34.08	0.99	7.7	6.80	0.98	107	2.75	4.53	265.00	39.01

Table 4.2. contd.....

SN	Name of Germplasm/ Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
31	IC49956	74	142.2	3.5	9.40	0.65	17.27	0.67	4.3	5.74	0.77	108	2.60	3.10	217.50	15.01
32	IC49965	74	131.4	3.7	8.70	0.74	33.13	0.94	5.7	4.25	0.71	107	2.80	3.72	325.50	37.32
33	IC49979-B	76	131.9	3.9	9.00	0.77	23.54	0.75	4.3	5.53	0.75	107	2.90	5.54	313.00	6.03
34	IC49981-A	75	138.1	3.7	10.25	0.85	34.20	0.93	7.8	6.14	0.96	111	2.40	4.64	219.50	41.04
35	IC49983	76	126.6	3.5	10.30	0.76	25.10	0.85	7.1	4.98	0.72	108	2.70	4.93	209.50	5.96
36	IC49985	76	138.2	4.4	11.77	0.80	34.75	0.95	7.1	7.06	0.91	109	2.55	5.95	374.50	15.84
37	IC49988	77	119.2	4.5	12.55	0.71	29.53	0.85	6.7	5.91	0.87	106	1.90	3.51	296.50	30.41
38	IC49990-B	76	129.2	4.4	11.12	0.74	25.81	0.87	5.9	5.43	0.79	109	2.45	3.57	394.50	9.06
39	IC49992	74	111.5	4.7	9.20	0.78	29.22	0.75	5.7	4.50	0.67	106	1.90	3.34	286.00	16.12
40	IC49992-A	74	116.7	4.4	12.46	0.74	33.10	0.89	6.7	5.81	1.04	109	2.25	3.49	347.50	7.10

Table 4.2. contd.....

SN	Name of Germplasm/ Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
41	IC49995-A	80	110.0	4.5	7.20	0.75	25.98	0.78	6.4	4.85	0.83	110	1.85	1.94	287.50	0.77
42	IC49998-A	73	108.1	5.3	9.04	0.79	26.47	0.95	8.1	6.04	0.84	108	2.60	2.92	221.00	41.86
43	IC49999	74	118.8	5.3	8.41	0.91	21.07	0.77	7.7	5.40	0.88	106	1.50	2.74	336.50	1.32
44	IC49999-A	78	116.9	4.9	9.26	0.73	25.01	0.89	7.4	4.75	0.85	107	1.95	3.09	246.00	4.04
45	IC49999-B	77	126.3	3.8	9.34	0.83	31.14	0.94	8.1	4.76	0.94	104	2.45	2.61	242.50	6.01
46	IC50000	80	119.8	4.5	8.25	0.87	27.00	0.95	5.7	5.43	0.87	112	2.60	3.51	215.00	2.32
47	IC50000-B	77	129.3	4.0	9.55	0.75	27.92	0.97	6.6	6.49	0.85	108	1.90	2.93	267.50	6.33
48	IC50001	80	126.5	5.2	9.41	0.90	26.03	0.99	6.2	6.83	0.91	108	1.50	3.20	323.00	27.71
49	IC50002	76	124.0	4.0	10.98	1.15	35.40	0.95	7.5	7.75	0.92	107	1.50	3.10	216.50	45.00
50	IC50004	73	122.0	4.6	11.34	0.91	33.00	0.93	8.5	7.11	0.83	105	1.95	3.07	244.00	53.69

Table 4.2.contd....

SN	Name of Germplasm/ Genotype	Days to 50 % flowerin g	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
51	IC50006	73	116.8	2.7	8.55	0.85	36.16	0.99	9.1	5.35	0.93	104	1.45	2.46	236.50	21.02
52	IC50009	73	118.0	3.2	8.82	0.83	28.58	1.06	8.0	5.57	0.85	107	2.45	3.41	378.50	30.55
53	IC50011	73	122.1	4.0	9.20	0.91	33.10	0.93	7.1	5.13	0.86	107	1.65	3.07	357.00	10.32
54	IC50012-A	80	125.9	2.9	10.45	0.86	28.58	0.85	5.4	6.74	0.84	112	2.50	2.48	381.00	41.76
55	IC50013	76	129.6	3.5	8.24	0.73	31.00	0.88	7.1	4.50	0.87	108	1.70	3.80	286.50	22.09
56	IC50013-B	75	130.1	3.6	8.73	0.85	31.48	0.95	7.9	5.96	0.83	107	1.65	4.05	410.50	27.03
57	IC50015-A	77	133.1	4.4	9.17	0.85	31.40	0.89	6.7	5.70	0.83	110	2.45	3.35	210.00	11.97
58	IC50019	69	135.9	3.2	10.49	0.75	26.28	0.91	4.5	5.59	1.04	98	1.80	2.41	326.50	15.69
59	IC51458	81	130.7	3.6	8.65	0.93	25.81	1.03	6.9	7.17	0.87	112	2.30	3.42	203.50	5.20
60	IC65559	73	133.0	4.6	10.45	0.83	34.58	0.95	6.1	6.58	0.97	106	2.05	2.00	318.50	29.52

Table 4.2.contd....

SN	Name of Germplasm/ Genotype	Days to 50 % flowerin g	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
61	IC65558-B	74	132.4	4.1	11.88	0.93	38.22	1.05	7.8	8.00	0.87	107	2.25	2.30	376.50	26.95
62	IC65595	75	133.5	4.7	10.77	0.77	38.44	1.04	8.0	6.31	0.97	107	1.95	4.96	276.50	16.83
63	IC65632-A	68	120.0	3.3	11.51	0.85	32.74	0.96	7.3	7.19	1.07	99	1.80	3.39	199.00	41.61
64	IC65696-B	81	129.3	3.3	10.69	0.87	33.12	0.94	4.6	6.37	1.06	114	2.45	4.60	203.00	12.94
65	IC66048-A	81	116.5	3.9	9.33	0.76	25.88	0.85	10.1	5.07	1.15	115	2.30	3.98	208.50	32.79
66	IC66172	75	125.8	4.7	9.58	0.96	37.72	1.03	7.4	6.38	1.03	107	2.05	2.39	205.00	37.76
67	IC66235	74	133.8	4.9	8.87	0.96	27.87	1.02	6.3	6.58	0.87	106	2.30	2.09	267.50	6.07
68	IC66255	73	130.1	3.9	9.72	0.93	32.88	1.14	7.5	6.88	0.83	103	1.70	2.51	348.00	53.89
69	IC66337	77	131.6	4.1	7.86	0.75	29.91	0.97	6.3	7.87	0.84	108	2.25	2.34	381.50	38.64
70	IC66588	83	136.2	4.1	9.61	1.04	33.99	1.24	10.0	8.65	0.94	115	1.65	3.49	387.50	11.95

Table 4.2.contd....

SN	Name of Germplasm/ Genotype	Days to 50 % flowerin g	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
71	IC69596-A	85	130.9	4.6	8.55	0.73	25.90	0.94	5.8	4.70	0.97	117	2.70	3.99	375.50	5.95
72	IC69598	86	134.7	3.6	11.63	0.93	31.94	1.03	7.1	6.14	0.98	119	2.70	2.13	219.00	27.79
73	IC71330-A	80	134.7	4.4	11.39	0.83	29.78	0.84	5.6	6.81	0.94	113	2.10	2.16	377.50	17.11
74	IC71340	85	134.2	2.8	11.10	0.97	34.19	0.94	6.5	5.22	1.01	117	2.55	4.11	264.50	42.01
75	IC71342	80	139.2	3.9	9.75	0.86	31.46	0.96	5.4	5.77	1.03	111	2.60	4.55	219.50	7.975
76	IC71377-C	80	126.9	3.8	10.95	1.07	29.30	1.12	7.7	5.45	0.97	111	1.80	2.47	234.50	22.94
77	IC71378-B	82	123.1	3.8	9.99	0.84	27.87	0.93	6.2	6.87	0.95	113	2.05	3.49	388.00	9.00
78	IC71378-C	81	123.6	4.9	11.60	1.15	28.68	1.13	8.0	6.46	1.05	115	2.45	5.54	200.00	28.03
79	IC71379-A	81	105.7	3.3	8.51	0.75	27.08	0.97	6.0	5.26	0.96	113	1.60	3.37	214.00	54.94
80	IC71380	85	133.5	4.0	10.98	0.95	25.21	1.05	7.9	6.04	0.85	117	1.55	3.31	321.00	9.22

Table 4.2.contd....

SN	Name of Germplasm/ Genotype	Days to 50 % flowerin g	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
81	IC71381	80	121.3	3.0	9.85	0.97	32.26	1.01	6.8	5.63	0.91	114	2.05	3.69	356.50	12.89
82	IC71382-B	81	137.5	3.1	11.72	0.97	30.86	0.99	6.9	5.08	1.03	112	2.55	2.42	263.50	30.98
83	IC71395	79	135.2	3.1	9.51	1.05	37.98	1.01	5.5	5.09	0.85	111	2.20	2.59	412.50	6.83
84	IC71395-A	81	138.9	3.5	9.26	0.90	24.64	0.94	7.4	8.35	1.01	110	1.80	4.51	364.50	16.31
85	IC71399	81	132.4	3.5	10.23	0.89	29.82	0.99	6.4	5.38	0.95	110	2.90	3.45	386.50	29.71
86	IC71400-A	85	135.9	4.2	8.02	0.85	21.58	0.95	6.7	5.57	0.94	117	3.20	2.99	388.50	29.10
87	IC71408	81	129.6	3.1	9.87	0.85	26.73	0.97	7.1	5.05	0.98	111	2.45	2.89	223.50	16.07
88	IC71410	80	130.7	3.5	10.03	0.87	24.99	0.93	6.9	4.83	0.82	111	1.95	6.09	267.50	44.90
89	IC71411-A	78	126.6	3.5	8.14	0.97	30.72	0.93	7.7	4.55	0.81	112	1.70	2.28	359.50	12.82
90	IC71411-B	78	129.4	3.4	9.00	0.85	31.94	0.77	6.2	5.70	0.95	109	1.75	1.99	298.50	9.31

Table 4.2.contd....

SN	Name of Germplasm/ Genotype	Days to 50 % flowerin g	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
91	IC71413	75	124.2	3.4	11.40	1.01	31.94	0.94	6.5	6.16	1.04	102	3.25	3.65	285.50	6.95
92	IC71413-A	81	128.5	3.6	10.33	1.05	27.94	0.96	6.6	5.65	1.13	111	2.80	4.22	311.00	32.79
93	IC71418-A	85	125.4	3.9	10.31	0.75	26.81	0.84	5.4	5.50	1.05	116	2.75	4.68	419.50	23.33
94	IC71418-B	86	116.4	4.0	10.29	0.73	24.62	0.83	6.0	5.64	1.05	118	2.95	5.15	337.50	38.00
95	IC71419-A	67	125.5	3.9	11.61	0.77	25.03	0.75	6.1	6.33	0.95	99	2.85	3.19	278.50	40.93
96	IC71420	79	113.5	4.0	10.07	0.78	32.20	0.94	7.3	6.20	0.75	111	1.50	5.41	213.50	33.97
97	IC71420-A	81	119.5	3.6	11.38	0.80	32.30	0.96	9.9	6.11	0.85	111	1.30	3.48	263.50	27.35
98	IC71581	71	125.7	3.3	10.75	0.71	26.84	0.83	7.4	6.33	0.93	104	2.65	4.02	319.50	10.38
99	IC73541-A	71	133.2	2.5	11.47	0.75	30.75	0.80	7.3	6.29	0.86	104	2.30	4.66	316.50	15.00
100	IC87458-A	69	137.2	3.7	10.65	0.75	31.10	0.93	7.3	6.50	0.90	102	2.40	2.66	397.50	13.07

Table 4.2.contd....

SN	Name of Germplasm /Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
101	IC87469	79	142.3	5.5	11.15	0.91	34.85	0.85	4.7	7.63	1.20	111	2.50	2.30	216.50	30.78
102	IC87470	85	140.4	3.2	9.76	0.76	25.36	0.87	5.5	6.27	0.97	117	2.20	2.69	355.00	27.16
103	IC87471	81	132.7	3.5	7.39	0.83	24.03	0.87	5.0	4.25	0.98	113	2.85	4.02	275.00	12.72
104	IC87472	81	127.9	3.1	10.30	0.91	30.80	1.01	6.1	5.66	0.97	112	1.75	4.17	351.50	26.98
105	IC87476	58	135.8	3.8	11.14	0.99	32.35	1.08	17.7	8.24	0.91	90	2.30	5.51	406.50	24.02
106	IC87478	80	131.5	2.8	9.04	0.95	30.43	0.94	7.7	5.52	1.07	111	2.25	4.52	297.50	7.16
107	IC87483	81	135.2	5.2	10.79	0.75	36.10	0.74	5.7	8.65	0.75	112	1.95	2.71	233.50	23.86
108	IC87485	81	132.3	3.9	12.25	0.97	37.05	1.14	7.1	10.18	0.86	112	2.40	5.12	246.50	23.77
109	IC87486	80	136.9	3.1	11.37	0.79	32.35	0.99	6.6	8.09	0.93	114	1.60	4.44	375.00	6.185
110	IC87487	77	127.2	3.7	11.33	0.95	35.62	1.04	5.9	9.75	0.93	109	2.35	3.67	238.50	53.65

Table 4.2.contd....

SN	Name of Germplasm /Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
111	IC87488	70	141.7	3.6	11.81	0.87	34.64	1.14	6.6	9.32	1.03	103	1.70	2.45	244.50	39.82
112	IC87490	76	130.1	4.7	9.70	0.79	31.94	0.75	6.8	5.39	0.77	108	1.80	3.27	229.00	54.96
113	IC87494-A	81	133.2	4.7	11.57	0.93	27.01	0.97	5.6	6.08	1.01	113	2.95	4.95	244.50	13.13
114	IC87494-B	82	132.5	4.4	9.12	0.75	32.04	0.78	6.0	6.13	0.75	113	2.80	3.61	346.50	41.78
115	IC87497-A	78	126.8	2.9	11.05	0.95	35.63	0.87	6.7	5.64	0.90	112	2.25	4.43	414.50	1.30
116	IC87498	78	127.1	3.5	11.42	0.83	33.28	0.91	6.1	6.19	0.97	110	2.55	2.90	276.50	0.57
117	IC87500	74	129.6	4.3	12.57	0.95	25.36	0.99	7.5	6.60	0.87	107	2.40	2.60	296.50	9.01
118	IC87502	67	124.3	3.7	9.55	0.89	30.57	0.93	8.4	6.50	0.92	99	2.10	3.24	197.50	27.83
119	IC87504	80	128.9	3.4	9.69	0.81	30.84	0.93	4.7	5.53	1.00	111	2.25	2.46	274.50	13.17
120	IC87514-A	80	126.4	3.6	10.92	1.03	31.05	0.85	6.2	6.24	0.85	113	2.60	4.18	270.50	45.89

Table 4.2.contd....

