

“Genetic Analysis of Fodder Yield and its Components in Maize”

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Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur

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the Degree of**

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In

**AGRICULTURE
(GENETICS & PLANT BREEDING)**

By

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2019

CERTIFICATE - I

This is to certify that the thesis entitled, "**Genetic Analysis of Fodder Yield and its Components in Maize**" submitted in partial fulfillment of the Degree of **MASTER OF SCIENCE IN AGRICULTURE (Genetics & Plant Breeding)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bona-fide research work carried out by **Miss. Kratika Alawe**, ID No/Roll No.170116004 under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction. No part of the thesis has been submitted for any other degree or diploma or has been published.

All the assistance and help received during the course of these investigations has been acknowledged by the scholar.

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Declaration and Undertaking by the Candidates

I Kratika Alawe D/o Kishore Kumar Alawe certify the work embodied in thesis entitled “Genetic Analysis of Fodder Yield and its Components in Maize” in my own first hand bona-fide work carried out by me under the guidance of Dr. S.K. Bilaiya at Department of Plant Breeding and Genetics, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 2018-19.

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

I undertake the complete responsibility that any act misinterpretation, mistakes and errors of fact are entirely of my own.

I also abide myself with the decision taken by my advisor for the publication of material extracted from the thesis work and subsequent improvement, on mutually beneficial basis, provided the due credit is given, thereof.

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LIST of ABBREVIATIONS

%	-	Percentage
±	-	Plus or minus
>	-	More than
<	-	Less than
-	-	Hyphen
()	-	Parenthesis
:	-	Colon
;	-	Semicolon
,	-	Coma
.	-	Full stop
√	-	Square root
Σ	-	Summation
σ	-	Standard deviation (Sigma)
m ²	-	Square Meter
't' test	-	Student 't' test
cm	-	Centimeter
cm ²	-	Centimeter square
m	-	Meter
m ²	-	Meter square
mm	-	Millimeter
ml	-	Milliliter
mt/ha	-	Million tonnes per hectare
df	-	Degree of freedom
<i>et al.</i>	-	And other
Fig.	-	Figure
g	-	Gram
t	-	tones
SE	-	Standard Error

CD	-	Critical Difference
SV	-	Sources of Variations
SS	-	Sums of Squares
MSS	-	Mean Sums of Squares
<i>i.e.</i>	-	That is
e.g.	-	For example
etc	-	And the rest
/	-	Per
@	-	At the rate of
<i>viz.,</i>	-	Namely
Min	-	Minimum
Max	-	Maximum
Kg	-	Kilogram
N	-	North
S	-	South
E	-	East
W	-	West
No.	-	Number
CV	-	Coefficient of Variation
PCV	-	Phenotypic Coefficient of Variation
GCV	-	Genotypic Coefficient of Variation
h^2 (bs)	-	Broad sense heritability
GA	-	Genetic Advance
SN	-	Serial Number
Wt.	-	Weight
CV	-	Coefficient of Variation
Mor.	-	Morning
Eve.	-	Evening
°C	-	Degree Celsius
DFT	-	Days to 50% Tasseling
DFS	-	Days to 50% Silking

PH	-	Plant height
NLPP	-	Number of leaves per plant
LA	-	penultimate Leaf area
SG	-	Stem Girth
LSR	-	Leaf stem ratio
INL	-	Inter nodal length
GFYP	-	Green fodder yield per plant
DMYP	-	Dry matter yield per plant
DMYPD	-	Dry matter yield per plant per day
CPYP	-	Crude Protein yield per plant
CPYPD	-	Crude Protein yield per plant per day
BV	-	Brix's Value
WT	-	White
BN	-	Brown
GN	-	Green
DK	-	Dark
LT	-	Light
MP	-	Madhya Pradesh
H ₂ SO ₄	-	Sulfuric acid
K ₂ SO ₄	-	Potassium sulfate
CuSO ₄	-	Copper sulfate

INTRODUCTION

Maize (*Zea mays* L.) is native crop of America. It was introduced to India by Portuguese during 17th century. Maize is a monoceous plant having two types of inflorescence, the female inflorescence develops into cobs and the male inflorescence contains the male flowers. It is grown in *Kharif* season in northern India. However, in South India maize is sown from April to October, as climate is warm during winter season. It requires considerable moisture and warmth from germination to flowering. The most suitable temperature for germination is 21°C and for growth 32°C; extremely high temperature and low humidity during flowering damage the foliage, desiccates the pollens and interfere with pollination, resulting in poor grain formation. In general about 500 to 750 mm of well distributed rain is conducive to proper growth. Maize is very sensitive to stagnant water, particularly during its early stages of growth

Maize is one of the most important cereal crops in world agricultural economy for both man and animals. It is also known as miracle crop, it has very high yield potential. It is third major cereal crop in the world after wheat and rice. It is used for both livestock feed and human consumption. The crop also has other industrial and non-industrial uses. Maize contributes 10 per cent of the world's protein and 19 per cent of the calories derived from food crops. India ranks 6th in the production of maize. The crop is also an important component of livestock feed, especially in developed nations where 78 per cent of total maize production is used for livestock feed. Maize is grown in almost all the states of India. It occupies an area of about 6 million hectares. The total area under cultivated fodders is 8.3 million hectare on individual crop basis under which maize contributes about 900 hectare land area and green fodder production is about 30 to 35 tonnes per hectare (agropedia.iitk.ac.in, 2013). Fodder cultivation is still in a nascent stage in Madhya Pradesh. The cultivators of Madhya Pradesh devoted only their 3 per cent of gross cropped area under fodder. Total fodder area is about 0.74 lakh hectares which is used by the cultivators for growing fodder crops.

For livestock purpose, around 40 kg of green fodder is required to feed per animal per day. At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44 % concentrate feed ingredients. The demand will reach to 1012 million tones of green fodder and 631 million tones of dry forage by the year 2050 (IGFRI, Vision 2050). At the current level of growth in forage resources, there will be 18.4% deficit in green fodder and 13.2% deficit in dry fodder in the year 2050. To meet out the deficit, green forage supply has to grow at 1.69% annually (IGFRI, Vision 2050).

Urbanisation and shift to cash crops reduces the area under fodder crops by about two per cent every decade but there are various ways to overcome fodder shortage. One of them is growing maize as forage crop. It is considered as ideal forage because it grows quickly, produces high yields, palatable, rich in nutrients and helps to increase body weight and milk quality in cattle (Sattar *et al.* 1994). As fodder for livestock, maize is excellent, highly nutritive and sustainable (Hukkeri *et al.* 1977, Iqbal *et al.* 2006). On average, it contains 9-10% CP, 60-64% NDF, 38-41% ADF, 23-25% hemicellulose and 28-30% cellulose on dry matter basis when harvested at milk to early-dough stage. Forage maize has the potential to supply large amounts of energy-rich forage for daily animal diets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum (Dahmardeh *et al.* 2009). Hence, the crop is known as “King of Fodder”.

Maize in India, contributes nearly 9 per cent in the National food basket and more than Rs. 100 billion to the agricultural GDP at current prices apart from the generating employment to over 100 million man-days at the farm and downstream agricultural and industrial sectors. The consumption pattern for maize produced in India at present includes poultry feed 52 per cent, human food 24 per cent, animal feed 11 per cent and more than 22 per cent going towards industrial processing. With the growing demand of poultry feed the demand for maize is also going up in the country. It is the crop with the highest per day productivity. Estimates indicate that India may have to produce 55

million tones of maize to meet its requirement for human consumption, poultry, piggery, farm industry and fodder by 2030.

Crude protein and in-vitro dry matter digestibility (IVDMD) are two important nutritional quality parameters governing fodder quality. Both crude protein as well as IVDMD in maize are highest among the other competitive fodders. The biomass production of maize is also equivalent to sorghum and pearl millet. Pearl millet is a hardy crop and cultivated in the dry regions of the country whereas, Sorghum though cultivated throughout the country, but contains toxic anti-quality component.

It is evaluated that the yield potential and nutritional quality of some promising baby corn genotypes grown along with two most common fodder maize varieties viz., African Tall and J-1006. The biomass from baby corn stalks was little less as compared to fodder maize J-1006 and African tall, there is little difference in terms of crude protein where baby corn crude protein is more than African Tall and J-1006 and in vitro dry matter digestibility. The woodiness is also comparable. It means the baby corn is as good as fodder maize and used for cultivation in periurban area (Chaudhary *et al.* 2012).

To realize forage potential of maize there is an urgent need to develop better inside of ancillary character under selection, correlation, path analysis and principal component analysis are the tools which are being effectively used for determining the rate of various yield component in forage maize, leading to the selection of superior genotypes. Therefore, a rational approach to the improvement of fodder yields of forage maize. Keeping these parameters in view to achieve these goals, the present investigations were carried out with the following objectives.

Objectives of Investigation:

1. To estimate various parameters of genetic variability.
2. To estimate the extent of association and determine direct and indirect effect.
3. To rank the genotypes based on Principal Component Analysis.
4. To identify superior lines for forage yield and quality traits.

REVIEW OF LITERATURE

Crop improvement depends on the magnitude of genetic variability, heritability, genetic advance, inter-relationship between various characters, and their direct and indirect effect on yield is of utmost importance to achieve a dynamic crop improvement programme. It is only possible when we pass on the knowledge of previous work done in the concern field. In maize substantial contribution has been made to the literature regarding its genetics and breeding in recent years.

The available, relevant literature related to various quantitative and qualitative parameters of present investigation “Genetic Analysis of Fodder Yield and its Components in Maize” has been reviewed under the following headings:

2.1 Genetic variation

2.1.1 Genotypic and phenotypic coefficient of variation

2.1.2 Heritability and genetic advance as percentage of mean

2.2 Association analysis

2.2.1 Correlation coefficient analysis

2.2.2 Path coefficient analysis

2.3 Principal Component Analysis

2.1 Genetic variation

2.1.1 Genotypic and phenotypic Coefficient of variation

Variability that exists among the population forms the main basis for selection in any crop improvement programme. Frankel (1974) also emphasized the importance of plant population in designing the most effective breeding programme. Fisher (1918), Wright (1921), Lush (1940) and Robinson *et al.* (1955) have derived different techniques for the estimation of the components of variance.

Bai and Rani (2000) estimated the variability parameters in ten fodder genotypes and reported that, plant height recorded high genotypic coefficient of variation, heritability and genetic advance and also noticed that PCV and GCV was maximum for green fodder yield.

Srivas and Singh (2004) estimated the genetic variability for fodder yield and its contributing traits in hundred maize accessions along with the control cv. African Tall. The phenotypic coefficients of variability estimates were relatively higher than the corresponding genotypic coefficient of variation for forage contributing traits.

Warkad *et al.* (2008) estimated range for genotypic and phenotypic coefficients of variation in 63 landraces and improved sorghum variety. The collection of landraces showed considerable amount of variability for all the traits studies *viz.* plant height, days to 50% flowering, number of nodes, number of leaves per plant, flag leaf area, leaf stem ratio, crude protein and brix's value.

Patel *et al.* (2013) observed high PCV for green fodder yield than dry fodder yield. High GCV was reported for green fodder yield and it's per day productivity, leaf breadth, plant height, stem girth, tillers/plant, crude protein and brix's value.