SN	Name of Germplasm /Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
121	IC87517	76	127.4	3.2	11.91	0.85	29.06	0.71	6.2	7.23	0.84	104	2.60	4.43	322.50	31.95
122	IC87518	78	128.6	3.9	11.10	0.82	32.00	0.83	5.7	7.28	0.93	107	1.80	2.88	325.50	22.21
123	IC87519	73	116.9	3.1	10.30	0.75	27.88	0.72	4.4	5.52	0.91	106	2.25	2.92	387.50	41.75
124	IC87519-B	79	121.3	3.9	12.33	0.85	25.94	0.79	4.2	7.59	0.93	109	2.45	2.70	266.50	31.17
125	IC87522	73	119.4	4.2	9.06	0.83	29.22	0.87	5.5	6.64	0.82	103	2.25	2.71	210.50	13.92
126	IC87526	76	119.9	4.0	11.48	0.77	21.78	0.65	5.7	5.48	0.91	108	2.25	2.43	217.50	8.88
127	IC87529-A	78	125.9	3.3	10.64	0.87	25.85	0.75	5.5	6.51	0.91	109	2.85	3.56	323.50	39.88
128	IC87530	85	129.4	3.0	10.67	0.71	22.25	0.76	5.2	6.27	0.92	117	2.35	2.93	318.50	54.72
129	IC87565-B	77	123.8	3.9	11.32	0.85	22.06	0.88	6.5	5.04	0.92	109	2.80	5.05	240.50	43.06
130	IC203961	74	111.2	3.5	9.55	0.75	28.71	0.77	6.1	5.73	0.95	107	2.45	2.89	397.50	12.85

Table 4.2.contd....

SN	Name of Germplasm /Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
131	IC203970	76	118.2	3.7	10.20	0.83	30.95	0.81	5.1	4.81	0.92	111	2.35	5.19	348.50	5.81
132	IC203975	74	105.6	3.2	7.88	1.02	23.31	0.93	7.4	6.27	0.87	107	1.95	3.12	252.00	11.32
133	IC203978	80	115.0	2.9	10.85	0.97	29.73	0.94	6.3	8.64	0.93	108	2.45	4.37	367.50	21.86
134	IC204141	68	115.5	3.1	12.00	0.77	22.64	0.83	7.1	8.42	0.85	100	2.45	2.99	270.50	53.62
135	IC204143	65	118.9	3.5	11.48	0.87	35.21	0.77	6.9	6.30	0.81	97	2.65	3.09	208.50	22.63
136	IC206167	66	120.1	2.8	12.36	1.06	28.57	0.96	6.6	6.32	0.87	98	2.15	3.19	342.50	6.92
137	IC206171	64	124.4	3.0	10.07	0.85	27.67	0.85	5.5	5.25	0.93	97	2.25	2.53	321.50	23.11
138	IC340116	78	123.0	3.2	11.25	1.03	26.86	0.85	8.3	12.47	0.93	109	2.20	5.61	299.50	6.96
139	IC340136	75	114.6	3.8	10.98	1.10	38.98	0.94	7.6	7.09	0.91	105	2.35	3.21	297.50	40.05
140	IC340138	74	124.9	3.2	11.69	1.00	34.94	0.95	7.7	7.77	0.93	107	1.80	3.06	329.00	7.90

Table 4.2.contd....

SN	Name of Germplasm /Genotype	Days to 50 % flowerin g	Plant height (cm)	Producti ve tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger numbe r per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
141	IC340142	70	110.5	2.8	10.45	0.94	29.34	0.93	7.3	4.59	0.94	102	2.85	2.62	311.00	1.62
142	IC361118	77	128.9	4.3	10.14	0.97	32.82	0.95	6.9	6.07	0.94	111	2.60	2.99	260.00	3.90
143	IGPM-14-3	80	118.4	3.2	11.31	0.90	29.34	0.85	7.7	6.49	0.76	111	2.50	2.95	367.50	16.10
144	IGPM-20-3	86	127.6	4.0	9.94	0.97	31.22	0.93	7.4	6.99	0.72	117	1.95	2.36	351.50	8.66
145	IC395842	62	120.1	2.7	8.69	0.77	26.39	0.83	5.8	6.02	0.93	96	1.50	2.45	241.50	5.96
146	12-3	81	119.4	3.3	10.45	0.96	24.21	0.92	6.5	5.25	0.93	111	2.70	3.78	212.50	16.36
147	14-3	81	127.6	2.9	8.37	0.96	27.84	0.83	7.1	7.46	0.87	111	1.70	2.97	218.50	33.05
148	17-3	80	115.7	3.5	8.79	1.01	20.16	0.97	7.3	7.37	1.04	110	2.30	4.43	365.50	2.33
149	LS-5L	79	125.6	3.3	11.70	0.92	22.03	0.80	5.9	6.29	0.51	113	2.75	4.15	391.50	16.63
150	RDV-10	76	124.9	4.2	10.96	0.80	25.03	0.83	4.5	6.46	1.04	106	2.35	5.15	276.50	32.94

Table 4.2.contd....

SN	Name of Germplasm /Genotype	Days to 50 % flowerin g	Plant height (cm)	Producti ve tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger numbe r per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
151	GPU-28	79	108.8	4.2	10.72	1.15	35.83	1.13	6.2	7.24	0.93	111	3.70	6.33	297.50	23.41
152	VL-149	79	125.5	3.2	10.90	0.93	26.84	0.95	6.9	6.09	0.87	102	2.50	4.58	453.50	22.82
153	HR-374	69	110.1	3.9	11.01	1.18	35.33	1.19	8.1	6.40	0.93	103	2.75	6.32	398.00	55.06
154	JK439	74	118.5	3.0	10.10	0.86	23.15	0.91	6.2	6.18	0.85	106	2.70	2.93	317.50	43.63
155	BR-708	55	119.4	2.8	10.28	0.96	31.53	0.91	7.3	6.80	0.88	90	2.35	3.89	399.00	14.00
156	Phule Nachani	78	115.3	4.7	9.26	1.04	24.22	0.93	6.1	6.47	1.00	120	3.45	6.62	369.00	33.24
157	GPU67	77	112.2	4.7	10.77	1.04	26.08	1.14	11.0	8.00	1.03	115	2.70	6.04	340.50	57.83
158	GPU45	80	113.6	3.9	12.96	0.96	30.01	1.00	7.6	6.65	1.05	107	3.55	9.18	411.50	48.68

Table 4.2.contd....

SN	Name of Germplasm /Genotype	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100 gm)	Iron content (mg/100g m)
	Mean	77	125.7	3.78	10.23	0.85	29.32	0.91	7	6.19	0.90	109	2.28	3.54	295.52	22.69
	C.V. %	1.28	7.39	11.13	6.10	3.73	5.80	3.81	6.12	6.63	7.27	0.64	8.07	8.11	1.24	3.26
	S.E. +/-	0.69	6.55	0.29	0.44	0.02	1.20	0.02	0.28	0.29	0.04	0.49	0.13	0.20	2.60	0.52
	C.D. 5%	1.95	18.30	0.83	1.23	0.06	3.36	0.06	0.80	0.81	0.12	1.37	0.36	0.56	7.28	1.46

4.2 Mean performance and the range of variability

The mean values of the genotypes for different characters studied are given in Table 4.2, while the estimates of variability parameter are given in Table 4.3

4.2.1 Days to 50 per cent flowering

The variation in days to 50 per cent flowering ranged between 54 to 87 days. Genotype IC45861 flowered in (54) days while highest days (87) were taken by IC45845-A. Eighty seven genotypes were late in flowering than the mean flowering of genotypes 77 days.

4.2.2 Plant height (cm)

The plant height was maximum in case of IC45844 while it was minimum in case of IC45861. The value recorded for maximum height was 144.3 cm while minimum height was 102.7 cm. seventy nine genotype highest plant height than mean value 125.7 cm.

4.2.3 Productive tillers per plant

The number of tillers per plant ranged from 1.6 to 5.5 with general mean of 3.78. Genotype IC44840 lowest (1.6) while highest (5.5) in IC87469. Seventy nine genotypes were highest productive tillers than general mean value.

4.2.4 Flag leaf sheath length (cm)

Flag leaf sheath length ranged from 7.20 (IC49995-A) to 12.96 cm (GPU45). Eighty three genotypes recorded more flag leaf sheath length (cm) than the mean. Mean value for this character was 10.23 cm.

4.2.5 Flag leaf sheath width (cm)

Flag leaf sheath width ranged from 0.64 to 1.18 cm. The lowest flag leaf sheath width was recorded for the genotype IC49949-A while the highest was recorded for the genotype HR-374 (Check). Sixty seven genotypes were highest flag leaf sheath width than mean value 0.85 cm.

4.2.6 Flag leaf blade length (cm)

Flag leaf blade length ranged from 17.27 to 38.98 cm. The lowest flag leaf blade length was recorded for the genotype IC49956 while the highest was recorded for the genotype IC340136. Seventy nine genotypes were highest flag leaf blade length than mean value 29.32 cm.

4.2.7 Flag leaf blade width (cm)

Flag leaf blade width ranged from 0.65 to 1.24 cm. The lowest flag leaf blade width was recorded for the genotype IC87526 while the highest was recorded for the genotype IC66588. Eighty three genotypes were highest flag leaf blade width than mean value 0.91 cm.

4.2.8 Finger number per panicle

Finger number per panicle ranged from 4.2 to 17.7. The lowest finger number per panicle was recorded for the genotype IC49944-B and IC87519-B while the highest was recorded for the genotype IC87476. Seventy three genotypes were highest finger number per panicle than mean value 7.0.

4.2.9 Finger length (cm)

Finger length ranged from 4.25 to 12.47 cm. The lowest finger length was recorded for the genotype IC49965 and IC87471 while the highest was recorded for the genotype IC340116. Sixty nine genotypes were highest finger length than mean value 6.19 cm.

4.2.10 Finger width (cm)

Finger width ranged from 0.51 to 1.20 cm. The lowest finger width was recorded for the genotype LS-5L while the highest was recorded for the genotype IC87469. Eighty seven genotypes were highest finger width than mean value 0.90 cm.

4.2.11 Days to maturity

The variation in days to maturity ranged between 87 to 120 days. Genotype IC45862 matured in least number of days (87) while Phule Nachani (Check) and IC45845-A matured very late (120 days). Mean value for this character was 109 days and eighty genotypes were late matured than mean value.

4.2.12 1000 grain weight (g)

The variation in thousand grain weight ranged between 1.30 to 3.70 gm. the lowest thousand grain weight was recorded for the genotype IC71420-A while the highest was recorded for the genotype GPU-28 (Check). Eighty seven genotypes were more thousand grain weight than mean value 2.28 g.

4.2.13 Seed yield /plant (g)

The variation seed yield per plant ranged between 1.94 to 9.18 gm. the lowest seed yield per plant was recorded for the genotype IC49995-A while the highest was recorded for the genotype GPU45 (Check). Sixty three genotypes were more seed yield per plant than mean value 3.54.

4.2.14 Calcium content (mg/100g)

The variation for calcium content mg/100g ranged between 197.5 to 453.5 mg/100g. The lowest calcium content mg/100g was recorded in case of IC87502 while maximum in case of VL-149 (Check) and the mean value for this character was 295.52 mg/100g.

4.2.15 Iron content (mg/100g)

The variation for iron content mg/100g ranged between 0.57 to 57.83 mg/100g. The lowest iron content mg/100g was recorded in case of IC87498 while maximum in case of GPU67 (Check) and the mean value for this character was 22.69 mg/100g.

Table 4.3. Estimates of variability parameters for fifteen quantitative characters in finger millet

Sr. No.	Name of the characters	Range	Mean	σ^2g	σ^2p	σ^2e	GCV (%)	PCV (%)	h^2 (b.s.) (%)	G.A.	G.A. as % of mean
1.	Days to 50% flowering	54-87	77	33.96	34.94	0.97	7.59	7.70	97.2	11.83	15.43
2.	Plant height (cm)	102.7-144.3	125.37	36.52	122.43	85.90	4.82	8.82	29.8	6.80	5.42
3.	Productive tillers per plant	1.6-5.5	3.78	0.33	0.55	0.17	16.47	19.88	68.6	1.06	28.12
4.	Flag leaf sheath length (cm)	7.2-12.96	10.23	1.37	1.768	0.39	11.47	12.99	77.9	2.13	20.85
5.	Flag leaf sheath width (cm)	0.64-1.18	0.86	0.012	0.013	0.001	12.54	13.08	91.8	0.21	24.75
6.	Flag leaf blade length (cm)	17.27-38.98	29.32	16.33	19.22	2.89	13.78	14.95	84.9	7.67	26.16
7.	Flag leaf blade width (cm)	0.65-1.24	0.91	0.011	0.01	0.001	11.38	12.00	89.9	0.20	22.23
8.	Finger number per panicle	4.2-17.7	7.00	2.07	2.24	0.16	21.81	22.65	92.7	2.86	43.25
9.	Finger length (cm)	4.25-12.47	6.19	1.33	1.49	0.16	18.61	19.75	88.7	2.23	36.11
10	Finger width (cm)	0.51-1.20	0.90	0.008	0.012	0.004	10.08	12.43	65.7	0.15	16.82
11	Days to maturity	87-120	109	34.02	34.51	0.48	5.37	5.41	98.6	11.93	10.98
12	Thousand grain weight (g)	1.3-3.7	2.28	0.18	0.22	0.034	18.92	20.57	84.6	0.82	35.86
13	Seed yield per plant (g)	1.94-9.18	3.54	1.23	1.31	0.083	31.38	32.41	93.7	2.21	62.59
14	Calcium content (mg/100g)	197.5-453.5	295.52	4305.39	4318.99	13.59	22.20	22.23	99.7	134.95	45.66
15	Iron content mg (mg/100g)	0.57-57.83	22.69	230.03	230.58	0.55	66.84	66.92	99.8	31.20	137.52

4.3 variability and genetic parameters

The estimates of variability (Genotypic and Phenotypic coefficients of variation), heritability (broad sense), genetic advance and genetic advance as per cent of mean for fifteen characters in one hundred fifty eight genotypes of finger millet were presented in Table 4.3.

4.3.1 Genetic variability

The phenotypic variance is greater than the genotypic variance in phenotypic variance highest for calcium content (4318.99) followed by iron content (230.58), plant height (122.43), days to 50% flowering (34.94), days to maturity (34.51), flag leaf blade length (19.22), finger number per panicle (2.24), flag leaf sheath length (1.76), finger length (1.49) , Seed yield per plant (1.31), productive tillers per plant (0.55), thousand grain weight (0.222), flag leaf sheath width (0.013), finger width (0.0126) and flag leaf blade width (0.012).

At genotypic level calcium content (4305.39) followed by iron content (230.03), plant height (36.52), days to maturity (34.02), days to 50% flowering (33.96), flag leaf blade length (16.33), finger number per panicle (2.07), flag leaf sheath length (1.37), finger length (1.33) , Seed yield per plant (1.23), productive tillers per plant (0.33), thousand grain weight (0.18), flag leaf sheath width (0.012), flag leaf blade width (0.011) and finger width (0.008).

4.3.2 Genotypic and phenotypic coefficients of variation

GCV and PCV values were categorized as low (0-10%), moderate (10-20) and high (20% and above)

Genotypic coefficient of variation (GCV) was highest for iron content (66.84 %) followed by seed yield per plant (31.38%), calcium content (22.2%), finger number per panicle (21.81%), thousand grain weight (18.92%), finger length (18.61%), productive tillers per plant (16.47%), flag leaf blade length (13.78%), flag leaf sheath width (12.54%), flag leaf sheath length (11.47%), flag leaf blade width (11.38%), finger width (10.08%), days to 50% flowering (7.59%), days to maturity (5.37%) and plant height (4.82%).

The maximum phenotypic coefficient of variation was recorded for iron content (66.92%) followed by seed yield per plant (32.41%), finger number per panicle (22.65%), calcium content (22.23%), thousand grain weight (20.57%) ,

productive tillers per plant (19.88%), finger length (19.75%), flag leaf blade length (14.95%), flag leaf sheath width (13.08%), flag leaf sheath length (12.99%), finger width (12.43%), flag leaf blade width (12%), plant height (8.82%), days to 50% flowering (7.70%) and days to maturity (5.41%).

In general, the magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation.

4.3.2 Heritability and genetic advance

Maximum heritability was observed for iron content (99.8%) followed by calcium content (99.7%), days to maturity (98.6%), days to 50% flowering (97.2%), seed yield per plant (93.7%), finger number per panicle (92.7%), flag leaf sheath width (91.8%), flag leaf blade width (89.9%), finger length (88.7%), flag leaf blade length (84.9%), thousand grain weight (84.6%), flag leaf sheath length (77.9%), productive tillers per plant (68.6%), finger width (65.7%) and plant height (29.8%). High heritability (> 70 %) was observed in most of the characters studied. The estimates of Genetic Advance ranged from 0.151 to 134.95 with the highest estimate in case of number of calcium content (134.95 %) followed by iron content (31.20%), days to maturity (11.93%), days to 50% flowering (11.83%), flag leaf blade length (7.67%), plant height (6.80%), finger number per panicle (2.86%), finger length (2.23 %), seed yield per plant (2.21%), flag leaf sheath length (2.13 %), productive tillers per plant (1.06 %), thousand grain weight (0.821%), flag leaf sheath width (0.213%), flag leaf blade width (0.202%), and finger width (0.151%).

Genetic advance as per cent of mean ranged from 5.42 to 137.52 per cent. Iron content (137.52%) recorded highest genetic advance as per cent mean followed by seed yield per plant (62.59%), calcium content (45.66%), finger number per panicle (43.25%), finger length (36.11%), thousand grain weight (35.86%), productive tillers per plant (28.12%), flag leaf blade length, (26.16%), flag leaf sheath width (24.75%), flag leaf blade width (22.23%) and flag leaf sheath length (20.85%). Moderate genetic advance mean was recorded for finger width (16.82%), days to 50% flowering (15.43%), days to maturity (10.98%) and lowest plant height (5.42%).

4.4 Genetic divergence

4.4.1 Mahalanobis's generalized distance (D^2)

Wilk's criterion showed significant differences between the genotypes for the pooled effect of the fifteen characters studied. Hence, further analysis was done to calculate D^2 values for all the possible pairs of comparison among one hundred fifty eight genotypes. The calculated D^2 values ranged from 50073.01 to 9231753.02.

The mean values of one hundred fifty eight genotypes $[(X_1)-(X_2)]$ were transformed into standardized uncorrelated mean values $[(Y_1)-(Y_2)]$. The D^2 values were computed for all the possible $158(158-1)/2 = 12403$ pairs of genotypes.

4.4.2 Clustering pattern of the genotypes

The clustering pattern obtained on the basis of magnitude of D^2 values studied, are presented in Table 4.4.

These one hundred fifty eight genotypes were grouped into thirteen clusters. The cluster I was with the highest number of genotypes (58) followed by cluster IV (43), clusters II (40), cluster V (8), and cluster III, VI, VII, VIII, IX, X, XI, XII, XIII had single genotype.

4.4.3 Intra and inter cluster divergence

The average intra and inter cluster D^2 and D values are presented in Table 4.5 and Table 4.6.

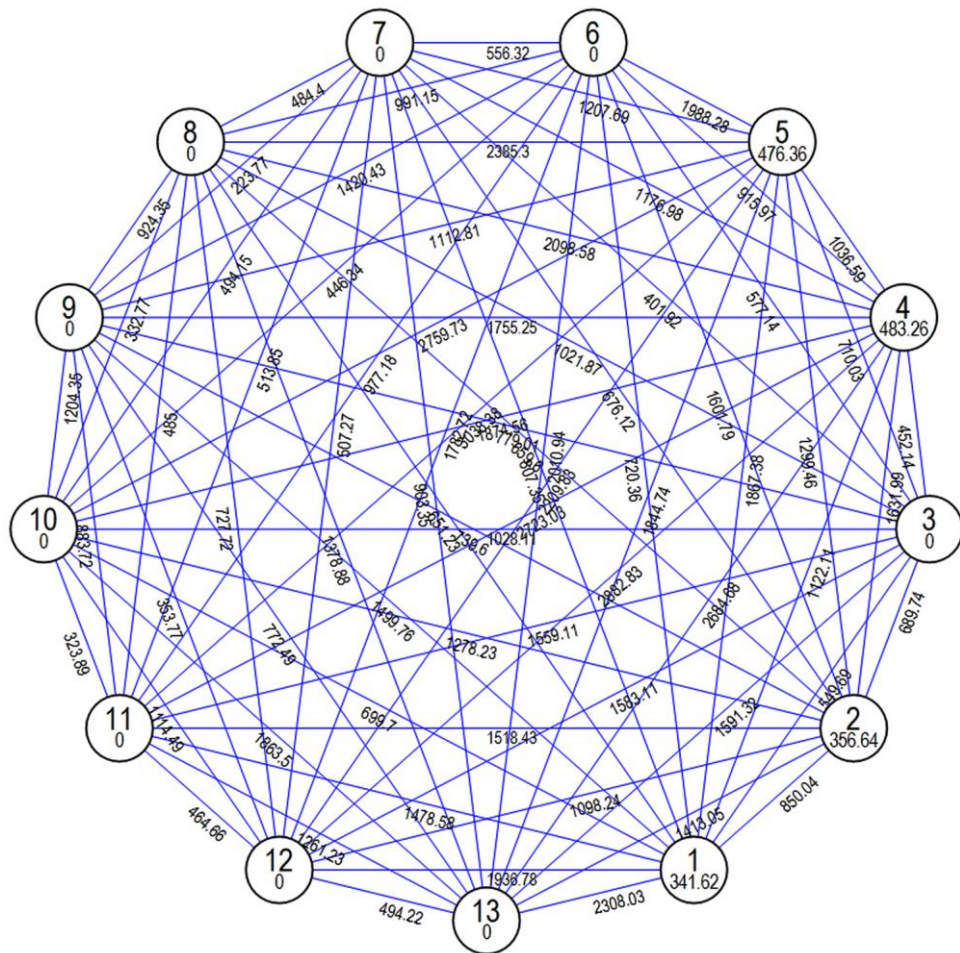
The intra cluster distance (D) range from 223.77 to 3038.38. The maximum inter cluster distance ($D = 3038.38$) was observed between cluster XI and cluster V, followed by cluster XII and IV ($D = 2882.83$), cluster X and cluster V (2759.73), cluster XI and cluster IV ($D = 2723.03$), cluster XIII and cluster IV ($D = 2684.68$). The minimum inter cluster distance ($D = 223.77$) was between IX and VII.

At inter cluster level, cluster XI and V had the highest value which was followed by cluster XII and IV.

Table. 4.4. Composition of one hundred fifty eight finger millet genotypes into different clusters by Tocher's method.

Cluster No.	No. of genotypes	Genotypes included in the cluster
I	58	IC71408, 12-3, IC50015-A, IC65696-B, IC71342, IC87494-A, IC45866 IC87504, IC49940, IC51458, IC49983, IC50000, IC45863-A, IC87526 IC49999-A, IC203975, IC49999-B, IC361118, IC50000-B, IC45865, IC87471, IC87522, IC49956, IC44840, IC49979-B, IC66235, IC45852 IC43276-A, IC87498, IC87478, IC71411-B, IC49992, IC65595, IC87500 IC45850, IC45876, IC50013, IC45859, IC49995-A, IC71413, IC50006 IC71377-C, IC45845-A, IC45864, IC45844-A, IC45841-A, IC87483 IC45847, IC87485, , IC49947-A, IC73541-A, IC87518, IC71380 IC340116, IC71581, IC340138, IC71420-A.
II	40	IC71381, IC71411-A, IGPM-14-3, IC71395-A, IC71330-A, IC71378-B LS-5L, IC203978, IC49985, IC45844, IC50011, IC49947, IC49990-B IC340116, IC45862, IC49992-A, IC203970, IC87486, IC69596-A, 17-3 IGPM-20-3, IC66588, IC71395, IC49949-A, IC87497-A, IC49999 IC87458-A, IC71418-A, IC50013-B, IC87472, IC65558-B, IC71399 IC87470, IC50009, IC50001, IC71400-A, VL-149, IC206167, IC50019 IC65559.
III	1	IC49988.
IV	43	IC44032-A, IC45863, IC71379-A, IC87490, IC87487, IC50004, IC45878-A IC87514-A, IC87565-B, IC49981-A, IC50002, IC49998-A, IC71410 IC71340, IC66172, IC49953, IC71420, 14-3, IC49942, IC66048-A, IC87469 IC71382-B, IC87488, IC87519-B, RDV-10, IC340136, IC65632-A, JK-439 IC87529-A, IC71413-A, IC49965, IC71419-A, IC49946-A, IC204141 IC87517, IC69598, IC71378-C, IC87494-B, IC87530, IC45867, IC87502 GPU-28, IC71418-B.
V	8	IC50012-A, IC66337, IC87519, GPU67, HR-374, GPU45, PhuleNachani IC66255.
VI	1	IC204143
VII	1	IC206171
VIII	1	IC340142
IX	1	IC49944-B
X	1	IC395842
XI	1	IC45861
XII	1	BR-708
XIII	1	IC87476

Fig.1. Cluster diagram in Finger millet.



Mahalanobis Euclidean Disatnce (Not to the Scale)

Table. 4.5. Average intra and inter cluster D² values in finger millet.

Cluster No.	I	II	III	IV	V	VI	VII
I	116704.224	722568.0016	302159.0961	1259130.85	3487108.064	518918.5296	651814.0225
II		127192.0896	475741.2676	2663391.36	1688596.292	2565731.204	457138.2544
III			0	204430.58	504142.6009	333090.5796	161539.6864
IV				233540.228	1074518.828	839001.0409	1385281.92
V					226918.8496	3953257.358	1458515.136
VI						0	309491.9424
VII							0
VIII							
IX							
X							
XI							
XII							
XIII							

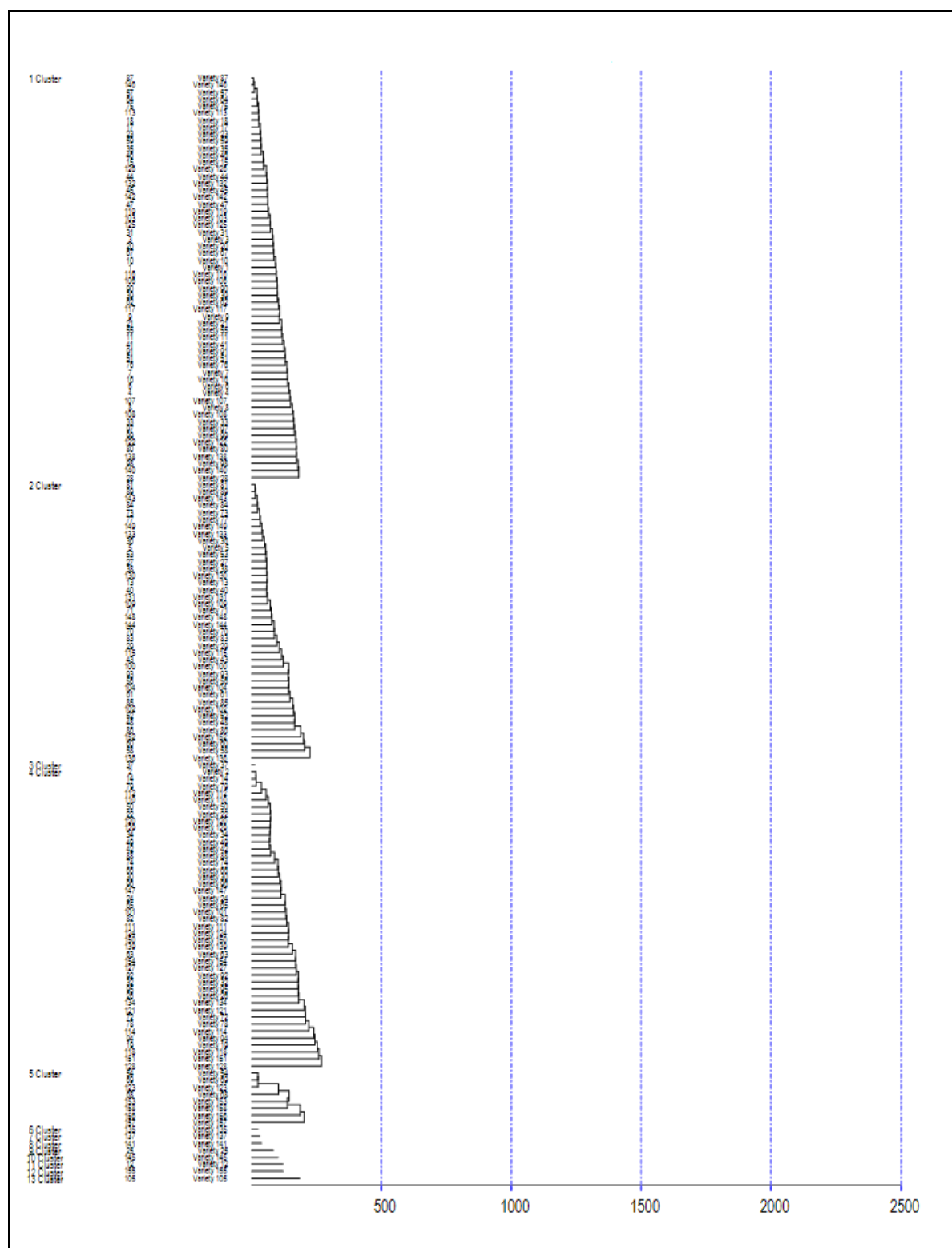
Table. 4.5. contd...

Cluster No.	VIII	IX	X	XI	XII	XIII
I	424100.5129	2249280.058	489580.09	2186198.816	3751116.768	5327002.481
II	435072.16	547008.16	1633871.933	2305629.665	1206131.098	1996710.303
III	1044218.297	606856.5801	1057010.172	2430823.992	2506237.272	2532299.342
IV	4404038.016	3080902.563	3513975.194	7414892.381	8310708.809	7207506.702
V	5689656.09	1238346.096	7616109.673	9231753.024	4883348.629	3403065.668
VI	982378.3225	2017621.385	199219.3956	954880.7524	3178090.598	4043879.684
VII	234643.36	50073.0129	244184.2225	264041.8225	257322.8529	816041.2225
VIII	0	854422.9225	110735.8729	235225	529576.3984	1901310.054
IX		0	1450458.923	780961.0384	125153.2129	596740.8001
X			0	104904.7321	1242087.96	3472632.25
XI				0	215908.9156	1590701.113
XII					0	244253.4084
XIII						0

Table. 4.6. Average intra and inter cluster distance (D) values in finger millet.