Ammanullah *et al.* (2014) assessed ten sorghum varieties for growth character and fodder productivity. Significant variation for plant height, leaf area and fresh fodder yield were observed in the material studies.

Kapoor *et al.* (2015) estimated that the phenotypic coefficients of variation (PCV) were invariably higher than their corresponding genotypic coefficient of variation (GCV) thereby suggesting the environmental influences. High estimates of GCV and PCV were observed for plant height, leaf length, stem girth, number of cobs, number of seeds, dry matter yield and green fodder yield, suggesting that selection based on these characters would facilitate successful isolation of desirable types.

Malik *et al.* (2015) observed genetic parameters for twelve characters and revealed significant variability for all the traits. The GCV and PCV were high for leaf breadth, leaves per plant, leaf area, leaf stem ratio and green fodder yield and moderate was observed for leaf length, inter node length, stem girth and protein content and low for days to 50% flowering.

Rana *et al.* (2016) found the high genotypic coefficient of variation was recorded for leaf stem ratio, dry matter yield per plant (g), green fodder yield per plant (g), number of leaves per plant, stem girth, number of tillers per plant, and dry matter content (%) shows high GCV.

Singh *et al.* (2016) observed GCV and PCV the estimates were high for plant height, leaves per plant, leaf area, stem girth, leaf stem ratio and green fodder yield.

2.1.2 Heritability and genetic advance

Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection. Heritability is a property not only of character but also of the environmental circumstances to which the individuals are subjected. Since the value of the heritability depends on the magnitude of all the components of variance a change in any one of these will affect it. Fisher (1918) observed the relative importance of genotypic and environmental variance. Lush (1940) carried out the term broad sense heritability for the genetic variance to total variance. The term narrow sense heritability is for the ratio of additive genetic variance to phenotypic variance. High heritability along with high genetic advance indicated that improvement could be made effective by simple phenotypic performance. A brief review of heritability and genetic advance estimates for different morphological characters are reviewed as follows:

Rohman and Hussain (2003) observed high heritability along with genetic advance was recorded for plant height, leaf length and leaf stem ratio in maize. Heritability with phenotypic variance and the severity of selection provide

estimates of genetic advance or responds to the selection which is very useful in the selection of promising lines.

Singh (2004) found high heritability for characters days to 50% flowering, leaf stem ratio, green fodder yield per plant per day, crude protein (%), stem girth and brix's value of sorghum.

Warkad *et al.* (2008) estimated high heritability coupled with high genetic advance for sorghum was observed for stem girth and dry matter yield per plant indicating the presence of additive gene effects.

Jain *et al.* (2009) studied genetic variability in 48 genotypes of dual sorghum for yield and their contributing traits. Significant variations among all the genotypes were recorded for all characters. Most of the characters had higher genotypic and phenotypic coefficients of variation. The genotypes also exhibited varying degree of heritability and genetic advance. Characters such as grain yield per plant, dry fodder yield per plant and plant height responded positively to selection because of high broad sense heritability and high genetic advance. Leaf breadth was positively and significantly associated with grain yield per plant.

Fekadu (2014) reported low value of genetic advance as per cent of mean and which correspondingly indicated low value of genetic variation for the traits as indicated by low GCV and PCV values for days to maturity and 50% silking. This implies the importance of genetic variability in improvement through selection.

Kapoor and Batra (2015) observed high heritability along with genetic advance for plant height, leaf length, leaf width, ear girth, number of leaves, crude protein, acid detergent fiber, dry matter yield and green fodder yield indicating the predominance of additive effect in the inheritance of these characters.

Ranjith *et al.* (2017) reported high genotypic coefficient of variation in Sorghum for the character fodder yield per plant followed by 1000-seed weight whereas moderate for panicle breadth, plant height, grain yield per plant and

low for the character 50 per cent flowering. High phenotypic coefficient of variation was observed for the character fodder yield per plant followed by 1000-seed weight and panicle breadth whereas moderate for plant height and grain yield per plant and low for the character days to 50 per cent flowering.

2.2 Association analysis

2.2.1 Correlation coefficient

Correlation refers to the degree and direction of association between two or more than two variables. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement of yield. The original concept of correlation was presented by Galton (1888). There is necessity to estimate the genotypic and phenotypic correlation coefficients as an aid in estimating the true association due to genetic causes. A brief review of correlation is summarized below

Correlation coefficient is a statistical measure to find out the degree and direction of relationship between two or more variables. A positive value of correlation shows that the changes of two variables are in same direction, whereas in negative correlation movements of two variables are in opposite direction. It measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. There are three types of correlation *viz.*, phenotypic, genotypic and environmental. Phenotypic correlation is the observable correlation between two variables. It includes both genotypic and environmental effects. Genotypic correlation on the other hand measures the inherent association between two variables. It may be either due to pleiotropic action of genes or linkage, more likely both or developmentally induced relationships.

Kumar and Kumar (1997) observed that the values of genotypic correlations were slightly higher than the corresponding phenotypic values. Significant positive correlations were reported for plant height, days to 50 per cent maturity, ear length and cob height with yield per plant in maize.

Ravindra Babu (2002) reported in his studies that oil and protein content had significant positive correlation with each other and negative correlation with yield.

Srivas and Singh (2004) reported association study between fodder yield and its contributing traits in hundred maize accessions of forage maize revealed that dry fodder yield per plant, a dependent trait was significant and positive associated with green fodder yield and its contributing traits such as plant height, days to 50 per cent silking, number of leaves per plant, stem girth, leaf blade length, leaf width and sheath length.

Bini and Bai (2005) studied correlation between different characters contributing to green fodder yield in fifty accessions of fodder Sorghum. The results showed that correlation was significant in the case of plant height at harvest, leaf number per plant, crude protein content and plant stand after germination. Genotypic correlation was higher than phenotypic correlation for all the characters indicating that there is less influence of environment on these characters.

Patel *et al.* (2005) carried out correlation analysis in fifty nine genotypes of forage maize for forage yield component characters namely days to 50 per cent silking, plant height, number of leaves per plant, leaf length, leaf breadth, stem girth, crude protein content, dry matter yield per plant and green fodder yield per plant. Except for crude protein content, all the component characters had significant and positive correlation with both the types of yield (green and dry matter).

Warkad *et al.* (2008) carried out estimation of 64 genotypes of sorghum for correlation studies and showed that selection could be practiced for days to

50% flowering, days to maturity and plant height as these characters manifested positive significant correlation with dry fodder yield.

Borad *et al.* (2007) revealed high positive and significant association of stem girth, stem weight, leaf weight and crude protein yield with green fodder as well as dry matter yields both at phenotypic and genotypic levels. Among the inter-character correlations, stem girth, stem weight, leaf weight, dry matter yield and crude protein yield were significantly and positively associated with each other. Plant height had negative but non-significant association with most of the characters. In general genotypic correlation coefficients were higher than that of phenotypic correlation coefficients.

Bhoite *et al.* (2007) worked out correlation analysis for yield and yield components in forty five diverse genotypes of forage maize and revealed that green forage yield had significant positive correlation with dry matter yield and crude protein yield and significant negative correlation with days to 50 per cent flowering. Among interrelationships, days to 50 per cent flowering showed a significant positive correlation with plant height.

Bodi *et al.* (2008) in a study observed positive correlation between plant height and main ear attachment height.

Icoz and Kara (2009) reported high value of positive and significant correlation between green fodder yield and dry matter yield, closely followed by leaf width, stem girth. The highest value of negative and significant correlation was exhibited by leaf length and leaf stem ratio

Iyanar *et al.* (2010) observed that dry fodder yield exhibited high correlation with green fodder yield per plant followed by leaf length, plant height and number of leaves, while crude protein had significant negative association with dry fodder yield.

Shinde *et al.* (2010) carried out association analysis for green forage yield and yield contributing characters in bajra x napier grass hybrids and

revealed that green forage yield was significantly and positively associated with dry matter yield, crude protein yield and plant height.

Parkash *et al.* (2014) observed that characters plant height, number of tillers, leaf length, crude protein yield, number of leaves/plant and stem diameter were significant and positive correlated with green fodder yield per plant, while days to 50% flowering showed negative association with green fodder yield per plant indicating that these characters may be considered as selection indices in sorghum breeding programme.

Singh *et al.* (2016) observed green fodder yield exhibits significant and positive correlation with leaf area, plant height, leaves per plant, leaf breadth and stem girth at genotypic and phenotypic level.

Dubey *et al.* (2016) carried out an investigation on dual purpose sorghum the characters like flag leaf area, panicle length, number of grains per panicle, thousand grain weight showed highly significant positive correlation with grain yield per panicle.

Vendruscolo *et al.* (2016) evaluated agro-morphological traits *i.e.* flowering date, stem diameter, plant height, no. of leaves, green mass production, and dry matter production. Highest genotypic correlation was found between the traits green mass production and dry matter production.

2.2.2 Path coefficient analysis

Path coefficient analysis is a plant breeder's technique to study the partitioning of the correlation into the components of direct and indirect effects (Li, 1956). The concept of path analysis was originally developed by Wright (1921) which was first used for plant selection by Dewey and Lu (1959). Path coefficient analysis is a technique used to study the partitioning of the correlation into the components of direct and indirect effects (Li, 1956). In agriculture path analysis has been used by plant breeders in identifying traits that are useful as selection criteria to improve crop yield (Dewey and Lu, 1959).

Sreekumar and Bai (1995) in fodder maize reported that plant height contributed to fodder yield directly.

Reddy and Mohammad (1999) reported that association of characters with yield and among themselves were influenced by the environment. Plant height, number of leaves and leaf area per plant had more effect on forage production during *Rabi* than *Kharif*. The direct effect of stem girth was positive in *Kharif*. The direct influence of crude protein on forage production was the most significant in both season and concluded that selection of plants with high crude protein contents would help in the improvement of forage yield in maize.

Singh *et al.* (2003) observed that ear leaf area had the highest positive direct effect on green fodder yield per plant at genotypic and phenotypic levels followed by dry matter yield per plant, ear length and days to 50 per cent silking. Ear length had the maximum direct effect on grain yield followed by 500-kernel weight and ear leaf area. Number of leaves per plant, leaf stem ratio and girth of basal inter node had also highly positive direct effect on grain yield per plant.

Kumar and Singh (2004) observed that days to 50 per cent silking and cob length had the maximum positive direct effect on grain yield at genotypic and phenotypic levels, respectively.

Srivas and Singh (2004) used path coefficient analysis in forage maize, and revealed that characters such as plant height, days to 50 per cent silking, stem girth, leaf length, leaf width and number of leaves per plant had positive direct effect on dry fodder yield.

Bini and Bai (2005) in fodder sorghum reported that leaf weight per plant, leaf area index and plant height at harvest had positive direct effect on green fodder yield along with high genotypic correlation.

Shelake *et al.* (2005) path analysis revealed high magnitude of direct effects for all characters at the genotypic level. The number of days to 50 per cent tasseling, number of days to 50 per cent silking and harvest index showed

higher genotypic direct effect. Biological yield per plant had the highest negative genotypic direct effect on grain yield.

Patel *et al.* (2005) reported that dry matter yield per plant, number of leaves per plant, days to 50 per cent silking and plant height had positive direct effects on green fodder yield.

Bhoite *et al.* (2007) studied path coefficient analysis for green forage yield and related characters in forty five diverse genotypes of forage maize and reported that crude protein yield, dry matter yield, plant height and days to 50 per cent flowering had positive direct effects with green forage yield.

Borad *et al.* (2007) reported path analysis in fodder sorghum and revealed that the component traits namely plant height, inter nodal length, dry matter yield, leaf stem ratio and Brix's value had negative direct association with green fodder yield, while rest of the characters had positive direct effect crude protein percent, stem girth and tillers/plant with green fodder yield.

Awasthi *et al.* (2009) based on their studies on path analysis for eight forage characters of maize and reported that plant height, leaf breadth and green fodder yield have positive direct effect on dry fodder yield while leaf length and days to flowering showed negative direct effects. Number of leaves per plant showed negative direct effect on dry fodder yield but positive and high indirect effects via plant height, leaf breadth, stem girth and green fodder yield. Stem girth also had negative direct effect on dry fodder yield but positive and high indirect effects via days to flowering, plant height, leaf breadth and green fodder yield.

Icoz and Kara (2009) reported that ear weight, leaf number, and stem diameter had highest direct effects on plant weight and lowest plant densities. Positive and significant genotypic correlation values of traits viz., plant height, leaf length and dry matter yield with green fodder yield and their positive direct effect values on green fodder yield. It indicated a true picture of association between these traits.

Iyanar *et al.* (2010) carried out path coefficient analysis in one hundred and nine genotypes of multi cut fodder sorghum between fourteen fodder yields and its related characters for each cut and subjected to pooled analysis. It revealed that characters namely plant height, leaf breadth and stem thickness had positive direct effect on green fodder yield and concluded that due importance should be given for plant height because of its significant correlation and high direct effect, apart from its high indirect contribution through dry fodder yield.

Prakash *et al.* (2010) estimated direct and indirect effects of fodder yield components on green fodder yield per plant. Plant height contributed high direct effect to green fodder yield per plant followed by leaf breadth (Moderate) and leaf length (Moderate). Stem diameter also exerted positive direct effect on green fodder yield.

Shinde *et al.* (2010) worked out path analysis for green forage yield and its contributing characters in bajra x napier hybrids and revealed that character *viz.*, dry matter yield exhibited the highest positive direct effect on green forage yield followed by crude protein content, stem girth and plant height. Considering both, the correlation coefficients and path coefficients together they suggested that dry matter yield, plant height, and crude protein content should be given due importance during indirect selection for green forage yield improvement.

Jain and Patel (2012) reported that leaf width, number of leaves per plant, days to 50 per cent flowering and plant height had higher direct effect on fodder yield of sorghum.

Kumar and Singh (2012) studied different character combinations and observed the path coefficient analysis showed that leaf length, leaf breadth, leaves per plant, leaf area and were the most important characters controlling directly green fodder yield. High indirect positive contribution of leaf length, leaf breadth leaves per plant and stem girth via leaf area and leaf stem ratio, total soluble solids and protein content via leaves per plant.

Jain and Patel (2013) analyzed that the path coefficient analysis at phenotypic level is done to partition the correlation coefficients in to direct and indirect effects. Green fodder yield per plant was taken as dependent variable while computing the path coefficient. The path coefficient analysis revealed that the characters like green and dry fodder yield and number of leaves per plant which had positive significant association with green fodder yield also exerted positive and high direct effects on green fodder yield.

Sadish *et al.* (2014) revealed that the highest direct effect on seed yield of sweet corn genotype was exhibited by green cob yield followed by ear length appeared to be the main factor for their strong association with seed yield (wet). Other traits like days to 50% silking, green fodder yield, sugar content in kernel and number of kernels per row also showed positive direct effect. Most of the traits showed their positive indirect effect through plant height, ear height and ear girth. The sugar content in kernel showed its indirect positive effect through days to 50% silking and days to maturity.

Singh *et al.* (2016) analyzed that the path coefficient analysis of genotypic and phenotypic exhibited high positive and direct effect of leaves per plant, leaf breadth and leaf stem ratio on green fodder yield in fodder maize.

2.3 Principal Component of Analysis

PCA is a well-known method of dimension reduction (Massay, 1965; Jolliffe, 1986). Principal component analysis is intended to derive a small number of linear combinations (principal components) of a set of variables that retain many of the existing information in the original variables. Thus, this analysis may also be seen as an attempt of evidencing the approximate linear dependences existing between variables. Often a small number of principal components may be used to replace the original variables, to draw graphical representations, regression analysis, cluster analysis, factor analysis, among others traits. A brief reviews has been summarized below:

Ahmed *et al.* (2010) in PCA, the characters viz., plant height and grain yield per plant in PC1 and days to tasseling and maturity were loaded in PC2

and number of kernels per row and ear length in PC3 contributing more towards variability. Principal factor analysis revealed that plant height and grain yield per plant and days to 50% tasseling as major contributors to the total divergence.

Bhanupriya *et al.* (2014) studied forty nine germplasm and principal component analysis (PCA) indicated that five components (PC1 to PC5) accounted for about 75 % of the total variation. Out of total principal components retained PC1, PC2 and PC3 with values of 25.9%, 17.1% and 13.3% respectively contributed to the total variation. The first principal component had high positive loading for 9 characters out of 16 *viz.*, weight of grains per spike, number of grains per spike, number of spikelets per spike, spike length, plant height, days to heading and days to flowering, grain protein content and yield per plant which contributed more to the diversity.

Krishna *et al.* (2014) studied 50 genotypes of oat using principal component analysis which revealed the first six most informative components accounted for 84.9% variance. Traits were determined on the basis of factor loadings and traits with higher weighting were plant height, panicle length, number of spikelets per panicle, days to flower, dry weight, grain weight, green fodder yield, dry matter yield in PC1. Plant height, number of leaves, leaf length, leaf breadth, panicle length, spike length, number of spikelets per panicle in PC2; plant height, number of leaves, stem girth, 1000 seed weight, dry weight, in PC3; plant height, number of leaves, leaf length, leaf breadth, spike length, number of spikelets per panicle, 1000 seed weight, great yield , days to flower, grain weight , dry matter yield in PC4; plant height, number of leaves, leaf length, 1000 seed weight, great yield, dry matter yield in PC5; plant height, number of leaves, panicle length, grain weight, dry matter yield in PC6.

Mehrnaz *et al.* (2014) studied genetic diversity of 13 maize hybrids based on morphological traits. According to cluster analysis with UPGMA method, all of hybrids were grouped into 4 major groups. Principal Component Analysis (PCA) showed that first two PC justified 94.63% of total variance. Clustering pattern obtained from first two component analysis almost confirmed the cluster analysis grouping of genotypes.

Chikuta *et al.* (2015) studied PCs and they reported the first four principle components exhibited 89% of the total variations observed in the genotypes.

Muhammad *et al.* (2015) studied 54 genotypes of maize under both normal and water stress conditions to identify the major parameters responsible for the variation among genotypes using single linkage cluster analysis and PCA for 13 characters. The PCA showed that the first six component with eigen values more than 1 contributed 82.30% of variability among the genotypes under normal field irrigation conditions. Under drought condition the first four PCs with eigen value more than 1 contributed 64.79% of the variability among genotypes. Cluster with superior agronomic types were identified and could be exploited for the transfer of desirable genes to improve the yield potential of the maize crop.

MATERIAL AND METHODS

This chapter deals with the procedure employed for data collection the techniques of data analysis of experimental material used and other details to this study are presented under following sub headings

3.1 Experimental site and location

The experiment was carried out at Seed Breeding Farm, Department of Genetics and Plant Breeding, College of Agriculture, Jabalpur (Madhya Pradesh) during *Kharif* 2018. Jabalpur is situated at 411.78 meters above the mean sea level at 23.9°N altitude and 79.58°E longitude. The experimental area occupied was quite uniform in respect of topography and fertility.

3.2 Climate and Weather

The climate of Jabalpur is typically semi-humid and subtropical with severe winter and summer season. Jabalpur traditionally comes under rice - wheat crop zone of Madhya Pradesh and classified as "Kymore plateau and Satpura hills agro-climatic zone". The maximum temperature during the month of May and June reaches up to 33°C, whereas minimum temperature goes below 5.5°C in the month of December or January. The average rainfall in this region is 1107.1 mm which is mostly received during monsoon season between last - June to entire august with little occasional showers in other seasons.

According to National Bureau of Soil Science and Land Use Planning of the ICAR, this area belongs to agro-ecological sub-region number 10.1 as (sub-humid dry eco-region). The data related to weekly maximum and minimum temperature, relative humidity, wind velocity, rainfall, number of rainy days, sunshine hours and evaporation during entries crop growing period of experiment, recorded at metrological observatory Krishi Nagar, J.N.K.V.V., Jabalpur have been presented in Appendix-1.

3.3 Experimental material and methods

Table 3.1 31 Genotypes of maize fodder including check

1	TNFM131-9	TNAU, Coimbtore	12	AH-8071 R	UAS, Dharwad	23	PAC-745	Pro Agro seed
2	PFM-9	PAU, Ludhiyana	13	MF-2018	Dholi, Muzzaffara bad	24	ADV-9293	Advanta Pvt. Ltd.
3	VMH-45	VPKAS, Almora	14	Star-111	Star Agro Pvt. Ltd.	25	JM-216	JNKVV, Chhindwara
4	PFM-10	PAU, Ludhiyana	15	TSFM-16- 10	PJTSAU, Hydrabad	26	JM-218	JNKVV, Chhindwara
5	HPFM-9	HPKV, Palampur	16	SCH-201	Rabi seed Pvt. Ltd.	27	Jawahar pop corn 11	JNKVV, Chhindwara
6	DFH-1	GBPUA & T Pantnagar	17	AH-8070	UAS, Dharwad	28	Sugar 75	Advanta Pvt. Ltd.
7	ADV-6781	Advanta seed Ltd.	18	IMHBG- 18KF2	IIMR, Begusarai	29	Jawahar baby corn-1	JNKVV, Chhindwara
8	AFH-6	IARI, New Delhi	19	CMVLBC-2	VPKAS, Almora	30	J-1006 (C)	PAU, Ludhiyana
9	IMHBG-18KF	IIMR, Begusarai	20	KDFM-3	SKUASTK, Srinagar	31	African Tall (C)	MPKV, Rahuri
10	BAIF, maize-6	BAIF, Uralikhanc han	21	Bioseed- 9544	Bioseeds, Hyderabad			
11	COHM-6	TNAU, Coimbtore	22	ADV-759	Advanta Pvt. Ltd.			

Experimental detail

Experiment design	: RCBD
No. of replications	: 3
No. of genotypes	: 31
No. of rows per genotypes	: 3
Sowing date	: <i>kharif</i> (2018)
Plot size	: 4 × 0.9 m ²

3.4 Observations recorded for fodder and allied traits

Five competitive plants were randomly selected and tagged in each plot per replication for recording observations on the following characters. However, days to 50 per cent tasseling were recorded on plot basis.

3.4 A Morphological traits

3.4 a.1 Days to 50 per cent tasseling

Number of days taken from date of sowing to date of 50 per cent plants shedding pollen was recorded.