Cluster No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	341.62	850.04	549.69	1122.11	1867.38	720.36	807.35	651.23	1499.76	699.7	1478.58	1936.78	2308.03
II		356.64	689.74	1631.99	1299.46	1601.79	676.12	659.6	739.6	1278.23	1518.43	1098.24	1413.05
III			0.00	452.14	710.03	577.14	401.92	1021.87	779.01	1028.11	1559.11	1583.11	1591.32
IV				483.26	1036.59	915.97	1176.98	2098.58	1755.25	1874.56	2723.03	2882.83	2684.68
V					476.36	1988.28	1207.69	2385.3	1112.81	2759.73	3038.38	2209.83	1844.74
VI						0.00	556.32	991.15	1420.43	446.34	977.18	1782.72	2010.94
VII							0.00	484.4	223.77	494.15	513.85	507.27	903.35
VIII								0.00	924.35	332.77	485	727.72	1378.88
IX									0.00	1204.35	883.72	353.77	772.49
X										0.00	323.89	1114.49	1863.5
XI											0.00	464.66	1261.23
XII												0.00	494.22
XIII													0.00

Fig.2.Clustering of finger millet genotypes by Tocher method.



4.4.4 Cluster means for different characters

The cluster mean for the fifteen characters are presented in Table 4.7 A considerable inter cluster variation was observed among the cluster means for the characters studied viz., day to 50 % flowering, plant height, productive tillers per plant, flag leaf sheath length ,flag leaf sheath width, flag leaf blade length, flag leaf blade width, finger number per panicle, finger length, finger width, days to maturity, thousand grain weight, seed yield per plant (gm), calcium content and iron content mg/100gm .

The cluster mean for days to 50 per cent flowering varied from 54 (XI) to 78 days (I) and (II). The cluster means for plant height ranged between 102.7 (XI) to 135.8 cm (XIII). The cluster mean for productive tillers per plant ranged between 2.70 (X) to 4.50 (III). The cluster mean for flag leaf sheath length ranged from 8.69 (cluster X) to 12.55 (cluster III). The cluster mean for flag leaf sheath width ranged between 0.71 (cluster III) and 0.99 (cluster XIII). The cluster mean for flag leaf blade length was maximum in cluster (VI) 35.22 and it was minimum in cluster (IX) 24.74. The cluster mean for flag leaf blade width was maximum in cluster (XIII) 1.08 and it was minimum in cluster (XI) 0.73. The cluster mean for finger number per panicle was minimum in cluster IX (4.2) and it was maximum in cluster XIII (17.7). The cluster mean for finger length ranged between 4.59 (cluster VIII) and 8.24 (cluster XIII). The cluster mean for finger width ranged between 0.81(cluster VI) and 0.95 (cluster XI). The cluster mean for days to maturity was maximum in cluster (I) 110 and minimum in case of cluster (XI) 87. The cluster mean for thousand grain weight was maximum in cluster (VIII) 2.85 and it was minimum in cluster (X) 1.5. The cluster mean for seed yield per plant was maximum in cluster (XIII) 5.51 and it was minimum in cluster (IX) 2.42. The cluster mean for calcium content was minimum in cluster (VI) 208.5 and it was maximum in cluster (XIII) 406.5. The cluster mean for iron content was maximum in cluster (V) 46.36 and it was minimum in cluster (XIII)

Table 4.7. Cluster means of different characters to genetic diversity in finger millet.

SN	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant (g)	Calcium content (mg/100gm)	Iron content (mg/100g)
I	78	126.2	3.76	10.06	0.84	29.04	0.90	6.46	6.00	0.89	110	2.24	3.35	257.52	12.45
II	78	128.1	3.75	10.20	0.86	29.21	0.93	6.59	6.16	0.90	109	2.20	3.50	372.03	15.61
III	77	119.2	4.50	12.55	0.71	29.53	0.85	6.70	5.91	0.87	106	1.90	3.51	296.50	30.41
IV	77	124.1	3.89	10.43	0.87	29.72	0.90	6.58	6.39	0.92	109	2.37	3.66	255.53	39.84
V	76	119.5	3.90	10.29	0.94	29.36	0.99	7.05	6.82	0.93	109	2.64	4.80	377.13	46.36
VI	65	118.9	3.50	11.48	0.87	35.22	0.77	6.90	6.30	0.81	97	2.65	3.09	208.50	23.12
VII	64	124.4	3.00	10.07	0.85	27.68	0.85	5.50	5.25	0.93	97	2.25	2.54	321.50	22.64
VIII	70	110.5	2.80	10.45	0.94	29.34	0.93	7.30	4.59	0.94	102	2.85	2.62	311.00	1.62
IX	61	115.6	4.00	9.73	0.76	24.74	0.85	4.20	6.16	0.88	97	2.40	2.42	389.00	27.39
X	62	120.1	2.70	8.69	0.77	26.4	0.83	5.80	6.02	0.93	96	1.50	2.46	241.50	5.96
XI	54	102.7	4.10	10.32	0.77	30.15	0.73	5.50	5.99	0.95	87	2.50	3.58	297.50	5.78
XII	55	119.4	2.80	10.28	0.96	31.53	0.91	7.27	6.80	0.88	90	2.35	3.89	399.00	14.01
XIII	58	135.8	3.80	11.14	0.99	32.35	1.08	17.70	8.24	0.91	90	2.30	5.51	406.50	24.03

The utility of D^2 analysis was enhanced by its application to estimate the relative contribution of the various plant characters to genetic divergence. The per cent contribution of fifteen characters studied, towards total divergence is presented in Table 4.8.

It was observed that, iron content (47.68%) contributed highest for divergence. It was followed by calcium content (39.77%), days to maturity (9.63%), seed yield per plant (0.73 %), flag leaf sheath width (0.53%), finger length (0.53%), finger number per panicle (0.49%), flag leaf blade width (0.2 %), flag leaf blade length (0.17%), days to 50% flowering (0.1%), thousand grain weight (0.07%), flag leaf sheath length (0.05%), productive tillers per plant (0.02%), finger width (0.01%) and plant height (0%).

Table 4.8. Per cent contribution of different characters to genetic diversity in finger millet

Sr. No.	Characters	No. of times appearing 1 st in ranking	% contribution
1.	Days to 50% flowering	13	0.1
2.	Plant height (cm)	0	0
3.	Productive tillers per plant	2	0.02
4.	Flag leaf sheath length (cm)	6	0.05
5.	Flag leaf sheath width (cm)	66	0.53
6.	Flag leaf blade length (cm)	21	0.17
7.	Flag leaf blade width (cm)	25	0.2
8.	Finger number per panicle	61	0.49
9.	Finger length (cm)	66	0.53
10.	Finger width (cm)	1	0.01
11.	Days to maturity	1195	9.63
12.	Thousand grain weight (g)	9	0.07
13.	Seed yield per plant (g)	91	0.73
14.	Calcium content (mg/100g)	4933	39.77
15.	Iron content mg (mg/100g)	5914	47.68
	Total	12403	100

Table 4.9. Estimation of genotypic (above diagonal) correlation coefficients in finger millet.

SN	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle
	1	2	3	4	5	6	7	8
1	1.0000	0.2656***	0.0683	-0.1476**	-0.0016	-0.1122*	0.0508	-0.2019***
2		1.0000	-0.0179	0.0912	-0.1322*	0.2217***	0.1968***	-0.0080
3			1.0000	-0.0667	-0.0927	0.0195	0.0419	-0.0013
4				1.0000	0.2004***	0.2529***	0.1625**	0.0760
5					1.0000	0.3290***	0.5940***	0.3677***
6						1.0000	0.4249***	0.2553***
7							1.0000	0.4649***
8								1.0000
9								
10								
11								
12								
13								
14								
15								

* Significant at 5 % and ** Significant at 1 % level of probability or level of significance,

Table 4.9. contd.....

SN	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Calcium content (mg/100gm)	Iron content (mg/100g)	Seed yield per plant
	9	10	11	12	13	14	15
1	-0.1062	-0.0146	0.9488***	0.0143	-0.1206*	-0.0165	0.0271
2	0.1935***	0.0311	0.2154***	-0.0445	0.1045	-0.1328*	-0.1612**
3	0.0527	-0.0135	0.0777	-0.0332	-0.1436*	0.0525	-0.0162
4	0.3952***	0.2055***	-0.1647**	0.2224***	0.0578	0.1072	0.2558***
5	0.3547***	0.2849***	-0.0097	0.0920	0.0728	0.0468	0.2322***
6	0.2659***	0.1480**	-0.1100	-0.1902***	-0.0192	0.0945	-0.0248
7	0.2708***	0.3413***	0.0493	-0.0373	0.0576	0.0523	0.2066***
8	0.2515***	0.0557	-0.1852**	-0.1742**	0.0867	0.0948	0.1998***
9	1.0000	0.1401*	-0.1324*	-0.0968	0.0676	0.1871***	0.1460**
10		1.0000	-0.0272	0.1768**	-0.0469	0.0012	0.2377***
11			1.0000	0.0434	-0.1073	-0.0076	0.0464
12				1.0000	0.1314*	0.0968	0.4273***
13					1.0000	-0.0752	0.1928***
14						1.0000	0.1476**
15							1.0000

* Significant at 5 % and ** Significant at 1 % level of probability or level of significance,

Table 4.10 Estimation of phenotypic (above diagonal) correlation coefficients in finger millet.

SN	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle
	1	2	3	4	5	6	7	8
1	1.0000	0.1457 **	0.0523	-0.1277 *	-0.0023	-0.1072	0.0512	-0.1893 ***
2		1.0000	-0.0355	0.0815	-0.0718	0.1205 *	0.1246 *	-0.0182
3			1.0000	-0.0394	-0.0825	0.0266	0.0389	-0.0113
4				1.0000	0.1881 ***	0.2222 ***	0.1385 *	0.0520
5					1.0000	0.2755 ***	0.5474 ***	0.3405 ***
6						1.0000	0.3669 ***	0.2143 ***
7							1.0000	0.4377 ***
8								1.0000
9								
10								
11								
12								
13								
14								
15								

Table 4.10. contd.....

SN	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Seed yield per plant	Calcium content (mg/100gm)	Iron content (mg/100g)
	9	10	11	12	13	14	15
1	-0.0985	0.0180	0.9271 ***	0.0191	0.0225	-0.1179 *	-0.0163
2	0.0743	0.0165	0.1406 *	-0.0236	-0.0906	0.0588	-0.0735
3	0.0446	0.0127	0.0644	0.0080	0.0002	-0.1236 *	0.0412
4	0.3538 ***	0.1488 **	-0.1368 *	0.1757 **	0.2076 ***	0.0501	0.0941
5	0.3399 ***	0.2257 ***	-0.0091	0.0832	0.2150 ***	0.0694	0.0452
6	0.2078 ***	0.1187 *	-0.0953	-0.1662 **	-0.0344	-0.0162	0.0856
7	0.2551 ***	0.2924 ***	0.0499	-0.0421	0.1876 ***	0.0545	0.0499
8	0.2322 ***	0.0450	-0.1817 **	-0.1698 **	0.1876 ***	0.0836	0.0912
9	1.0000	0.1189 *	-0.1275 *	-0.0821	0.1361 *	0.0627	0.1774 **
10		1.0000	-0.0240	0.1147 *	0.1854 ***	-0.0382	0.0033
11			1.0000	0.0445	0.0434	-0.1064	-0.0080
12				1.0000	0.3954 ***	0.1207 *	0.0882
13					1.0000	0.1873 ***	0.1422 *
14						1.0000	-0.0747
15							1.0000

* Significant at 5 % and ** Significant at 1 % level of probability or level of significance,

4.5 Correlation studies

The correlation study was undertaken in 158 genotypes of finger millet in order to find out interrelation of different yield components at genotypic and phenotypic level. The genotypic and phenotypic correlation coefficient for fifteen characters as presented in Table 4.9 and 4.10 respectively.

4.5.1 Association of seed yield with its components

From Table 4.9, 4.10 and Fig. 3 reveals that, seed yield per plant had significant positive association with thousand grain weight (0.4273), flag leaf sheath length (0.2558), finger width (0.2377), flag leaf sheath width (0.2322), flag leaf blade width (0.2066), finger number per panicle (0.1928), calcium content (0.1928), iron content (0.1476), finger length (0.1460), Correlation of seed yield per plant with plant height (-0.1612) was negative and significant. However flag leaf blade length (-0.0248), productive tillers per plant (-0.0162) and flag leaf blade length (-0.0344), plant height (-0.0906) had non-significant and negative association with seed yield at genotypic and phenotypic level respectively. Correlation of seed yield per plant with days to 50% flowering (0.0271), days to maturity (0.0464) was non-significant and positive association at genotypic and phenotypic level. Productive tillers per plant had positive association with seed yield per plant at phenotypic level.

4.5.2 Interrelationship of yield components

4.5.2.1 Days to 50 per cent flowering with other character

Days to 50 per cent flowering showed significant and positive correlation with days to maturity (0.9488), plant height (0.2656). The character finger number per panicle (-0.2019), flag leaf sheath length (-0.1476), calcium content (-0.1206) had significant and negative association both genotypic and phenotypic level.

4.5.2.2 Plant height (cm)

The character plant height had positively significant correlation with flag leaf blade length (0.2217), days to maturity (0.2154), flag leaf blade width (0.1968) and finger length (0.1935) while it had significant and negative relation with seed yield per plant (-0.1612), iron content (-0.1328) and flag leaf sheath width (-0.1322) at genotypic level. days to maturity (0.1406), flag leaf blade width (0.1246),

Fig.3.Genotypical correlation in finger millet.