3.4 a.2 Days to 50 per cent silking

Number of days taken from the date of sowing to the date of 50 per cent of plants with silk emergence was recorded.

3.4 a.3 Plant height (cm)

Plant height (cm) Height of the plant was measured in centimeters at maturity from the base of the plant (ground level) to the tip of the tassel.

3.4 a.4 Number of leaves per plant

Numbers of fully opened leaves per plant were recorded at 50 per cent tasseling.

3.4 a.5 Stem girth (mm)

Stem girth was measured by vernier caliper's scale from fourth node of the plant from bottom.

3.4 a.6 Inter nodal length (cm)

It was measure in centimeter (cm) by meter scale from the between 3rd and 4th nodes of plant at 50 per cent tasseling.

3.4 a.7 Leaf area (cm²)

The total leaf area of the leaves of main stem was calculated by multiplying the length and width of a single leaf and a factor (0.76). Here the leaf product constant.

$$\text{Total leaf area (cm}^2\text{) /plant} = \text{leaf length (cm)} \times \text{leaf width (cm)} \times 0.76$$

3.4 a.8 Leaves colour per plant

Leaf color is observed visually; the color may be yellow, light green, green and dark green.

3.4 a.9 Leaf mid rib colour per plant

Leaf mid rib color is observed visually; the colour may be yellow, light green, green, dark green and brown.

3.4. B Agronomical traits

3.4 b.1 Leaf stem ratio

Leaf stem ratio is calculated by using formula-

$$\text{Leaf stem ratio} = \frac{\text{Weight of fresh green leaves per plant (g)}}{\text{Weight of fresh green stem per plant (g)}}$$

3.4 b.2 Green fodder yield per plant (g)

Green fodder yield/plant was recorded in grams by weighing whole fresh plant after harvesting at 50 per cent (%) flowering.

3.4 b.3 Green fodder yield per plant per day (g)

It was calculated by using the following formula

$$\text{Green fodder yield/plant/day (g)} = \frac{\text{Green fodder yield/plant (g)}}{\text{Numbers of days to harvest}}$$

3.4 b.4 Dry matter yield per plant

Dry matter yield was recorded in grams by weighing whole plant after drying it with sunrays and then in hot air oven at 65°C till constant weight for dry matter not obtained.

$$\text{Dry matter yield/plant(g)} = \frac{\text{Dm\% X green fodder/plant(g)}}{100}$$

3.4 b.5 Dry matter yield per plant per day (g)

It was calculated by using follows formula

$$\text{Dry matter yield/plant/day (g)} = \frac{\text{Dry matter yield/plant (g)}}{\text{Numbers of days to harvest}}$$

3.4. C Biochemical traits

3.4 c.1 Crude protein yield per plant (g)

Crude protein content of maize will be determined by using Microkjeldal method by (AOAC, 1995). Total nitrogen will be estimated by using Kel-plus (digestion and distillation unit) process by the application of Con. (H₂SO₄), Catalyst mix (K₂SO₄ : CuSO₄ .5 H₂O) in 5:1 ratio, 40% NaOH etc. Crude protein value will be obtained by multiplying the total nitrogen by the conversion factor.

$$\text{Crude protein percent} = \text{Percent Nitrogen content} \times 6.25$$

Where, 6.25 is constant factor

$$\text{Crude protien yield/plant (g)} = \frac{\text{CP\% X Dry matter yield/plant (g)}}{100}$$

3.4 c.2 Crude protein yield per plant per day (g)

It was calculated by using follows formula

$$\text{Crude protein yield/plant/day (g)} = \frac{\text{Crude protein yield/plant (g)}}{\text{Numbers of days to harvest}}$$

3.4 c.3 °Brix's value (%)

°Brix is the measurement in percentage by weight of sucrose in pure water and it is measured by refractometer. Take the third node from bottom at physiological maturity and note the sugar contents per cent using brix's meter for three plants.

3.5 Statistical analysis

The mean value of the recorded data were subjected to analysis of variance (ANOVA) using the statistical analysis procedures.

3.5.1 Mean

It was calculated by using the following formula

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

where,

$\sum X_i$ = sum of all observations

n = Number of observations

3.5.2 Range

Range is the difference between the minimum and the maximum value of a series of observations and thus provides the information about the dispersion present in the genotypes.

3.5.3 Analysis of variance

The data on fodder and grain component traits were statistically analyzed on the basis of model for randomized complete block design. In order

to test the significance of treatments, critical difference was computed (Fisher 1918).

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

where,

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

μ = General mean

b_j = j^{th} block effect

t_i = i^{th} genotype effect

e_{ij} = Random error which are supposed to be normally independently and identically distributed with mean zero and variance σ^2_e .

Table 3.2 Skeleton of ANOVA for Randomized Complete Block Design.

Source of	Df	Sum of	Mean	Expected	F value
Replication	(r-1)	RSS	M_1	$\sigma^2_e + g\sigma^2_r$	RMS/EMS
Genotypes	(g-1)	TSS	M_2	$\sigma^2_e + r\sigma^2_g$	TMS/EMS
Error	(r-1)(g-1)	ESS	M_3	σ^2_e	
Total	(rg-1)				

1. Genotypic variance (σ^2_g) = $\frac{M_2 - M_3}{r}$

2. Phenotypic variance (σ^2_g) = $\frac{M_2 - M_3}{r} + M_3$

3. Error variance (σ^2_g) = M_3

where,

r = Number of replications

g = Number of genotypes

df = Degrees of freedom

RSS = Replication sum of squares

TSS = Treatment sum of squares

ESS = Error sum of squares

M₁ = Mean square due to replications

M₂ = Mean square due to genotypes

M₃ = Mean square due to error

A significant value of F-test indicates that the test entries differ significantly among themselves, which requires computing the critical difference (CD).

$$\text{Coefficient of variation (CV)} = \frac{\sqrt{EMS}}{G.M.} \times 100$$

$$\text{Standard error of any treatment mean} = \sqrt{\frac{EMS}{b}}$$

$$\text{Standard error of difference SE (between any two check means) (d)} = \sqrt{\frac{2EMS}{b}}$$

$$\text{Critical difference (CD)} = t_{(0.01)} \times S.E_{(d)}$$

where,

G.M. = General mean

t_(0.01) = t-value at 1% probability level at error d.f.

b = number of blocks

3.5.4 Estimation of phenotypic and genotypic coefficients of variation

The phenotypic and genotypic coefficient of variation in per cent were computed by the following formulae, given by Burton (1952).

$$\text{PCV (\%)} = \frac{\text{Phenotypic Standard Deviation}}{\text{Mean}} \times 100$$

$$\text{GCV (\%)} = \frac{\text{Genotypic Standard Deviation}}{\text{Mean}} \times 100$$

where,

PCV = Phenotypic coefficient of variation

GCV = Genotypic coefficient of variation

The estimates of PCV and GCV were classified as low, moderate and high according to Sivasubramanian and Madhavamenon (1973).

< 10 percent = low

10-20 percent = moderate

> 20 percent = high

3.5.5 Heritability in broad sense

It was calculated in broad sense by the formula proposed by Hanson *et al.* (1956).

$$\text{Heritability (h}^2 \text{ bs \%)} = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

where,

h^2 (bs) = heritability in broad sense

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

By Johnson *et al.* (1955) the range of heritability was categorized as below:

High = More than 70%

Medium = 50% to 70%

Low = Less than 50%

3.5.6 Genetic advance (GA)

Genetic advance is calculated by the formula suggested by Johnson *et al.* (1955).

$$GA = h^2(\text{bs}) \times \sigma_p \times K$$

where,

GA = Genetic advance

σ_p = Phenotypic standard deviation

h^2 (bs) = Heritability in broad sense of the character

K= Selection intensity at 5% level of significance *i.e.*, 2.06

3.5.6.2 Genetic advance as percentage of mean

It was calculated by the following formula

$$\text{GA as percentage of mean} = \frac{\text{Genetic advance}}{\text{General mean}} \times 100$$

The range of genetic advance as percent of mean is classified as suggested by Johnson *et al.* (1955).

< 10 percent = low

10-20 percent = moderate

> 20 percent = high

3.5.7 Correlation Coefficients Analysis

Correlation coefficients were calculated for combination of all characters under study at genotypic, phenotypic and environmental levels with the help of formula suggested by Miller *et al.* (1958).

$$r_{ij} = \frac{\text{Cov}(ij)}{\sqrt{(\sigma^2_i)(\sigma^2_j)}}$$

where,

r_{ij} = Correlation coefficient between i^{th} and j^{th} traits

Cov (ij) = Covariance between i^{th} and j^{th} traits

σ^2_i = Variance of i^{th} trait

σ^2_j = Variance of j^{th} trait

To test the significance of phenotypic correlation coefficients, the estimated values were compared with the tabulated values of Fisher and Yates (1963) at $n-2$ d.f. at two levels of probability, viz., 5% and 1%.

$$T_{\text{cal.}} = \frac{r}{\sqrt{(1-r^2)}} \times \sqrt{n-2} \quad \text{at } (n-2)\text{d.f.}$$

3.5.8 Path coefficient analysis

Path coefficients are standardized partial regression coefficient and such as provide the means to direct influence of one character upon another character. It also permits partitioning of correlation coefficient into direct and indirect effects via other character. For the path coefficient analysis the method originally proposed by Wright, (1921), which was further modified by Dewey and Lu, (1959). The cause and effect relationship is well defined in path coefficient analysis. It is possible to represent the whole system of variables in the form of a diagram known as path diagram.

Path coefficient analysis can be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect. In other words; it is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects, *i.e.*, it measures the direct and indirect contribution of various independent characters on a dependent character.

Wright (1921) proposed the original technique in which analysis was carried out by modified method devised by Dewey and Lu, (1959). Following set of simultaneously equations were formed and solved for estimating direct and indirect effects. Genotypic path coefficients were calculated separately for yield and yield components. The dependent variable was yield per plant. The unexplained variation in the dependent variable was obtained as residual factor from the following equation.

$$r_{1y} = p_{1y} + r_{12}p_{2y} + r_{13}p_{3y} + \dots + r_{1y}p_{1y}$$

$$r_{2y} = r_{2y}p_{iy} + p_{2y} + r_{23}p_{3y} + \dots + r_{21y}p_{1y}$$

$$r_{ky} = r_{ki} + r_{ki}p_{2y} + r_{13}p_{3y} + \dots + r_{2iy}p_{iy}$$

$$r_{xky} = r_{xki} p_{iy} + r_{zk2} p_{2y} + r_{xk3} p_{3y} + \dots + p_{ky}$$

r_{xky} = Coefficient of correlation between the independent character

p_{iy} to p_{ky} = Direct effects of character 1 to k on dependent character y

3.5.8.1 Direct effect

The direct effects were calculated as follows –

$$P_{Ky} = \sum_{i=1}^k C_{Ki} r_{Ky}$$

3.5.8.2 Indirect effect

Indirect effect of any independent traits on the dependent one via other independent traits was computed by multiplying the direct effect (P_{ky}) of that independent variable with the corresponding correlation coefficient as follows:

$$K^{\text{th}} \text{ trait via } (n-1) = r_{k(n-1)} P_{(n-1)Y}$$

3.5.8.3 Residual effect

Residual effect was obtained as per the formula given below:

$$R = \sqrt{1 - E_{di} r_{ji}}$$

where,

d_i = Direct effect of character

r_{ij} = Correlation coefficient of i^{th} character with j^{th} character

Later the path coefficients were rated based on the scales given below (Lenka and Mishra, 1973).