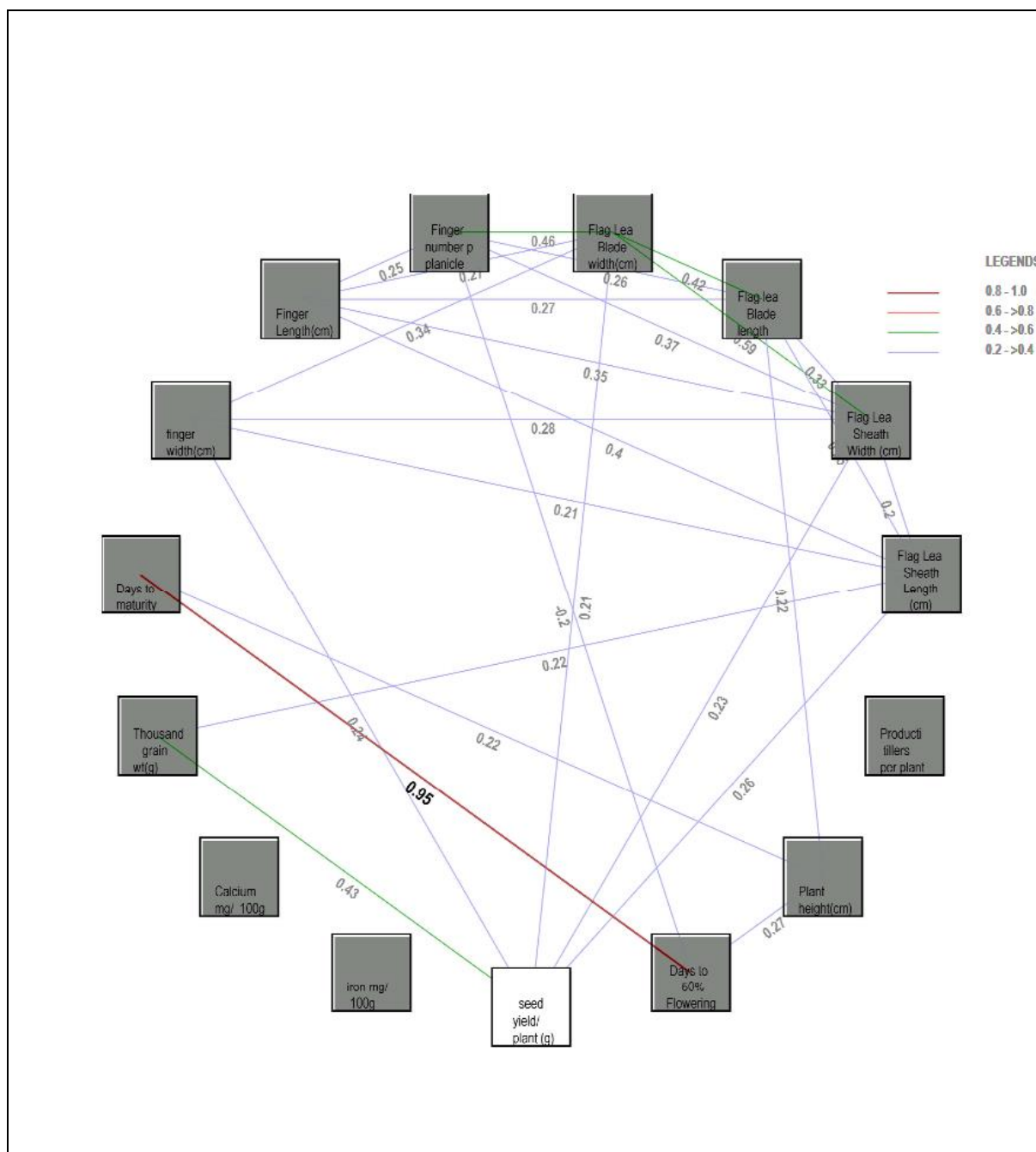
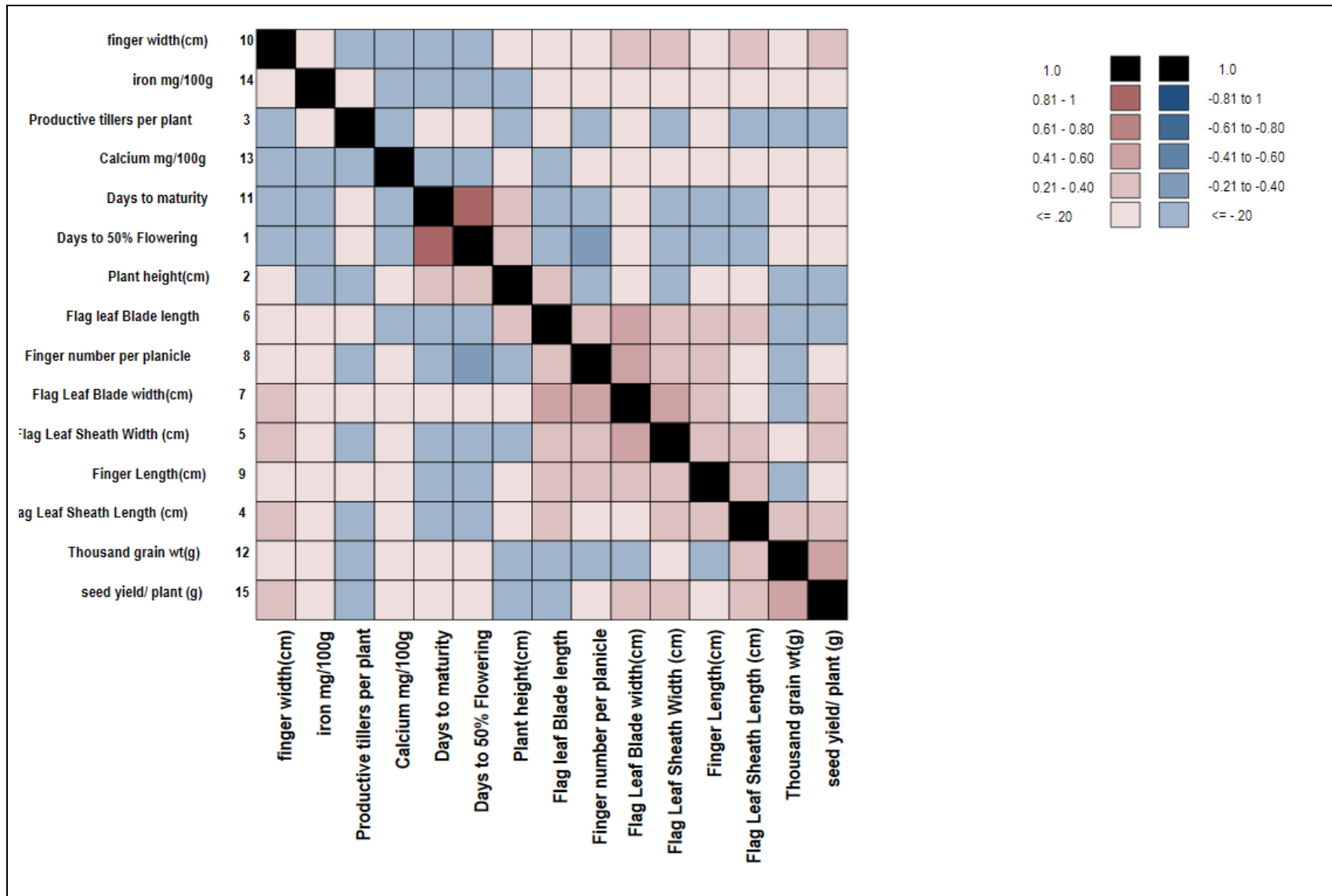


Fig.4..Shaded Correlation Matrix in finger millet.



flag leaf blade length (0.1205) had significant and positive association at phenotypic level.

4.5.2.3 Productive tillers per plant

The productive tillers per plant showed significant negative correlation with calcium content (-0.1436) at genotypic level and calcium content (-0.1236) at phenotypic level.

4.5.2.4 Flag leaf sheath length (cm)

flag leaf sheath length showed significant positive correlation with finger length (0.3952), seed yield per plant (0.02558), flag leaf blade length (0.2529), thousand grain weight (0.2224), finger width (0.2055), flag leaf sheath width (0.2004) and flag leaf blade width (0.1625) while significant and negative relation with days to maturity (-0.1647) at genotypic level. Finger length (0.3538), flag leaf blade length (0.2222), seed yield per plant (0.2076), flag leaf sheath width (0.1881), thousand grain weight (0.1757), finger width (0.1488), flag leaf blade width (0.1385) had significant positive correlation and days to maturity (-0.1368) had significant negative correlation at phenotypic level.

4.5.2.5 Flag leaf sheath width (cm)

Flag leaf sheath width showed highly significant positive correlation with flag leaf blade width (0.5940), finger number per panicle (0.3677), finger length (0.3547), flag leaf blade length (0.3290), finger width (0.2849), and seed yield per plant (0.2322) at genotypic level. flag leaf sheath width showed highly significant positive correlation with flag leaf blade width (0.5474), finger number per panicle (0.3405), finger length (0.3399), flag leaf blade length (0.2755), finger width (0.2257), and seed yield per plant (0.2150) at phenotypic level.

4.5.2.6 Flag leaf blade length (cm)

Flag leaf blade length had significant positive correlated with flag leaf blade width (0.4249), finger length (0.2659), finger number per panicle (0.2553), and finger width (0.1480) at genotypic level and flag leaf blade width (0.3669), finger number per panicle (0.2143), finger length (0.2078), and finger width (0.1187) at phenotypic level. Thousand grain weight (-0.1902) had negative significant

association at genotypic level and thousand grain weight (-0.1662) had negative significant association at phenotypic level.

4.5.2.7 Flag leaf blade width (cm)

Flag leaf blade width highly significant positive correlation with finger number per panicle (0.4649), finger width (0.3413), finger length (0.2708) and seed yield per plant (0.2066) at genotypic level and finger number per panicle (0.4377), finger width (0.2924), finger length (0.2551) and seed yield per plant (0.1876) phenotypic level.

4.5.2.8 Finger number per panicle

Finger number per panicle had significant positive correlated with finger length (0.2515) and seed yield per plant (0.1998) at genotypic level and finger length (0.2322), seed yield per plant (0.1876) at phenotypic level. Days to maturity (-0.1852) and thousand grain weight (-0.1742) had significant negative association at genotypic level. Days to maturity (-0.1817) and thousand grain weight (-0.1698) had significant negative association at phenotypic level.

4.5.2.9 Finger length (cm)

The character iron content (0.1871), seed yield per plant (0.1460) and finger width (0.1401) had significant and positive association with finger length, while it had the significant and negative association with days to maturity (-0.1324) at genotypic level.

The character iron content (0.1774), seed yield per plant (0.1360) and finger width (0.1189) had significant and positive association with finger length, while it had the significant and negative association with days to maturity (-0.1275) at phenotypic level.

4.5.2.10 Finger width (cm)

The character seed yield per plant (0.2377) and thousand grain weight (0.1768) had significant and positive association with finger width at genotypic level and seed yield per plant (0.1854) and thousand grain weight (0.1147) at phenotypic level.

4.5.2.11 Days to maturity

The character seed yield per plant (0.3954) and calcium content (0.1207) had significant and positive association with days to maturity at phenotypic level, while it had the significant and negative association with calcium content (-0.1073) at genotypic level.

4.5.2.12 Thousand grain weight (gm)

The character seed yield per plant (0.4273) and calcium content (0.1207) had significant and positive association with thousand grain weight at genotypic level. Seed yield per plant (0.3954) and calcium content (0.1207) at phenotypic level.

4.5.2.13 Calcium content (mg/100g)

The character seed yield per plant (0.1928) had significant and positive association with calcium content at genotypic level.

4.5.2.14 Iron content (mg/100g)

The character seed yield per plant (0.1476) had significant and positive association with iron content at genotypic level.

Table. 4.11. Direct and indirect effect of fifteen causal variables on seed yield in finger millet.

SN	Days to 50 % flowering	Plant height (cm)	Productive tillers per plant	Flag leaf sheath length (cm)	Flag leaf sheath width (cm)	Flag leaf blade length (cm)	Flag leaf blade width (cm)	Finger number per panicle
	1	2	3	4	5	6	7	8
1	<u>0.1543</u>	0.0410	0.0105	-0.0228	-0.0002	-0.0173	0.0078	-0.0312
2		<u>-0.2804</u>	0.0050	-0.0256	0.0371	-0.0622	-0.0552	0.0022
3			<u>-0.0124</u>	0.0008	0.0012	-0.0002	-0.0005	0.0000
4				<u>0.1194</u>	0.0239	0.0302	0.0194	0.0091
5					<u>-0.1165</u>	-0.0383	-0.0692	-0.0428
6						<u>-0.0249</u>	-0.0106	-0.0064
7							<u>0.1351</u>	0.0628
8								<u>0.2248</u>
9								
10								
11								
12								
13								
14								
15								

Table. 4.11.contd.....

SN	Finger length (cm)	Finger width (cm)	Days to maturity	Thousand grain weight (g)	Calcium content (mg/100gm)	Iron content (mg/100g)	correlation with seed yield/plant
	9	10	11	12	13	14	15
1	-0.0164	-0.0023	0.1464	0.0022	-0.0186	-0.0025	0.0271
2	-0.0543	-0.0087	-0.0604	0.0125	-0.0293	0.0372	-0.1612
3	-0.0007	0.0002	-0.0010	0.0004	0.0018	-0.0007	-0.0162
4	0.0472	0.0245	-0.0197	0.0266	0.0069	0.0128	0.2558
5	-0.0413	-0.0332	0.0011	-0.0107	-0.0085	-0.0055	0.2322
6	-0.0066	-0.0037	0.0027	0.0047	0.0005	-0.0024	-0.0248
7	0.0366	0.0461	0.0067	-0.0050	0.0078	0.0071	0.2066
8	0.0566	0.0125	-0.0416	-0.0392	0.0195	0.0213	0.1998
9	<u>0.1352</u>	0.0189	-0.0179	-0.0131	0.0091	0.0253	0.1460
10		<u>0.1207</u>	-0.0033	0.0213	-0.0057	0.0001	0.2377
11			<u>0.0334</u>	0.0015	-0.0036	-0.0003	0.0464
12				<u>0.4021</u>	0.0528	0.0389	0.4273
13					<u>0.1621</u>	-0.0122	0.1928
14						<u>0.0283</u>	0.1476

Residual effect = 0.7850, Underlined figures indicate direct effect.

*, ** indicates significant at 5 and 1 % level of significant respective

4.6 Genotypic path coefficient analysis

To find out the direct and indirect contribution from each of the characters towards seed yield per plant, path coefficient analysis was carried out. The genotypic correlation coefficients being more important are only partitioned to direct and indirect effects which are presented in Table 4.11.

4.6.1 Days to 50 per cent flowering

Days to 50 per cent flowering expressed positive direct effect (0.1543) on seed yield per plant. It had negative indirect effect through , flag leaf sheath length (-0.0228), flag leaf sheath width (-0.0002), flag leaf blade length (-0.0173), finger number per panicle (-0.0312), finger length (-0.0164), finger width (-0.0023), calcium content (-0.0186), iron content (-0.0025). While positive indirect effect through number of productive tillers per plant (0.0105), flag leaf blade width (0.0078) days to maturity (0.1464), thousand grain weight (0.0022). The total genotypic correlation with seed yield per plant was positive and non-significant (0.0271).

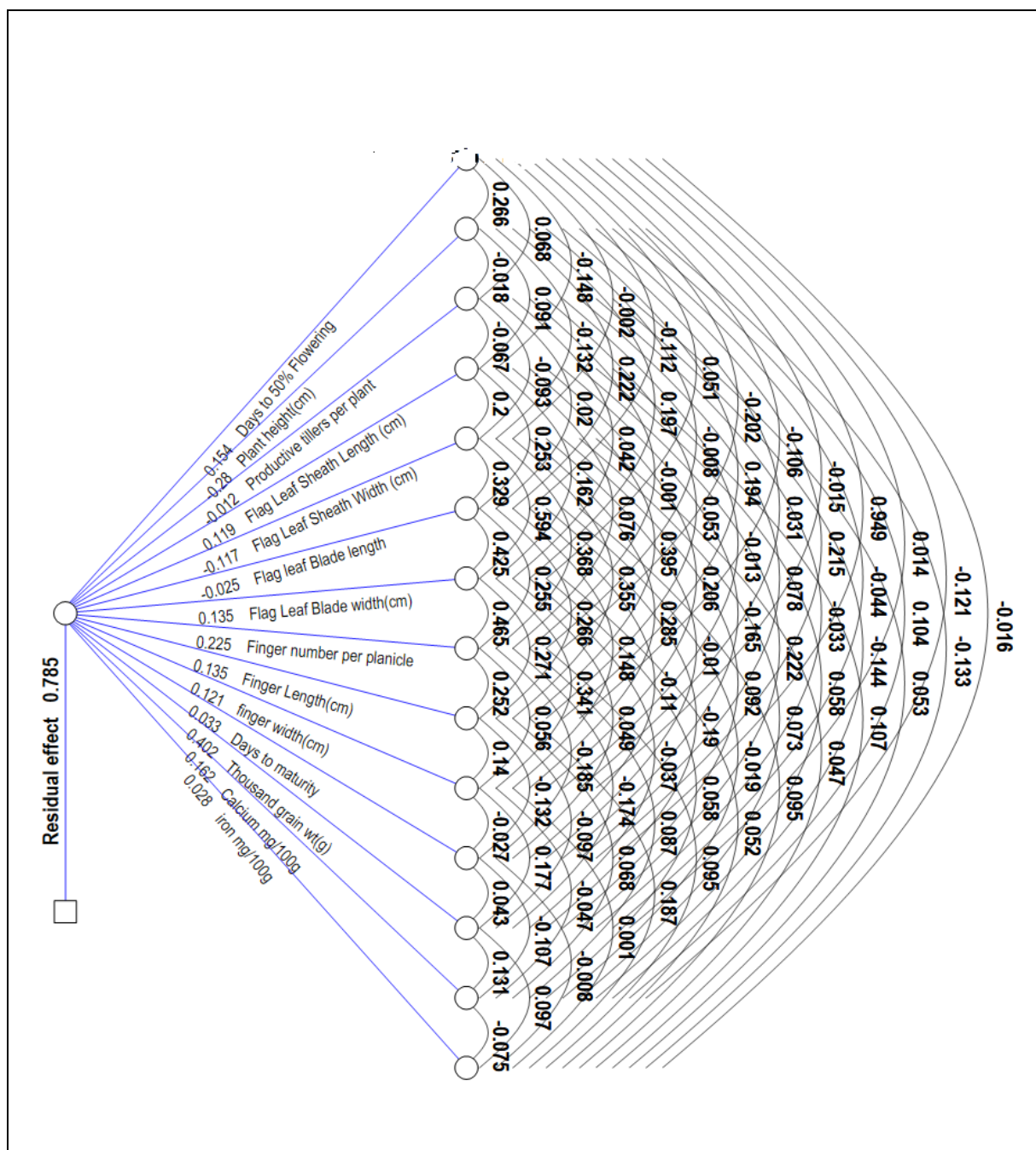
4.6.2 Plant height (cm)

Plant height showed negative direct effect (-0.2804) on seed yield per plant. It had positive indirect effects through productive tillers per plant (0.0050), flag leaf sheath width (0.0371), finger number per panicle (0.0022), thousand grain weight (0.0125), iron content (0.372) and negative indirect effect through days to 50% flowering (-0.0745), flag leaf sheath length (-0.0256), flag leaf blade length (-0.0622), flag leaf blade width (-0.0552), finger length (-0.0543), finger width (-0.0087), days to maturity (-0.0604), calcium content (-0.0293), Thus the total genotypic correlation with seed yield per plant was negative and significant (-0.1612).

4.6.3 Productive tillers per plant

Productive tillers per plant showed negative direct effect (-0.0124) on seed yield per plant. It has positive indirect effect character via plant height (0.0002), flag leaf sheath length (0.0008), flag leaf sheath width (0.0012), finger number per panicle (0.0000), finger width (0.0002), thousand grain weight (0.0004), calcium content (0.0018) and negative indirect effect via days to 50% flowering (-0.0008), flag leaf blade length (-0.0002) flag leaf blade width (-0.0005), finger length (-0.0007), days to maturity (-0.0010), iron content (-0.0007) Thus leading to negative correlation with seed yield per plant (-0.0162).

Fig.5 Genotypic path diagram for seed yield per plant (g) in finger millet.



4.6.4 Flag leaf sheath length (cm)

Flag leaf sheath length showed positive direct effect (0.1194) on seed yield per plant. It has positive indirect effect character via plant height (0.0109), flag leaf sheath width (0.0239), flag leaf blade length (0.0302), flag leaf blade width (0.0194), finger number per panicle (0.0091), finger length (0.0472), finger width (0.0245), thousand grain weight (0.0266), calcium content (0.0069), iron content (0.0128) and negative indirect effect via days to 50% flowering (-0.0176), productive tillers per plant (-0.0080 days to maturity (-0.0197) Thus the total genotypic correlation with seed yield per plant was positive and significant (0.2558).

4.6.5 Flag leaf sheath width (cm)

Flag leaf sheath width showed negative direct effect on seed yield per plant (-0.1165). It showed positive indirect effect of characters day to 50% flowering (0.0002), plant height (0.0154), productive tillers per plant (0.0108) and day to maturity (0.0011). Negative indirect effect flag leaf sheath length (-0.0233), flag leaf blade length (-0.0383), flag leaf blade width (-0.0692), finger number per panicle (-0.00428), finger length (-0.0413), finger width (-0.0332), thousand grain weight (-0.107), calcium content (-0.0085), iron content (-0.0055). The total genotypic correlation with seed yield per plant was positive and significant (0.2322).

4.6.6 Flag leaf blade length (cm)

Flag leaf blade length showed negative and direct effect correlation with seed yield per plant (-0.0249). It had negative indirect effect via almost character expect day to 50% flowering (0.0028), days to maturity (0.0027) thousand grain weight (0.047) calcium content (0.0005), The total genotypic correlation with seed yield per plant was negative and non significant (-0.0248).

4.6.7 Flag leaf blade width (cm)

Flag leaf blade width showed positive and direct effect correlation with seed yield per plant (0.1351). It had positive indirect effect via almost character expect thousand grain weight (-0.0050), the total genotypic correlation with seed yield per plant was positive and significant (0.2066).

4.6.8 Finger number per panicle

Finger number per panicle showed positive direct effect on seed yield (0.2248). It showed negative indirect effect through days to 50% flowering (-0.0454), plant height (-0.0018), productive tillers per plant (-0.0003), days to maturity (-

00416) and thousand grain weight (-0.0392), positive indirect effect those flag leaf sheath length (0.0171) flag leaf sheath width (0.0827), flag leaf blade length (0.0574), flag leaf blade width (0.1045), finger length (0.0566), finger width (0.0125), calcium content (0.0195), iron content (0.0213) The total genotypic correlation with seed yield per plant was positive and significant (0.1998).

4.6.9 Finger length (cm)

Finger length showed positive and direct effect correlation with seed yield per plant (0.1352). It had positive indirect effect via almost character expect days to 50% flowering (-0.0144), days to maturity (-0.0179), thousand grain weight (-0.0131), the total genotypic correlation with seed yield per plant was positive and significant (0.1460).

4.6.10 Finger width (cm)

Finger width showed positive and direct effect correlation with seed yield per plant (0.1207). It had positive indirect effect via almost character expect days to 50% flowering (-0.0018), productive tillers per plant (-0.0016) days to maturity (-0.0033), calcium content (-0.0057). The total genotypic correlation with seed yield per plant was positive and significant (0.2377).

4.6.11 Days to maturity

Days to maturity showed positive direct effect on seed yield (0.0334). It showed negative indirect effect through flag leaf sheath length (-0.0055), flag leaf sheath width ((-0.0003), flag leaf blade length (-0.0037), finger number per panicle (-0.0062), finger length (-0.0044), finger width (-0.0009), calcium content (-0.0036), and iron content (-0.0003). positive indirect effect those days to 50% flowering (0.0317), plant height (0.0072), productive tillers per plant (0.0026), flag leaf blade width (0.0016), thousand grain weight (0.0015). The total genotypic correlation with seed yield per plant was positive and non significant (0.0464).

4.6.12 Thousand grain weight (g)

Thousand grain weight showed positive direct effect on seed yield (0.1621). It showed negative indirect effect through plant height (-0.0179), productive tillers per plant (-0.134), flag leaf blade length (-0.0765), flag leaf blade width(-0.0150) finger number per panicle (-0.0700), finger length (-0.0389), positive indirect effect days to 50% flowering (0.0057) , flag leaf sheath length (0.0894), flag leaf sheath width (0.0370), finger width (0.0711), days to maturity (0.0175), calcium

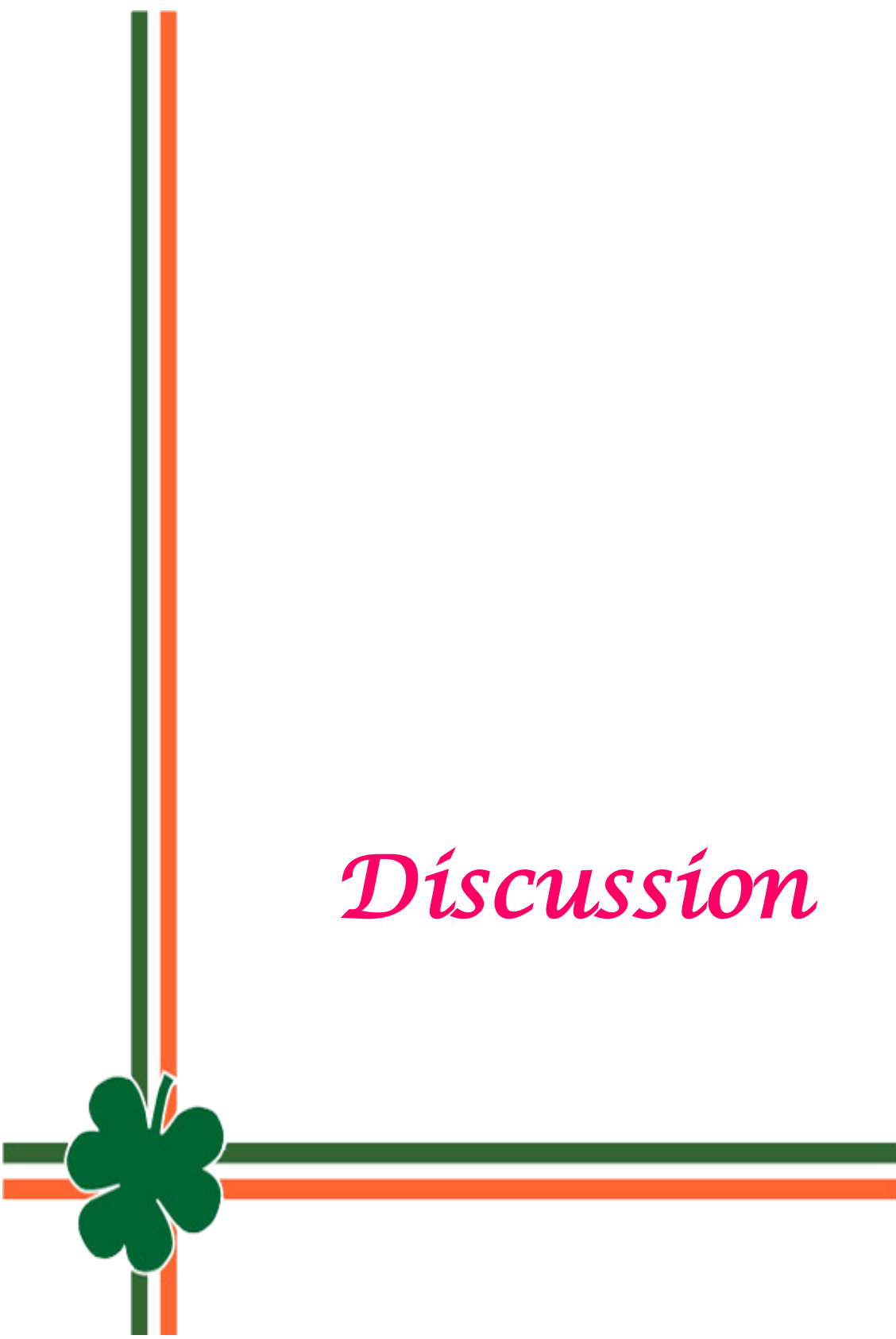
content (0.0528), iron content (0.0389) The total genotypic correlation with seed yield per plant was positive and significant (0.4273).

4.6.13 Calcium content mg/100g

Calcium content showed positive direct effect on seed yield (0.1621). It showed negative indirect effect through days to 50% flowering (-0.0195), productive tillers per plant (-0.0233), flag leaf blade length (-0.0031) finger width (-0.0076), days to maturity (-0.0174),), iron content (-0.0122) and positive indirect effect plant height (0.0169) flag leaf sheath length (0.0094), flag leaf sheath width (0.0118), flag leaf blade width (0.0093), finger number per panicle (0.0140), finger length (0.0110), thousand grain weight (0.0213) The total genotypic correlation with seed yield per plant was positive and significant (0.1928).

4.6.14 Iron content mg/100g

Iron content showed positive and direct effect correlation with seed yield per plant (0.0283). It had positive indirect effect via almost character expect days to 50% flowering (-0.0005), plant height (-0.0038) days to maturity (-0.0002), calcium content (-0.0021). The total genotypic correlation with seed yield per plant was positive and significant (0.1476).



Discusión

CHAPTER - V

DISCUSSION

Genetic variability and diversity are important pre requisites for success of any breeding programme and selection of elite genotypes. The genotypic and phenotypic coefficients of variation are the simple measures to assess the extent of variability present in a population for a particular character. Heritability on the other hand suggests the relative role of genetic factors in expression of phenotypes (Falconer, 1989). It also acts as an index of inheritance of a particular character to its off spring. Genetic advance on the other hand measures the expected genetic gain from the selection applied in a population. Heritability along with genetic advance gives the best efficiency of selection. The study of correlations provides the inter relationships among the quantitative traits which facilitates the choice of suitable breeding method for improvement of crop. The D^2 statistics suggested by Mahalanobis (1936) and Tocher's method described by Rao (1952) help to select the genetically diverse genotypes for hybridization programme.

In the present investigation entitled "Genetic diversity studies in finger millet [*Eleusine coracana* (L.) Gaertn]" attempts were made to study the variability, correlation and path analysis for 15 different quantitative characters among 158 genotypes.

The results obtained on these aspects are presented in chapter four and are discussed in this chapter under appropriate headings.

5.1 Mean performance

Mean is used for the measurement of all types of parameters. It is useful in comparing varieties or advanced generation breeding materials. Mean helps in reduction of huge individual observations in to a small and meaningful data. The mean performance of the genotypes for different characters studied is presented in Table 4.2

5.1.1 Days to 50 per cent flowering

The variation in days to 50 per cent flowering ranged between 54 to 87 days. Genotype IC45861 flowered in (54) days while highest days (87) were taken by IC45845-A. Eighty seven genotypes were late in flowering than the mean flowering of genotypes 77 days. Similar results were obtained by Ulaganathan and Nirmalakumari (2014).

5.1.2 Plant height (cm)

The plant height was maximum in case of IC45844 while it was minimum in case of IC45861. The value recorded for maximum height was 144.3 cm while minimum height was 102.7 cm. seventy nine genotype highest plant height than mean value 125.7 cm. Similar results were obtained by Patel *et al.* (2017)

5.1.3 Productive tillers per plant

The number of tillers per plant ranged from 1.6 to 5.5 with general mean of 3.78. Genotype IC44840 lowest (1.6) while highest (5.5) in IC87469. Seventy nine genotypes were highest productive tillers than general mean value. is also reported by Patel *et al.* (2017).

5.1.4 Flag leaf sheath length (cm)

Flag leaf sheath length ranged from 7.20 (IC49995-A) to 12.96 cm (Check- GPU45). Eighty three genotypes recorded more flag leaf sheath length (cm) than the mean. Mean value for this character was 10.23. Similar results were obtained by Ulaganathan and Nirmalakumari (2014).

5.1.5 Flag leaf sheath width (cm)

Flag leaf sheath width ranged from 0.64 to 1.18 cm. The lowest flag leaf sheath width was recorded for the genotype IC49949-A while the highest was recorded for the genotype HR-374 (Check). Sixty seven genotypes were highest flag leaf sheath width than mean value 0.85 cm. Similar results were obtained by Ulaganathan and Nirmalakumari (2014).

5.1.6 Flag leaf blade length (cm)

Flag leaf blade length ranged from 17.27 to 38.98 cm. The lowest flag leaf blade length was recorded for the genotype IC49956 while the highest was recorded for the genotype IC340136. Seventy nine genotypes were highest flag leaf blade length than mean value 29.32 cm. Similar results were obtained by kebere *et al.*, (2006).