>1.00 = Very high

0.3-0.99 = High

0.2-0.29 = Moderate

0.1-0.19 = Low

0.0-0.09 = Negligible

3.5.9 Principal Component Analysis

PCA is a well-known method of dimension reduction (Massy, 1965; Jolliffe, 1986), which seeks linear combinations of the columns of $\mathbf{X}$ with maximal variance, or equivalently, high information. It is routinely applied in chemometrics with the goal of providing the most compact representation of the

data. The original p variables $\mathbf{X} = [\mathbf{x}_1 \dots \mathbf{x}_p]$ are transformed in a new predictor set $\mathbf{T} = [\mathbf{t}_1 \dots \mathbf{t}_k]$, with $k \leq \min(n-1, p)$. The new variables $\mathbf{t}_j$, called scores, are a weighted average of the original $\mathbf{X}$ variables. The principal components are the eigen vectors, $\mathbf{u}_j$ from the eigen decomposition of $\mathbf{X}^*\mathbf{X}$ (and of the sample covariance matrix $\mathbf{S}$, up to a constant). PCA sequentially maximizes the variance of a linear combination of the original predictor variables

$$\mathbf{u}_j = \arg \max \text{Var}(\mathbf{X}\mathbf{u}), \mathbf{u} = 1$$

Subject to the constraint that $\mathbf{u}'_i \mathbf{S} \mathbf{u}_j = 0$ for all $1 \leq i < j$. This ensures that $\mathbf{t}_j = \mathbf{X}\mathbf{u}_j$ is uncorrelated with all the previous linear combinations $\mathbf{t}_i = \mathbf{X}\mathbf{u}_i$. The principal components are ordered in terms of the amount of variation of the original data they account for. The first principal component direction has the property that $\mathbf{t}_1 = \mathbf{X}\mathbf{u}_1$ has the largest sample variance among all normalized linear combinations of the columns of $\mathbf{X}$. Each subsequent component gives combinations with the largest possible variance which is uncorrelated with those that have been taken earlier.

There are various standard approaches to find the principal components, e.g. taking the singular value decomposition of $\mathbf{X}$. In chemometrics, it is common to estimate the principal components using the nonlinear iterative partial least-squares (NIPALS) algorithm (Wold, 1966). This is because the number of required components is usually much less than the total possible number ($k \ll p$). In fact, the NIPALS algorithm does not calculate all the principal components at once, but it first calculates $\mathbf{t}_1$ and $\mathbf{u}_1$ from the $\mathbf{X}$ matrix. Then the outer product $\mathbf{t}_1 \mathbf{u}_1^*$ is subtracted from $\mathbf{X}$ and the residual $\mathbf{X}_2$ is calculated. In turn, this residual can be used to calculate $\mathbf{t}_2$ and $\mathbf{u}_2$.

RESULTS

The result of the present study was carried out on 31 maize genotype including check in Randomized Complete Block Design with three replications at Seed Breeding Farm, Department of Plant Breeding and Genetics, JNKVV, Jabalpur during *Kharif* 2018.

According to the objectives for convenience of interpretation and experimental result of present investigation has been presented under following headings:

4.1 Analysis of Variance

4.2 Parameter of Genetic Variability

4.2.1 Range and mean performance for different characters

4.2.2 Genotypic and Phenotypic coefficient of variation

4.2.3 Heritability (%)

4.2.4 Genetic advance as percentage of mean

4.3 Association analysis

4.3.1 Correlation Coefficient Analysis

4.3.2 Path Coefficient Analysis

4.4 Principal Component Analysis

4.1 Analysis of variance

Analysis of variance refers to the observable differences in individuals for a particular trait. To know the extent of variation of observed characters among the genotypes in maize, analysis of variance was performed and is presented in Table 4.1. Analysis of variance indicated that the mean sum of squares due to genotypes were significant for all the characters which revealed that there was considerable genetic variability among the material under study, which can be exploited through selection. The variability was observed for all the traits are presented under following headings

Table 4.1: Analysis of variance for fodder Maize (mean sum of squares)
(Kharif 2018)

Source of variance	D.F.	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	No. of leaves/plant	Leaf area (cm ²)
Replications	2	3.559	3.889	44.653	0.357	298.963
Genotypes	30	10.718**	12.745**	584.334**	4.884**	5727.989**
Error	60	2.753	3.413	58.396	0.281	904.862

Source of variance	D.F.	Internodal length (cm)	Stem girth (mm)	Leaf stem ratio	Green fodder yield/plant (g)	Green fodder yield/ plant/ day (g)
Replications	2	0.057	0.074	0.0029	1944.526	1.026
Genotypes	30	4.280**	2.276**	0.0069**	5644.643**	1.809**
Error	60	0.202	0.209	0.0009	1009.293	0.313

Source of variance	D.F.	Dry matter yield/plant (g)	Dry matter yield /plant /day (g)	Crude protein yield/plant (g)	Crude protein yield/plant/day (g)	Brix value (%)
Replications	2	19.821	0.0044	0.520	0.466	0.860
Genotypes	30	476.398**	0.0392**	7.601**	3.913**	8.688**
Error	60	50.099	0.0037	0.489	0.330	0.887

Where, * significant at 5 per cent and ** significant for 1 per cent level

4.2 Parameters of genetic variability for fodder and allied traits

The parameters of genetic variability viz., mean, range, genotypic and phenotypic coefficient of variation (%) heritability (%) and genetic advance as percentage of mean for all the traits under study were analyzed for different traits and results are presented in Table 4.2.

4.2.1 Range and mean performance for different characters

The mean performance of 31 diverse genotypes of maize has been presented in Appendix-2. The value of mean and range for genotype are depicted in Table 4.2.

4.2.1.1 Days to 50 per cent tasseling

Days to 50 per cent tasseling initiation ranged from 54.17 to 61.10 days with mean value 57.28 days. The genotype IMHBG-18KF2 took 61.10 days which was followed by genotype AH 8071R (60.83 days) and the genotype KDFM-3 took least time of 54.17 days preceded by genotype TSFM-16-10 (54.33 days).

4.2.1.2 Days to 50 per cent silking

Days to 50 per cent silking ranged from 65.37 to 74.17 days with general mean value 68.99 days. Whereas, the genotype IMHBG-18KF2 was found to take maximum time of 74.17 days which was followed by the Jawahar baby corn-1 (73.80 days) and the genotype TSFM-16-10 required the least time of about 65.37 days and preceded by genotype KDFM-3 (66.00 days).

4.2.1.3 Plant height (cm)

Plant height ranged from 149.13cm to 200.93cm with mean value of 172.53cm. The genotype African tall (check variety) had maximum plant height of 200.93cm and was followed by the genotype TSFM-16-10 of (197.37cm). While, the genotype CMVLBC-2 had minimum plant height of 149.13cm preceded by genotype Bioseed 9544 (150.20cm).

Table 4.2: Estimates of genetic parameters of variations for various characters in fodder Maize (*Kharif 2018*)

Characters	Grand Mean	Range		Coefficient of variations		Heritability % (BS)	Genetic Advance	GA as % of mean
		Min.	Max.	Phenotypic	Genotypic			
Days to 50% tasselling	57.28	54.17	61.10	4.06	2.84	49.09	2.35	4.11
Days to 50% silking	68.99	65.37	74.17	3.70	2.56	47.68	2.51	3.64
Plant height (cm)	172.53	149.13	200.93	8.86	7.67	75.01	23.62	13.69
No. of leaves/plant	11.01	8.20	12.80	12.24	11.25	84.51	2.35	21.31
Leaf area (cm ²)	405.18	317.73	491.73	12.37	9.90	63.99	66.07	16.31
Internodal length (cm)	11.58	8.13	13.73	10.79	10.07	87.06	2.24	19.35
Stem girth (mm)	9.72	8.47	11.50	9.75	8.54	76.73	1.50	15.41
Leaf stem ratio	0.55	0.46	0.64	9.78	8.11	68.82	0.08	13.88
Green fodder yield/plant (g)	208.98	140.33	314.33	24.18	18.81	60.49	62.98	30.14
Green fodder yield/plant /day (g)	2.94	1.79	4.64	30.68	24.04	61.41	1.14	38.77
Dry matter yield/plant (g)	50.62	32.33	75.33	27.39	23.55	73.93	21.11	41.71
Dry matter yield/plant /day (g)	0.62	0.36	0.85	20.15	17.56	75.91	0.20	31.50
Crude protein yield/plant (g)	5.92	3.50	9.73	28.55	25.99	82.88	2.89	48.77
Crude protein yield/plant /day (g)	4.15	2.47	6.40	29.79	26.37	78.32	1.99	48.01
Brix value (%)	11.15	7.53	14.17	16.75	14.46	74.56	2.87	25.73

4.2.1.4 Number of leaves per plant

Variability ranged from 8.20 to 12.80 with mean value 11.01. The maximum number of leaves were borne by genotype AH 8070 12.80 followed by genotype ADV-6781, J 1006 (check variety) had 12.60 and minimum number of leaves was found in genotype Jawahar pop corn-11 i.e., 8.20 which was preceded by genotype ADV-759 (8.83).

4.2.1.5 Leaf area (cm²)

Leaf area ranged as 317.73cm² to 491.73cm² with its general mean value of 405.18cm². Maximum leaf area was carried by the genotype Jawahar baby corn-1 (491.73cm²) and followed by genotype PAC-745 460.07cm² and minimum variability was found in genotype Jawahar pop corn-11 of 317.73cm² preceded by genotype HPFM-9 (318.10cm²).

4.2.1.6 Inter nodal length (cm)

Inter nodal length ranged from 8.13cm to 13.73cm with general mean value 11.58cm. Whereas, the genotype African tall (check variety) was found to have maximum inter nodal length of 13.73cm followed by genotype HPFM-9 13.27cm and minimum length (8.13cm) carried out by genotype the Jawahar pop corn-11 preceded by genotype ADV-9293 (9.47cm).

4.2.1.7 Stem girth (mm)

In respect to stem girth the mean value was 9.72mm and ranged from 8.47mm to 11.50mm. The genotype IMHBG-18KF1 showed maximum value (11.50mm) followed by genotype PFM-10 (11.27mm). The genotype TSFM-16-10, African tall (check variety) had minimum stem girth of 8.47mm preceded by genotype ADV-759 (8.77mm).

4.2.1.8 Leaf stem ratio

General mean value of leaf stem ratio was 0.55 and its variability ranged from 0.49 to 0.64. Whereas, maximum variability carried by the genotype ADV-759, Sugar-75 (0.64) followed by genotype Bioseed-9544 (0.63). Whereas, leaf

stem ratio with minimum value was found in the genotype HPFM-9 (0.46) preceded by 0.47 in genotype VMH-45.