5.1.7 Flag leaf blade width (cm)

Flag leaf blade width ranged from 0.65 to 1.24 cm. The lowest flag leaf blade width was recorded for the genotype IC87526 while the highest was recorded for the genotype IC66588. Eighty three genotypes were highest flag leaf blade width than mean value 0.91 cm. Similar results were obtained by kebere *et al.*, (2006).

5.1.8 Finger number per panicle

Finger number per panicle ranged from 4.2 to 17.7. The lowest finger number per panicle was recorded for the genotype IC49944-B and IC87519-B while the highest was recorded for the genotype IC87476. Seventy three genotypes were highest finger number per panicle than mean value 7.0. Similar results were obtained by Ganapathy *et al.* (2011).

5.1.9 Finger length (cm)

Finger length ranged from 4.25 to 12.47 cm. The lowest finger length was recorded for the genotype IC49965 and IC87471 while the highest was recorded for the genotype IC340116. Sixty nine genotypes were highest finger length than mean value 6.19. Similar results were obtained by Ganapathy *et al.* (2011).

5.1.10 Finger width (cm)

Finger width ranged from 0.51 to 1.20 cm. the lowest finger width was recorded for the genotype LS-5L while the highest was recorded for the genotype IC87469. Eighty seven genotypes were highest finger width than mean value 0.90 cm. Similar results were obtained by Shet *et al.* (2010).

5.1.11 Days to maturity

The variation in days to maturity ranged between 87 to 120 days. Genotype IC45862 matured in least number of days (87) while Phule Nachani (Check) and IC45845-A matured very late (120 days). Mean value for this character was 109 days and eighty genotypes were late matured than mean value. Similar results were obtained by Ulaganathan and Nirmalakumari (2014).

5.1.12 1000 grain weight (gm)

The variation in thousand grain weight ranged between 1.3 to 3.7 gm. The lowest thousand grain weight was recorded for the genotype IC71420-A while the highest was recorded for the genotype GPU-28 (Check). Eighty seven genotypes were more thousand grain weight than mean value 2.28. Similar results were obtained by Shet *et al.* (2010).

5.1.13 Seed yield /plant (g)

The variation seed yield per plant ranged between 1.94 to 9.18 gm. The lowest seed yield per plant was recorded for the genotype IC49995-A while the highest was recorded for the genotype GPU45 (Check). Sixty three genotypes were more seed yield per plant than mean value 3.54. is also reported by Shet *et al.* (2010).

5.1.14 Calcium content (mg/100g)

The variation for calcium content mg/100g ranged between 197.5 to 453.5 mg/100g. The lowest calcium content mg/100g was recorded in case of IC87502 while maximum in case of VL-149 (Check) and the mean value for this character was 295.52 mg/100g. Similar results were obtained by Hiremath *et al.* (2018).

5.1.15 Iron content (mg/100g)

The variation for iron content mg/100g ranged between 0.57 to 57.83 mg/100g. The lowest iron content mg/100g was recorded in case of IC87498 while maximum in case of GPU67 (Check) and the mean value for this character was 22.69 mg/100g. Similar results were obtained by Manimozhi *et al.* (2015).

5.2.1 Range of variability

Wide range of variability was observed for majority of yield contributing characters. Range of variation on the basis of mean was more for traits viz. seed yield per plant, finger length, finger number per panicle. This indicates that these parameters can be effectively used as selection criteria of the genotype.

Estimates of phenotypic variance are higher than the genotypic variance in all characters. High genotypic variances and phenotypic variances were observed for calcium content, iron content, plant height, days to 50 % flowering days to maturity and flag leaf blade length. This suggests that the less influence of environment hence we can make effective selection of genotypes in breeding. Similar results observed by Wolie (2013) and Bhothikar *et al.*, (2014) in finger millet.

5.2.2 Genotypic and phenotypic coefficient of variation

In the present investigation the phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the traits this indicates that there is small effect of environment on characters and selection may be effective. Although range can provide a preliminary idea about the variability, coefficient of variation is reliable, as it is independent of unit measurement. The extent of variability as measured by GCV and PCV also gives information regarding relative amount of variation in different populations. The GCV and PCV showed wide variation for most of the characters. As expected the PCV was invariably higher than GCV for all the characters. GCV and PCV values were categorized as low (0-10%), moderate (10-20) and high (20% and above). The value for GCV ranged from 4.82 to 31.38 per cent.

The highest value of GCV and PCV were recorded for characters iron content, seed yield per plant, calcium content and finger number per panicle indicating presence of large variability among the genotypes and the possibilities of improvement of these traits through selection. Similar observations were observed by Bothikar *et al.*, (2014) for iron content, Wolie., (2013), Lule., (2012), Bendale *et al.*, (2002) for seed yield per plant. Kassahun and Solomon (2017) for finger number per panicle

The low estimates of PCV and GCV observed for days to 50% flowering, days to maturity, these results are in accordance with Dagnachew Lule *et al.* (2012), Ganapathy *et al.* (2011) and Kebera Bezaweleaw *et al.* (2006). In case of plant height recorded low GCV and PCV. Similar result recorded by Karad and Patil (2013), Srilakshmi *et al.*, (2013) and Wolie (2013).

The medium GCV and PCV observed for finger length, productive tillers per plant, flag leaf blade length, flag leaf sheath width, flag leaf sheath length, flag leaf blade width and finger width indicated moderate genetic variability for these traits in the material. Similar results was recorded Bothikar *et al.*, (2014) for productive tillers per plant. Similar results was recorded Ulaganathan and Nirmalakumari (2014) for finger length, flag leaf blade length, flag leaf sheath width, flag leaf sheath length and flag leaf blade width. Moderate to low variability of these characters indicated the need for improvement of base population.

Test weight 1000 seed weight recorded moderate GCV and High PCV. These results are in close agreement with Dhamdhare *et al.*, (2011).

5.2.3 Heritability and Genetic advance

Genotypic coefficient of variation alone does not indicate the proportion of total heritable variation. However, the heritability estimates are better indicator of heritable portion of the variation. The broad sense heritability includes the contribution of additive gene effects and allelic interaction due to dominance and allelic due to epistasis. Burton (1952) suggested that the genetic coefficient of variation and heritability estimates together give better idea about the amount of genetic advance expected through selection. Johnson *et al.* (1955) pointed out that in a selection programme, heritability values as well as genetic advance were more useful than heritability alone. The progress of any breeding programme is conditioned by the magnitude and the nature of genotypic and non-genotypic variation in the various characters since, most of the economic characters (e.g., yield) are complex in

inheritance and are greatly influenced by various environmental conditions, the study of heritability and genetic advance is very useful in order to estimate the scope for improvement by selection. The heritability magnitude indicates the reliability with which the genotype will be recognized by its phenotype expression. According to them heritability is categorized like, less than 30% as low, 30-60% as moderate and more than 60% as high heritability.

In the present study, estimate of heritability ranged from 29.8% for plant height to 99.8% for iron content.

High heritability was also exhibited by iron content (99.8%) followed by calcium content (99.7%), days to maturity (98.6%), days to 50% flowering (97.2%), seed yield per plant (93.7%), finger number per panicle (92.7%), flag leaf sheath width (91.8%), flag leaf blade width (89.9%) finger length (88.7%), flag leaf blade length (84.9%), thousand grain weight (84.6%), flag leaf sheath length (77.9%), productive tillers per plant (68.6%) and finger width (65.7%) indicating scope for selection on the basis of heritable performance. Similar results were observed for finger length Kumari and Singh (2015), Nitish (2013), Karad and Patil (2013) and Ulaganathan and Nirmalakumari (2012). Number of fingers per panicle recorded similar result by Priyadharshini *et al.*, (2011), Nitish (2013), Karad and Patil (2013), Kumari and Singh (2015) and Lule., (2012). For days to maturity Satish *et al.*, (2007), Karad and Patil (2013), Nitish., (2013), Wolie *et al.*, (2013) and Kumari and Singh (2015) observed similar results.

Calcium content (99.7%) recorded high broad sense heritability. Similar results recorded for calcium content by Vadivo *et al.*, (1998) and Srilakshmi *et al.*, (2013). Days to 50% flowering (97.2%) also showed high heritability, which is supported by the findings of Dhagate *et al.*, (1972) and Ganapathy (2011). For seed yield per plant Karad and Patil (2013) and Nitis, (2013) showed similar results.

The character flag leaf sheath width, flag leaf blade width, flag leaf blade length, thousand grain weight, flag leaf sheath length, productive tillers per plant, and finger width, similar results were observed by Ulaganathan and Nirmalakumari (2014). The iron content (99.8%) showed high heritability which is supported by the findings of Bothikar *et al.*, (2014).

Heritability which is the heritable portion of phenotypic variance is a good index of transmission of characters from parents to offspring (Falconer, 1960).

Genetic advance as per cent of mean ranged from 5.42 to 137.52 per cent. Iron content (137.52%) recorded highest genetic advance as per cent mean followed by seed yield per plant (62.59%), calcium content (45.66%), finger number per panicle (43.25%), finger length (36.11%), thousand grain weight (35.86%), productive tillers per plant (28.12%), flag leaf blade length, (26.16%), flag leaf sheath width (24.75%), flag leaf blade width (22.23%) and Flag leaf sheath length (20.85%). High genetic advance indicated that these characters are governed by additive genes and selection will be rewarding for improvement of these traits. Similar results were observed by Ulaganathan and Nirmalakumari (2014), Ganapathy (2011), Kassahun and Solomon (2017) and kebere *et al.*(2006).

Moderate genetic advance mean was recorded for finger width (16.82%), days to 50% flowering (15.43%) and days to maturity (10.98%), and lowest for plant height (5.42%) indicated these characters are governed by non additive genes and selection may not be efficient on this traits. Similar results were observed by Anuradha *et al.*(2017), Ulaganathan and Nirmalakumari (2014) for days to 50% flowering and finger width, days to maturity for Ulaganathan and Nirmalakumari (2014), Kebere *et al.*(2006) and Anuradha *et al.*(2017).

5.3 Genetic divergence

Genetic divergence, which is due to genetic factors, is the basis for heritable improvement. The plant breeders have always therefore, been fascinated by great amount of diversity in crop plants as could serve as raw material for crop improvement programme. The precise information about the genetic divergence is therefore, crucial for effective breeding programme. The genetically diverse parents are known to produce higher heterotic effects and consequently give desirable recombinants in the breeding material. Multivariate analysis as shown by Mahalanobis (1936), D^2 statistics is a measure that appraises the genetic variability quantitatively among a set of genotypes.

5.3.1. Diversity

The estimates of D^2 values ranged from 50073.01 to 9231753.02. this clearly indicates the presence of adequate diversity between genotypes studied. Negi

et al. (2017), Kumari and Singh (2015) and Jadhav *et al.* (2014) also reported wide genetic diversity in finger millet germplasm.

5.3.2 Cluster formation

The aim of cluster formation and measuring inter and intra cluster divergence is to provide the basis for hybridization programme. The theoretical concept behind such grouping is that, the genotypes grouped into the same cluster presumably are less diverse from each other than those belonging to the different clusters and will not give expected desired heterotic response and segregants in further generations.

Consequently breeding programme should be designed in such a way that, the parents are selected from different clusters with wider in genetic diversity in the genotypes. The crosses involving the parents with extreme divergence have also been reported to exhibit decrease in heterosis (Moll *et al.*, 1965). Therefore, while selecting the parents by considering the genetic diversity, their performance and cluster mean for the characters also need due consideration in the crop improvement programme.

In the present investigation, The cluster I was with the highest number of genotypes (58) followed by cluster IV (43), clusters II (40), cluster V (8) , and cluster III , VI , VII , VIII , IX , X , XI , XII , XIII had single genotype . The cluster formation in finger millet reported Jadhav *et al.* (2014), Kumari and Singh (2015), Devaliya *et al.* (2017) and Mahanthasha *et al.* (2017).

The intra cluster distance (D) range from 223.77 to 3038.38. The maximum inter cluster distance (D =3038.38) was observed between cluster XI and cluster V, followed by cluster XII and IV (D = 2882.83), cluster X and cluster V (2759.73), cluster XI and cluster IV (D = 2723.03), cluster XIII and cluster IV (D = 2684.68), indicating that the genotypes falling in these clusters were highly divergent from each other implying large amount of diversity within and between groups, which could be exploited in breeding programmes. The minimum inter cluster distance (D = 223.77) was between IX and VII, indicating that this cluster is less divergent. The cluster means revealed high variability among the clusters for the traits, the cluster mean for days to 50 per cent flowering varied from 54 (XI) to 78 days (I) and (II). The cluster means for plant height ranged between 102.70 (XI) to 135.80cm (XIII). The cluster mean for productive tillers per plant ranged between 2.70 (X) to 4.50 (III). The cluster mean for flag leaf sheath length ranged from 8.69 (cluster X) to 12.55

(cluster III). The cluster mean for flag leaf sheath width ranged between 0.71 (cluster III) and 0.99 (cluster XIII).

The cluster mean for flag leaf blade length was maximum in cluster (VI) 35.22 and it was minimum in cluster (IX) 24.74. The cluster mean for flag leaf blade width was maximum in cluster (XIII) 1.08 and it was minimum in cluster (XI) 0.73. The cluster mean for finger number per panicle was minimum in cluster IX (4.2) and it was maximum in cluster XIII (17.7). The cluster mean for finger length ranged between 4.59 (cluster VIII) and 8.24 (cluster XIII). The cluster mean for finger width ranged between 0.81(cluster VI) and 0.95 (cluster XI) .The cluster mean for days to maturity was maximum in cluster (I) 110 and minimum in case of cluster (XI) 87. The cluster mean for thousand grain weight was maximum in cluster (VIII) 2.85 and it was minimum in cluster (X) 1.5. The cluster mean for seed yield per plant was maximum in cluster (XIII) 5.51 and it was minimum in cluster (IX) 2.42.The cluster mean for calcium content was minimum in cluster (VI) 208.5 and it was maximum in cluster (XIII) 406.5 The cluster mean for iron content was maximum in cluster (V) 46.36 and it was minimum in cluster (XIII) 1.62. It was observed that, iron content (47.68%) contributed highest for divergence, followed by calcium content (39.77%), days to maturity (9.63%), seed yield per plant (0.73 %), flag leaf sheath width (0.53%), finger length (0.53%), finger number per panicle (0.49%), flag leaf blade width (0.2 %), flag leaf blade length (0.17%), days to 50% flowering (0.1%), thousand grain weight (0.07%), flag leaf sheath length (0.05%), productive tillers per plant (0.02%), finger width (0.01%) and Plant height (0%). Similar results were observed by Kumari and Singh (2015) for days to maturity, plant height, seed yield per plant.

5.4 Correlation studies

Correlated characters are of interest for three chief reasons, firstly in connection with the genetic cause of correlation through the linkage and pleiotropic action of genes, secondly in connection with the change brought about by selections. It is important to know, how the improvement of one character will cause simultaneous changes in other characters and thirdly in connection with natural selection (Falconer, 1960).

The value of correlation coefficient cannot be constant everywhere. It varies considerably according with kind of material handled, mode of observations taken, cultural practices followed and environmental conditions in which material is grown. Even though the material used is same, the environment including fertilization, plant population, cultural practices changes the value of correlation coefficient considerably. All correlations are greatest upon poorer soils and increased fertility tends to decrease the variability (Ramiah and Rao, 1953).

In present investigation, the genotypic correlation of seed yield per plant had significant positive association with thousand grain weight, flag leaf sheath length, finger width, flag leaf sheath width, flag leaf blade width, finger number per panicle, finger length, calcium content and iron content is mainly because of increase in one or more of the above characters and selection of genotypes on the basis of these traits will be effective for yield improvement. Similar result were reported by Kebera *et al.* (2006) for 1000 test weight, finger number per panicle, Ulaganathan and Nirmalakumari (2014) for flag leaf sheath length, finger width, Bendale *et al.* (2002), Sonnad (2005), John (2007) and Ganapathy (2011) for finger length. Correlation of seed yield per plant with plant height (-0.1612) was negative and significant. Correlation of seed yield per plant with productive tillers per plant was negative at genotypic level, Similar result were reported by Anuradha *et al.* (2013).

The positive correlation was reported between seed yield per plant with days to 50% flowering, days to maturity at genotypic and phenotypic level. Similar result were reported by Dhamdhare *et al.* (2013). Productive tillers per plant had positive association with seed yield per plant at phenotypic level.

5.4.1 Path coefficient analysis

It provides basis for selection of superior genotypes from the diverse breeding population. Seed yield is the product of interaction of component traits.

Apart from correlation studies, path coefficient analysis is important to obtain information about how the component characters influence the seed yield through each other.

It is evident from the data presented in Table 4.11 that positive direct effect on seed yield per plant were observed for days to 50 per cent flowering, flag leaf sheath length, flag leaf blade width, finger number per panicle, finger length, finger width, days to maturity, thousand grain weight, calcium content and iron content. These traits should be taken into consideration in breeding high yielding varieties in finger millet through selection. Similar results recorded by Kumar *et al.*, (2014), Wolie and Dessalegn (2011) ,Gani and Shinggu (2016) and Kebere *et al.*(2006).

Negative direct effect on seed yield per plant showed by the characters plant height, productive tillers per plant, flag leaf sheath width and flag leaf blade length. Similar results recorded by Kumar *et al.*, (2014) for productive tillers per plant, Anuradha *et al.* (2013) for plant height.

Negative indirect effect on seed yield per plant showed by the characters viz. plant height, productive tillers per plant and flag leaf blade length and on the basis of traits selection may not be done for enhancing yield in finger millet genotypes. Similar results were obtained by Kebere-Bezaweletaw *et al.*, (2006) for productive tillers per plant.

Positive indirect effect on seed yield per plant was recorded by characters day to 50% flowering, flag leaf sheath width, flag leaf sheath length, finger number per panicle, flag leaf blade width, finger length, finger width, days to maturity, thousand grain weight , calcium content and iron content. Similar results were obtained by Jyothsna *et al.*, (2016), Gani *et al.*, (2016), Dineshkumar *et al.*, (2014), Bothikar *et al.*, (2014), Lule., (2012), Kebere-Bezaweletaw *et al.*, (2006), Anuradha *et al.*, (2013) and Manyasa *et al.*, (2016).



Summary and Conclusion

CHAPTER - VI

SUMMARY AND CONCLUSION

The present study entitled “**Genetic diversity studies in finger millet [*Eleusine coracana* (L.) Gaertn]**” consisting of one hundred fifty eight germplasm of finger millet was carried out with a view to study the genetic diversity, genetic parameters, character association, path coefficient analysis. The experiment was carried out in a randomized block design with two replication at the College of Agriculture Badnapur, Jalna, during *kharif* 2017-2018.

Observations were recorded on randomly selected plants for fifteen characters viz., day to 50 % flowering, plant height, productive tillers per plant, flag leaf sheath length, flag leaf sheath width, flag leaf blade length, flag leaf blade width, finger number per panicle, finger length, finger width, days to maturity, thousand grain weight, seed yield per plant (gm), calcium content and iron content mg/100gm. Analysis of variance revealed significant differences for all the characters studied indicating the presence of considerable good amount of variability. In the present study, high estimates of genotypic and phenotypic coefficient of variation were observed for iron content, seed yield per plant, calcium content, finger number per panicle.

6.1 Variability and genetic parameters

The highest broad sense heritability (99.8%) was observed for iron content, followed by calcium content (99.7%), days to maturity (98.6%), days to 50% flowering (97.2%), seed yield per plant (93.7%), finger number per panicle (92.7%), flag leaf sheath width (91.8%). The highest genetic advance (134.95 %) was noticed for the character iron content followed by iron content (31.20%), days to maturity (11.93%), days to 50% flowering (11.83%). The remaining characters recorded low genetic advance.

6.2 Genetic divergence

The D^2 values showed adequate genetic diversity among the genotypes studied. On the basis of D^2 values all the genotypes were grouped into the thirteen clusters with varying number of genotypes in the clusters. The clustering pattern of these genotypes does not follow the geographical distribution. The maximum genetic distance (D) of 3038.38 was found between the clusters XI and cluster V.

Cluster formation

The aim of cluster formation and measuring intra and inter cluster divergence is to provide the basis for selecting parents for hybridization programme. Crossing between the genotypes belonging to the same clusters will not give desired improvement hence; the parents selected for crossing should be from different clusters. Greater the divergence between the two clusters, wider is the genetic diversity in the genotypes. The crosses involving the parents with extreme divergence have also been reported to exhibit decrease in heterosis. Therefore, while selecting the parents by considering the genetic diversity, their performance and cluster mean for the characters also need due consideration in the crop improvement programme. In the present investigation, the cluster means for the ten characters studied are presented in Table 4.7.

The cluster mean for days to 50 per cent flowering varied from 54 (XI) to 78 days (I) and (II). The cluster means for plant height ranged between 102.70 (XI) to 135.80 cm (XIII). The cluster mean for productive tillers per plant ranged between 2.70 (X) to 4.50 (III). The cluster mean for flag leaf sheath length ranged from 8.69 (cluster X) to 12.55 (cluster III). The cluster mean for flag leaf sheath width ranged between 0.71 (cluster III) and 0.99 (cluster XIII). The cluster mean for flag leaf blade length was maximum in cluster (VI) 35.22 and it was minimum in cluster (IX) 24.74. The cluster mean for flag leaf blade width was maximum in cluster (XIII) 1.08 and it was minimum in cluster (XI) 0.73. The cluster mean for finger number per panicle was minimum in cluster IX (4.2) and it was maximum in cluster XIII (17.7). The cluster mean for finger length ranged between 4.59 (cluster VIII) and 8.24 (cluster XIII). The cluster mean for finger width ranged between 0.81 (cluster VI) and 0.95 (cluster XI). The cluster mean for days to maturity was maximum in cluster (I) 110 and minimum in case of cluster (XI) 87. The cluster mean for thousand grain weight was maximum in cluster (VIII) 2.85 and it was minimum in cluster (X) 1.5. The cluster mean for seed yield per plant was maximum in cluster (XIII) 5.51 and it was minimum in cluster (IX) 2.42. The cluster mean for calcium content was minimum in cluster (VI) 208.5 and it was maximum in cluster (XIII) 406.5. The cluster mean for iron content was maximum in cluster (V) 46.36 and it was minimum in cluster (XIII) 1.62.

6.3 Correlation

Correlation studies at both genotypic and phenotypic levels were made to resolve the direction and magnitude of association among characters. It indicates that strong inherent association between various character studied and genotypic expression of correlation was comparatively less influenced by the environmental condition. The traits thousand grain wt, flag leaf sheath length, finger width, flag leaf sheath width, flag leaf blade width, finger number per panicle, calcium content, iron content and finger length exhibited significantly positive association with seed yield. This indicates the simultaneous improvement of these characters through selection.

6.4 Path coefficient analysis

The path coefficient analysis revealed that, thousand grain weight exerted the highest direct effect on seed yield followed by finger number per panicle, calcium content, finger length and flag leaf blade width.

CONCLUSION

On the basis of finding generated from the present investigation, following conclusion can be drawn, which may be considered for improvement in finger millet crop in future breeding programmes:

The wide range genetic variability observed for most of the characters as evidenced by significant variances due to genotypes suggesting that, it could be helpful in isolation of better germplasm. The phenotypic coefficients of variation were slightly higher than genotypic coefficients of variation which suggest the influence role of environment in governing these traits. Similarly, the magnitude of GCV and PCV was observed high to moderate for the characters namely, for iron content, followed by seed yield per plant, calcium content, finger number per panicle, thousand grain weight, finger length, productive tillers per plant, flag leaf blade length, flag leaf sheath width, flag leaf sheath length, flag leaf blade width and finger width, indicated that selection of desired germplasm for these traits may be worthwhile for improving grain yield in future breeding programme.

The high heritability was recorded for iron content followed by calcium content, days to maturity, days to 50% flowering, seed yield per plant, finger number per panicle, flag leaf sheath width, flag leaf blade width, finger length, flag leaf blade length, thousand grain weight, flag leaf sheath length. Genetic advance as percentage of mean

was observed iron content recorded highest genetic advance as per cent mean followed by seed yield per plant, calcium content, finger number per panicle, finger length, thousand grain weight, productive tillers per plant, flag leaf blade length, flag leaf sheath width, flag leaf blade width and flag leaf sheath length.

SUGGESTIONS FOR FUTURE RESEARCH WORK

On the basis of present study following suggestions could be drawn to plan out further improvement programme in selecting desirable genotypes in finger millet.

- ❖ The experiment should be repeated over the year to confirm the findings.
- ❖ Genotypes having high genetic diversity and desirable per se performance identified in present investigation may be involved in future breeding programme.
- ❖ The genotype identified as best general combiner for seed yield per plant should further be utilized in hybrid breeding programme.

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*Thesis
Abstract*

THESIS ABSTRACT

a) Title of the Thesis : “**Genetic Diversity Studies in Finger Millet**
[*Eleusine coracana* (L.) Gaertn.]”

b) Name of student : Vidhate Nilesh Mahadeo

c) Degree to be awarded : M.Sc. (Agriculture)

d) Year of award of degree : 2018

e) Major subject : Genetics and plant breeding

f) Total No. of pages in the thesis : 99

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h) Signature of the student :

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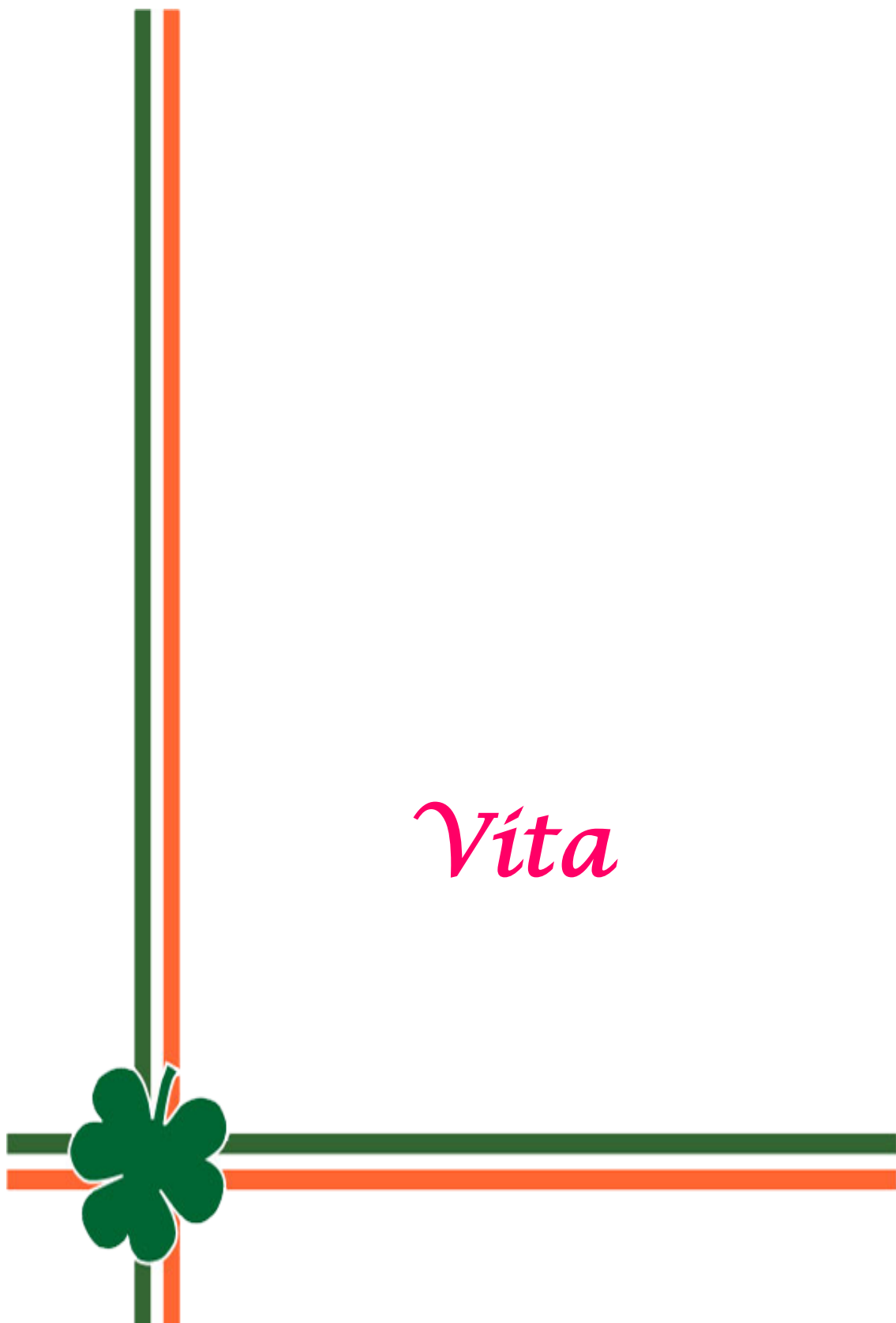
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ABSTRACT

The exploration of genetically variable accession is the key source of germplasm conservation and potential breeding material for the future. Assessment of genetic diversity existing in and within germplasm groups for yield and its components to obtain superior recombinants which will help in understanding pattern of variation was performed utilizing the one hundred fifty germplasm and eight standard checks of finger millet replicated twice. To study the nature and magnitude of genetic divergence using Mahalanobis (1936) D^2 statistics, genotypic and phenotypic variances, coefficient of variation, heritability, genetic advance, correlation coefficient and path coefficient were estimated and cluster analysis was performed. The data was recorded on fifteen traits. The one hundred fifty eight genotypes were grouped into XIII clusters. Clusters I was the largest with 58 genotypes. Maximum heritability was observed for iron content (99.8%), calcium content (99.7%), days to maturity (98.6%), days to 50% flowering (97.2%), seed yield per plant (93.7%), finger number per panicle (92.7%), flag leaf sheath width (91.8%), flag leaf blade width (89.9%), finger length (88.7%), flag leaf blade length (84.9%), thousand grain weight (84.6%), flag leaf sheath length (77.9%), productive tillers per plant (68.6%), finger width (65.7%). Genetic advance as per cent of mean ranged from 5.425 to 137.52 %. seed yield per plant had significant positive association with thousand grain wt, flag leaf sheath length, finger width, flag leaf sheath width, flag leaf blade width, finger number per panicle, calcium content, iron content, finger length. positive direct effect on seed yield per plant were observed for days to 50 per cent flowering, flag leaf sheath length, flag leaf blade width, finger number per panicle, finger length, finger width, days to maturity, thousand grain weight, calcium content, iron content, these traits should be taken into consideration in breeding high yielding varieties in finger millet through selection.



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