4.2.1.9 Green fodder yield per plant (g)

Green fodder yield per plant ranged from 140.33g to 314.33g with mean value of 208.98g. Genotype DFH-1 gave maximum fodder yield of 314.33g followed by the genotype ADV-6781 (280.00g). The genotype IMHBG-18KF2 obtained minimum value of 140.33g preceded by genotype KDFM-3 (146.00g).

4.2.1.10: Green fodder yield per plant per day (g)

Green fodder yield per plant per day ranged from 1.79g to 4.64g with its mean value of 2.94g. Maximum value was found in genotype Sugar-75 (4.64g) followed by genotype African tall (check variety) was (4.46g). The genotype AFH-6 recorded minimum value of 1.79g and was preceded by genotype IMHBG-18KF2 (1.90g).

4.2.1.11 Dry matter yield per plant (g)

Dry matter yield per plant ranged from 32.33g to 75.33g with mean value of 50.62g. Maximum yield found in the genotype Sugar-75 was 75.33g and was followed by genotype DFH-1 (75.00g). The genotypes BAIF, maize-6 recorded minimum yield of 32.33g and was preceded by genotype CMVLBC-2, KDFM-3 (33.33g).

4.2.1.12 Dry matter yield per plant per day (g)

General mean value of dry matter yield per plant per day was 0.62g and ranged from 0.36g to 0.85g. Genotype JM-216 observed maximum yield 0.85g followed by genotype Bioseed-9544 (0.81g) and the minimum of 0.36g was observed in genotype SCH-201 and was preceded by genotype AFH-6 (0.42g).

4.2.1.13 Crude protein yield per plant

It ranged from 3.50g to 9.73g with its mean value 5.92g. Genotype Sugar-75 showed maximum crude protein yield i.e., 9.73g followed by genotype

DFH-1 (8.07g) Genotype AFH-6, KDFM-3 observed minimum yield value of 3.50g and was preceded by genotype PFM-9 (3.80g).

4.2.1.14 Crude protein yield per plant per day

Crude protein yield per plant per day observed the general mean value of 4.15g and it ranged from 2.47g to 6.40g; maximum value found in genotype Sugar-75 was 6.40g followed by genotype DFH-1 (6.20g) and genotype AFH-6, KDFM-3 recorded minimum value of 2.47g and was preceded by genotype PFM-9, BAIF, Maize-6 (2.70g).

4.2.1.15 Brix's value per cent

It ranged from 7.53 per cent to 14.17 per cent with its general mean value of 11.15%. Maximum variability found in genotype SCH-201 was 14.17% followed by genotype VMH-45 (13.77%) and the genotype African tall (check variety) had minimum variability 7.53% preceded by genotype TSFM-16-10 (7.83%).

4.2.1.16 Leaf colour and leaf mid rib colour

Different genotypes were classified into three distinct group of leaf colour *i.e.*, dark green, green and light green out of which genotypes showed dark green colour *viz.*, DFH-8, Bioseed-9544, ADV-759, Jawahar pop corn-11 and Sugar-75, and TNFM-131-9, PFM-9, PFM-10, AFH-6, IMHBG-18KF1, BAIF, maize-6, AH-8071R, Star-111, SCH-201, KDFM-3, PAC-745, ADV-9293, Jawahar baby corn-1, J-1006 and African Tall with green colour. While, the genotypes VMH-45, HPFM-9, ADV-6781, COHM-6, MF-2018, TSFM-16-10, AH-8070, IMHBG-18KF2, CMVLBC-2, JM-216 and JM-218 had found light green colour (Table 4.3 and Plate 2).

On the basis of leaf mid rib colour different genotypes were categorized into two distinct group *viz.*, white and brown, out of which white mid rib colour observed in almost all the genotypes except SCH-201 and IMHBG-18KF2 has brown mid rib colour (Table 4.3 and Plate 2).

Table 4.3 Leaf colour and leaf mid rib colour of different genotypes of fodder maize (*kharif* 2018)

Genotypes	Leaf colour	Midrib colour
TNFM 131-9	GN	WT
PFM-9	GN	WT
VMH-45	LT GN	WT
PFM-10	GN	WT
HPFM-9	LT GN	WT
DFH-8	DK GN	WT
ADV-6781	LT GN	WT
AFH-6	GN	WT
IMHBG-18KF1	GN	WT
BAIF,maize-6	GN	WT
COHM-6	LT GN	WT
AH-8071 R	GN	WT
MF-2018	LT GN	WT
Star-111	GN	WT
TSFM-16-10	LT GN	WT
SCH-201	GN	BN
AH-8070	LT GN	WT
IMHBG-18KF2	LT GN	BN
CMVLBC-2	LT GN	WT
KDFM-3	GN	WT
Bioseed-9544	DK GN	WT
ADV-759	DK GN	WT
PAC-745	GN	WT
ADV-9293	GN	WT
JM-216	LT GN	WT
JM-218	LT GN	WT
Jawahar pop corn-11	DK GN	WT
Sugar-75	DK GN	WT
Jawahar baby corn-1	GN	WT
J-1006 (C)	GN	WT
African Tall (C)	DK GN	WT

GN- Green leaf, LT GN- Light green, DK GN- dark green, WT- White, BN- Brown

4.2.2 Phenotypic and Genotypic coefficient of variation

Genetic variability is the raw material for plant breeding on which selection acts to evolve superior genotypes. Thus, larger the amount of variation present for a character in the breeding materials more will be the scope for its improvement through selection. The phenotypic and genotypic coefficients of variation were computed to assess the existing variability in the material.

The estimation of phenotypic and genotypic coefficients of variation is of prime importance to get an idea about the relative extent of heritable and non heritable variation for all the characters studied. It indicated that there was little influence of environment on the expression of these traits.

PCV and GCV were classified as per Sivasubramanian and Menon (1973) as shown below: 0-10%- low; 10.1-20%- moderate; >20.1%- high.

4.2.2.1 Phenotypic coefficient of variation

Phenotypic coefficient of variation (PCV) ranged from 3.70 per cent (days to 50 per cent silking) to 30.68 per cent (green fodder yield per plant per day). Result is depicted in Table- 4.2.

High magnitude of PCV was observed in green fodder yield per plant per day (30.68%) followed by crude protein yield per plant per day (29.79%), crude protein yield per plant (28.55%), dry matter yield (27.39%), green fodder yield per plant (24.18%) and dry matter yield per plant per day (20.15%).

Moderate magnitude of PCV was observed in brix's value (16.75%), leaf area (12.37%). number of leaves per plant (12.24%) and inter nodal length (10.79%).

Low magnitude of PCV was observed in leaf stem ratio (9.78%), stem girth (9.75%), plant height (8.86%), days to 50 per cent tasseling (4.06%) and days to 50 per cent silking (3.70%).

4.2.2 Genotypic coefficient of variation

It is evident from the Table 4.2 that genotypic coefficient of variation (GCV) ranged from 2.56 per cent (50 per cent silking) to 26.37 per cent (crude protein yield per plant per day).

High magnitude of GCV was observed in crude protein yield per plant per day (26.37%) followed by crude protein yield per plant (25.99%), green fodder yield per plant per day (24.04%) and dry matter yield per plant (23.55%). Whereas, moderate magnitude of GCV was observed in green fodder yield per plant (18.81%) followed by dry matter yield per plant per day (17.56%), brix's value (14.46%), number of leaves per plant (11.25%) and inter nodal length (10.07%).

Low magnitude of GCV was observed in leaf area (9.90%), stem girth (8.54%), leaf stem ratio (8.11%), plant height (7.67%), days to 50 per cent tasseling (2.84%) and days to 50 per cent silking (2.56%).

4.2.3 Heritability for fodder and allied traits

Heritability estimates provides the assessment amount of transmissible genetic variability to total variability. It happens to be the most important basic factor that determines the genetic improvement attained through selection is not only dependent on heritability but also on the amount of genetic variation present in the breeding population and the extent of selection pressure applied by the breeder. Thus, heritability provides clear picture regarding the effectiveness of selection for improving the plant characters.

The range of heritability was categorized as low (below 50%), moderate (50%-70%) and high (above 70%) as given by Johnson *et al.* (1955).

It is evident from the Table 4.2 that heritability per cent in broad sense ranged from 47.68 per cent (days to 50 per cent silking) to 87.06 per cent (inter nodal length).

High magnitude of heritability were observed in inter nodal length (87.06%) followed by number of leaves per plant (84.51%), crude protein yield

per plant (82.88%), crude protein yield per plant per day (78.32%), stem girth (76.73%), dry matter yield per plant per day (75.91%), plant height (75.01%), brix's value (74.56%) and dry matter yield per plant (73.93%).

Moderate magnitude of heritability observed in leaf stem ratio (68.82%), leaf area (63.99%), green fodder yield per plant per day (61.41%) and green fodder yield per plant (60.49%). While, low magnitude of heritability observed in days to 50 per cent tasseling (49.09%) and days to 50% silking (47.68%).

4.2.4 Genetic advance as percentage of mean

The parameter of genetic advance as percentage of mean (GA) is more reliable index for understanding the effectiveness of selection in improving the traits because its estimate is derived by involvement of heritability, phenotypic standard deviation and intensity of selection.

Thus, genetic advance as percentage of mean along with heritability provides clear picture regarding the effectiveness of selection for improving the plant character.

Genetic advance as per cent mean was categorized as given below as suggested by Johnson et al. (1955). Range 0- 10%- Low; 10.1-20%- Moderate; >20%- High.

In Table 4.2 result showed that genetic advance as percentage of mean ranged from 3.64 per cent (days to 50 per cent silking) to 48.77 per cent (crude protein yield per plant).

High magnitude of genetic advance as percentage of mean observed in crude protein yield per plant (48.77%), crude protein yield per plant per day (48.01%), dry matter yield per plant (41.71%), green fodder yield per plant per day (38.77%), dry matter yield per plant per day (31.50%), green fodder yield per plant (30.14%), brix's value (25.73%) and number of leaves per plant (21.31%).

Moderate magnitude of genetic advance as percentage of mean was observed in inter nodal length (19.35%), leaf area (16.31%), stem girth (15.41%), leaf stem ratio (13.88%) and plant height (13.69%).

Low magnitude of genetic advance as percentage of mean was observed in days to 50 per cent tasseling (4.11%) and days to 50 per cent silking (3.64%).

4.3 Association analysis

4.3.1 Correlation Coefficient Analysis

The correlation coefficient analysis is the index of association between two variables. Phenotypic and genotypic correlation for various yield and quality attributing traits were estimated with green fodder yield as dependent variables. The results of all the characters studied are presented in Table 4.5.

4.3.1.1 Days to 50 per cent tasseling

Highly significant positive association (0.674) was recorded by days to 50 per cent silking.

4.3.1.2 Days to 50 per cent silking

No significant positive or negative association was found between days to 50 per cent silking and other characters under study.

4.3.1.3 Plant height (cm)

Highly significant and positive correlation with inter nodal length (0.630), green fodder yield per plant per day (0.405), crude protein yield per plant per day (0.400), crude protein yield per plant (0.389), dry matter yield per plant (0.310), dry matter yield per plant per day (0.293). Plant height also exhibited highly significant negative correlation with brix's value (-0.458) and significant negative correlation with stem girth (-0.265).

Table 4.4: Estimates of genotypic correlation coefficients among yield and its attributing traits in fodder Maize (*kharif 2018*)

Characters		Days to 50% silking	Plant height (cm)	No. of leaves /plant	Leaf area (cm ²)	Internod al length (cm)	Stem girth (mm)	Leaf stem ratio	GFY/pla nt /day (g)	DMY/ plant (g)	DMY /plant /day (g)	CPY/ plant (g)	CPY /plant /day (g)	Brix value (%)	GFY / plant (g)
Days to 50% tasselling	G	0.948	-0.097	0.075	0.223	0.019	-0.349	0.242	-0.042	-0.145	-0.138	-0.019	-0.035	0.216	-0.126
Days to 50% silking	G		0.009	0.226	0.345	0.085	-0.168	0.062	-0.027	-0.144	-0.115	-0.031	-0.01	-0.036	-0.01
Plant height (cm)	G			0.137	0.013	0.716	-0.252	0.286	0.507	0.369	0.358	0.491	0.485	-0.529	0.124
No. of leaves/ plant	G				0.109	0.28	0.062	-0.22	-0.123	-0.385	-0.337	-0.292	-0.308	0.148	-0.296
Leaf area (cm ²)	G					0.273	-0.36	0.249	0.105	-0.091	0.187	0.042	-0.007	0.102	-0.004
Internodal length (cm)	G						-0.385	0.156	0.151	-0.075	0.006	0.207	0.173	-0.261	-0.191
Stem girth (mm)	G							-0.241	-0.038	0.204	0.141	-0.177	-0.108	-0.112	0.404
Leaf stem ratio	G								0.246	0.327	0.39	0.316	0.303	-0.138	0.073
Green fodder yield/ plant /day (g)	G									0.831	0.457	0.694	0.74	-0.492	0.674
Dry matter yield/plant(g)	G										0.731	0.837	0.886	-0.271	0.837
Dry matter yield/plant /day (g)	G											0.598	0.655	-0.382	0.704
Crude protein yield/ plant (g)	G												0.945	-0.293	0.568
Crude protein yield/ plant /day (g)	G													-0.334	0.673
Brix value (%)	G														-0.261

Table 4.5: Estimates of phenotypic correlation coefficients among yield and its attributing traits in fodder Maize (*Kharif 2018*)

Characters		Days to 50% silking	Plant height (cm)	No. of leaves /plant	Leaf area (cm ²)	Internod al length (cm)	Stem girth (mm)	Leaf stem ratio	GFY/pla nt /day (g)	DMY/ plant (g)	DMY /plant /day (g)	CPY/ plant (g)	CPY /plant /day (g)	Brix value (%)	GFY / plant (g)
Days to 50% tasselling	P	0.674**	-0.071	0.033	0.181	0.055	-0.136	0.173	0.043	-0.047	-0.074	-0.011	-0.004	0.153	-0.002
Days to 50% silking	P		-0.046	0.065	0.125	0.07	-0.041	0.064	0.066	-0.053	-0.054	0.004	0.007	0.078	0.007
Plant height (cm)	P			0.117	0.04	0.630**	-0.265*	0.165	0.405**	0.310**	0.293**	0.389**	0.400**	-0.458**	0.086
No. of leaves/ plant	P				0.048	0.238*	0.037	-0.219*	-0.109	-0.276**	-0.259*	-0.233*	-0.222*	0.066	-0.153
Leaf area (cm ²)	P					0.206*	-0.187	0.18	0.032	-0.063	0.189	0.017	0.011	0.069	-0.071
Internodal length (cm)	P						-0.327**	0.117	0.177	-0.022	0.058	0.205*	0.177	-0.207*	-0.096
Stem girth (mm)	P							-0.203	-0.067	0.104	0.122	-0.173	-0.103	-0.006	0.254*
Leaf stem ratio	P								0.243*	0.229*	0.286**	0.249*	0.230*	-0.079	0.064
Green fodder yield/ plant /day (g)	P									0.672**	0.371**	0.578**	0.566**	-0.378**	0.612**
Dry matter yield/plant(g)	P										0.692**	0.790**	0.831**	-0.240*	0.693**
Dry matter yield/plant /day (g)	P											0.576**	0.603**	-0.307**	0.529**
Crude protein yield/ plant (g)	P												0.939**	-0.291**	0.510**
Crude protein yield/ plant /day (g)	P													-0.275**	0.542**
Brix value (%)	P														-0.231*

Significant at 5% level = *

Significant at 1% level = **

4.3.1.4 Number of leaves per plant

Number of leaves per plant is significant and positive correlation with inter nodal length (0.238). While, it also exhibit highly significant and negative correlation with dry matter yield per plant (-0.276) followed by significant negative correlation dry matter yield per plant per day (-0.259), crude protein yield per plant (-0.233), crude protein yield per plant per day (-0.222) and leaf stem ratio (-0.219).

4.3.1.5 Leaf area (cm²)

Leaf area had positive correlation and significantly correlation with inter nodal length (0.206).

4.3.1.6 Inter nodal length (cm)

Result showed that inter nodal length was highly significant and negative correlation with stem girth (-0.327) followed by significantly negative correlation with brix's value (-0.207). However, it had significant and positive correlation with crude protein yield per plant (0.205).

4.3.1.7 Stem girth (mm)

Stem girth was significant and positive correlation with green fodder yield per plant (0.254).

4.3.1.8 Leaf stem ratio

Leaf stem ratio was highly significant and positive correlation with dry matter yield per plant per day (0.286) followed by significant positive correlation with crude protein yield per plant (0.249), green fodder yield per plant per day (0.243), crude protein yield per plant per day (0.230) and dry matter yield per plant (0.229).

4.3.1.9 Green fodder yield per plant per day (g)

Green fodder yield per plant per day had highly significant and positive correlation with dry matter yield per plant (0.672) followed by green fodder yield per plant (0.612), crude protein yield per plant (0.578), crude protein yield per

plant per day (0.566) and dry matter yield per plant per day (0.371). It was also observed that fodder yield had highly significant and negative association with brix's value (-0.378).

4.3.1.10 Dry matter yield per plant (g)

Dry matter yield per plant had very high significant and positive correlation with crude protein yield per plant per day (0.831) followed by crude protein yield per plant (0.790), green fodder yield per plant (0.693) and dry matter yield per plant per day (0.692). Also observed that the dry matter yield per plant had significant and negative correlation with brix's value (-0.240).

4.3.1.11 Dry matter yield per plant per day (g)

Highly significant and positive correlation of dry matter yield per plant per day with crude protein yield per plant per day (0.603), crude protein yield per plant (0.576), green fodder yield per plant (0.529) and had highly significant and negative association with brix's value (-0.307).

4.3.1.12 Crude protein yield per plant (g)

Crude protein yield per plant was very highly significant and positive correlation with crude protein yield per plant per day (0.939), green fodder yield per plant (0.510). However, there was highly significant negative correlation associated with brix's value (-0.291).

4.3.1.13 Crude protein yield per plant per day (g)

Crude protein yield per plant per day was highly significant and positive correlation with green fodder yield per plant (0.542). It also showed highly significant negative correlation with brix's value (-0.275).

4.3.1.14 Brix's value (%)

Brix's value was significant and negative correlation with green fodder yield per plant (-0.231).

4.3.2 Path coefficient analysis

Path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlation (Wright, 1921). Hence, this important objective was undertaken in the present investigation. Based on the data recorded on the genotype in the present investigation, the phenotypic and genotypic correlation were estimated to determine direct effect and indirect effect of yield and yield contributing characters Table 4.6 and 4.7.

Direct effect

In the present study, path coefficient analysis was carried out using green fodder yield per plant as a dependent variable. Result revealed that high positive direct effect on green fodder yield per plant was exerted by crude protein yield per plant per day (0.589) followed by days to 50 per cent tasseling (0.421), stem girth (0.413), green fodder yield per plant per day (0.317) and dry matter yield per plant per day (0.312). Low positive direct effect exerted by leaf area (0.174) and dry matter yield per plant (0.172).

High negative direct effect exerted by crude protein yield per plant (-0.369), days to 50 per cent silking (-0.304). Moderate negative effect exerted by leaf stem ratio (-0.262). While other traits exerting negligible effect were plant height (-0.079), number of leaves per plant (-0.065), inter nodal length (-0.006).

Indirect effect

4.3.2.1 Days to 50 per cent tasseling

Days to 50 per cent tasseling imparted low positive indirect effect on green fodder yield per plant via leaf area (0.039). Whereas, low negative indirect effect on green fodder yield per plant via days to 50 per cent silking (-0.288) and low negative indirect effect on green fodder yield per plant via stem girth (-0.144). While, other imparted negligible indirect effect on green fodder yield per plant via all the traits irrespective of the sign.

Table 4.6: Genotypic path coefficients showing direct and indirect effects of different characters on green fodder yield per plant (g) in fodder Maize (Kharif 2018)

Characters	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	No. of leaves /plant	Leaf area (cm ²)	Internodal length (cm)	Stem girth (mm)	Leaf stem ratio	GFY/ plant /day (g)	DMY/ plant (g)	DMY/ plant /day (g)	CPY/ plant (g)	CPY/plant /day (g)	Brix value (%)	"r" value GFY/ plant (g)
Days to 50% tasselling	0.421	-0.288	0.008	-0.005	0.039	0.000	-0.144	-0.063	-0.013	-0.025	-0.043	0.007	-0.020	0.001	-0.126
Days to 50% silking	0.399	-0.304	-0.001	-0.015	0.060	-0.001	-0.069	-0.016	-0.008	-0.025	-0.036	0.012	-0.006	0.000	-0.010
Plant height (cm)	-0.041	-0.003	-0.079	-0.009	0.002	-0.004	-0.104	-0.075	0.161	0.063	0.112	-0.181	0.285	-0.003	0.124
No. of leaves/plant	0.032	-0.069	-0.011	-0.065	0.019	-0.002	0.026	0.057	-0.039	-0.066	-0.105	0.108	-0.182	0.001	-0.296
Leaf area (cm ²)	0.094	-0.105	-0.001	-0.007	0.174	-0.002	-0.149	-0.065	0.033	-0.016	0.058	-0.016	-0.004	0.001	-0.004
Internodal length (cm)	0.008	-0.026	-0.057	-0.018	0.047	-0.006	-0.159	-0.041	0.048	-0.013	0.002	-0.076	0.102	-0.002	-0.191
Stem girth (mm)	-0.147	0.051	0.020	-0.004	-0.063	0.002	0.413	0.063	-0.012	0.035	0.044	0.065	-0.063	-0.001	0.404
Leaf stem ratio	0.102	-0.019	-0.023	0.014	0.043	-0.001	-0.100	-0.262	0.078	0.056	0.122	-0.117	0.179	-0.001	0.073
GFY/ plant /day (g)	-0.018	0.008	-0.040	0.008	0.018	-0.001	-0.016	-0.064	0.317	0.143	0.142	-0.256	0.436	-0.003	0.674
DMY/ plant (g)	-0.061	0.044	-0.029	0.025	-0.016	0.000	0.084	-0.085	0.264	0.172	0.228	-0.309	0.522	-0.002	0.837
DMY/ plant /day(g)	-0.058	0.035	-0.028	0.022	0.033	0.000	0.058	-0.102	0.145	0.126	0.312	-0.221	0.386	-0.002	0.704
CPY/ plant (g)	-0.008	0.010	-0.039	0.019	0.007	-0.001	-0.073	-0.083	0.220	0.144	0.186	-0.369	0.557	-0.002	0.568
CPY/plant /day (g)	-0.015	0.003	-0.038	0.020	-0.001	-0.001	-0.044	-0.079	0.235	0.152	0.204	-0.349	0.589	-0.002	0.673
Brix value (%)	0.091	0.011	0.042	-0.010	0.018	0.002	-0.046	0.036	-0.156	-0.047	-0.119	0.108	-0.197	0.006	-0.261

Residual effect Genotypic = -0.8627

Table 4.7: Phenotypic path coefficients showing direct and indirect effects of different characters on green fodder yield per plant (g) in fodder Maize (Kharif 2018)

Characters	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	No. of leaves /plant	Leaf area (cm ²)	Internodal length (cm)	Stem girth (mm)	Leaf stem ratio	GFY/ plant /day (g)	DMY/ plant (g)	DMY/ plant /day (g)	CPY/ plant (g)	CPY/plant /day (g)	Brix value (%)	"r" value GFY/ plant (g)
Days to 50% tasselling	0.069	-0.021	0.016	0.001	-0.013	0.001	-0.019	-0.019	0.019	-0.012	-0.018	0.001	0.000	-0.005	-0.002
Days to 50% silking	0.046	-0.032	0.011	0.003	-0.009	0.001	-0.006	-0.007	0.028	-0.014	-0.014	0.000	0.001	-0.002	0.007
Plant height (cm)	-0.005	0.001	-0.233	0.005	-0.003	0.007	-0.037	-0.018	0.176	0.081	0.073	-0.021	0.044	0.014	0.086
No. of leaves/plant	0.002	-0.002	-0.027	0.045	-0.004	0.003	0.005	0.024	-0.047	-0.073	-0.065	0.012	-0.025	-0.002	-0.153
Leaf area (cm ²)	0.013	-0.004	-0.009	0.002	-0.073	0.002	-0.026	-0.020	0.014	-0.017	0.048	-0.001	0.001	-0.002	-0.071
Internodal length (cm)	0.004	-0.002	-0.147	0.011	-0.015	0.012	-0.046	-0.013	0.077	-0.006	0.015	-0.011	0.020	0.006	-0.096
Stem girth (mm)	-0.009	0.001	0.062	0.002	0.014	-0.004	0.140	0.022	-0.029	0.027	0.031	0.009	-0.011	0.000	0.254
Leaf stem ratio	0.012	-0.002	-0.039	-0.010	-0.013	0.001	-0.028	-0.109	0.105	0.060	0.072	-0.013	0.025	0.002	0.064
GFY/ plant /day (g)	0.003	-0.002	-0.094	-0.005	-0.002	0.002	-0.009	-0.027	0.434	0.177	0.093	-0.031	0.063	0.011	0.612
DMY/ plant (g)	-0.003	0.002	-0.072	-0.012	0.005	0.000	0.015	-0.025	0.292	0.263	0.174	-0.042	0.092	0.007	0.693
DMY/ plant /day(g)	-0.005	0.002	-0.068	-0.012	-0.014	0.001	0.017	-0.031	0.161	0.182	0.251	-0.031	0.067	0.009	0.529
CPY/ plant (g)	-0.001	0.000	-0.091	-0.010	-0.001	0.002	-0.024	-0.027	0.251	0.208	0.145	-0.053	0.104	0.009	0.510
CPY/plant /day (g)	0.000	0.000	-0.093	-0.010	-0.001	0.002	-0.014	-0.025	0.245	0.219	0.151	-0.050	0.110	0.008	0.542
Brix value (%)	0.011	-0.002	0.107	0.003	-0.005	-0.002	-0.001	0.009	-0.164	-0.063	-0.077	0.015	-0.030	-0.030	-0.231

Residual effect Phenotypic = -0.48

4.3.2.2 Days to 50 per cent silking

Days to 50 per cent silking imparted high positive indirect effect on green fodder yield per plant via days to 50 per cent tasseling (0.399) and leaf area (0.060) and negligible indirect effect on green fodder yield per plant via all the traits irrespective of the sign.

4.3.2.3 Plant height (cm)

Plant height imparted moderate positive indirect effect on green fodder yield per plant via crude protein yield per plant per day (0.285) and low positive indirect effect on green fodder yield per plant via green fodder yield per plant per day (0.161), dry matter yield per plant per day (0.112). Plant height had low negative indirect effect on green fodder yield per plant via crude protein yield per plant (-0.181), stem girth (-0.104). Remaining traits imparted their negligible magnitude.

4.3.2.4 Number of leaves per plant

Number of leaves per plant imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant (0.108) and low negative indirect effect on green fodder yield per plant via crude protein yield per plant per day (-0.182), dry matter yield per plant per day (-0.105). While, other had negligible indirect effect on green fodder yield per plant via all the traits with irrespective of the sign.

4.3.2.5 Leaf area (cm²)

Leaf area imparted low positive indirect effect on green fodder yield per plant via days to 50 per cent tasseling (0.094), dry matter yield per plant per day (0.058) and green fodder yield per plant per day (0.033). Whereas, low negative indirect effect on green fodder yield per plant via stem girth, days to 50 per cent silking. However, its other indirect effects, for either of the sign, manifested via other characters on green fodder yield per plant, were found to be negligible.

4.3.2.6 Inter nodal length (cm)

Inter nodal length imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant per day (0.102) and low negative indirect effect on green fodder yield per plant via stem girth (-0.159). While other imparted negligible indirect effect on green fodder yield per plant via all the traits irrespective of the sign.

4.3.2.7 Stem girth (mm)

Stem girth imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant (0.065), leaf stem ratio (0.063), days to 50 per cent silking (0.051), dry matter yield per plant per day (0.044), dry matter yield per plant (0.35). It also imparted low negative indirect effect on green fodder yield per plant via days to 50 per cent tasseling and negligible indirect effect on green fodder yield per plant via all the traits irrespective of the sign.

4.3.2.8 Leaf stem ratio

Leaf stem ratio imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant per day (0.179), dry matter yield per plant per day (0.122), days to 50 per cent tasseling (0.102) and negative indirect effect on green fodder yield per plant via crude protein yield per plant (-0.117), stem girth (-0.100). Remaining traits had negligible magnitude.

4.3.2.9 Green fodder yield per plant per day (g)

Green fodder yield per plant per day imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day (0.436) and low positive indirect effect on green fodder yield per plant via dry matter yield per plant (0.143), dry matter yield per plant per day (0.142). Green fodder yield per plant per day imparted moderate negative indirect effect on green fodder yield per plant via crude protein yield per plant (-0.256). Remaining all the traits showed negligible magnitude on green fodder yield per plant irrespective of the sign.

4.3.2.10 Dry matter yield per plant (g)

Dry matter yield per plant imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day (0.522) and moderate indirect effect on green fodder yield per plant via green fodder yield per plant per day (0.264), dry matter yield per plant per day (0.228). Dry matter yield per plant imparted highly negative indirect effect on green fodder yield per plant via crude protein yield per plant (-0.309). While, other characters showed their negligible indirect effect on green fodder yield per plant via all the traits irrespective of the sign.

4.3.2.11 Dry matter yield per plant per day (g)

Dry matter yield per plant per day imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day (0.386) and low positive indirect effect on green fodder yield per plant via green fodder yield per plant per day (0.145), dry matter yield per plant (0.126). Dry matter yield per plant per day imparted moderate negative indirect effect on green fodder yield per plant via crude protein yield per plant (-0.221) and low negative indirect effect on green fodder yield per plant via leaf stem ratio (-0.102). While other showed negligible indirect effect on green fodder yield per plant via all the traits irrespective of the sign.

4.3.2.12 Crude protein yield per plant (g)

Crude protein yield per plant imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day (0.557) and moderate positive indirect effect on green fodder yield per plant via green fodder yield per plant per day (0.220). Crude protein yield per plant imparted low positive indirect effect on green fodder yield per plant via dry matter yield per plant per day (0.186), dry matter yield per plant (0.144). While other negligible indirect effect on green fodder yield per plant via all the traits irrespective of the sign.

4.3.2.13 Crude protein yield per plant per day (g)

Crude protein yield per plant per day imparted highly negative indirect effect on green fodder yield per plant via crude protein yield per plant (-349). The moderate positive indirect effect on green fodder yield per plant via green fodder yield per plant per day (0.235), dry matter yield per plant per day (0.204) and low positive indirect effect on green fodder yield per plant via dry matter yield per plant (0.152). Crude protein yield per plant per day imparted negligible indirect effect on green fodder yield per plant via all the traits with irrespective sign.

4.3.2.14 Brix's value per cent

Brix's value imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant, days to 50 per cent tasseling (0.091), leaf stem ratio (0.036) and low negative indirect effect on green fodder yield per plant via crude protein yield per plant per day, green fodder yield per plant per day, dry matter yield per plant per day. Other indirect effect imparted negligible magnitude on green fodder yield per plant via all the traits irrespective of the sign.

4.4 Principal component analysis

Principal Component Analysis is a well-known method of dimension reduction that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set (Massay, 1965; Jolliffe, 1986). It is a mathematical procedure that transforms a number of (possibly) correlation variables into a (smaller) number of un correlation variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

The objective of Principal Component Analysis is to identify the minimum number of components, which can explain maximum variability out of the total variability and also to rank genotypes on the basis of PC scores. Principal

Components Analysis was performed using yield and quality attributing traits in maize genotypes include two checks. Out of fifteen, only 8 Principal Components (PCs) exhibited more than 0.5 eigen value and showed about 94.496% variability among the traits studied. The PC-1 accounted for 34.165% of total variability, whereas, PC-2, PC-3, PC-4, PC-5, PC-6, PC-7 and PC-8 exhibited 16.393%, 12.324%, 8.501%, 6.430%, 5.940%, 4.562% and 3.601% respectively for the traits under study (Table 4.8).

**Table 4.8 Eigen values, variability and cumulative percentage of fodder
Maize genotypes (Kharif 2018)**

Traits	Principal component	Eigen values	% of variance	Cumulative %
Days to 50% tasseling	PC 1	5.125	34.165	34.165
Days to 50% silking	PC 2	2.459	16.393	50.558
Plant height (cm)	PC 3	1.849	12.324	62.882
Number of leaves/plant	PC 4	1.275	8.501	71.383
Leaf area (cm)	PC 5	0.965	6.430	77.814
Stem girth (mm)	PC 6	0.891	5.940	83.754
Inter nodal length (cm)	PC 7	0.684	4.562	88.316
Leaf stem ratio	PC 8	0.540	3.601	91.917
Green fodder yield/plant	PC 9	0.387	2.579	94.496
Green fodder yield/plant/day	PC 10	0.306	2.037	96.533
Dry matter yield/plant	PC 11	0.224	1.494	98.027
Dry matter yield/plant/day	PC 12	0.148	0.989	99.016
Crude protein yield/plant	PC 13	0.103	0.685	99.701
Crude protein yield/plant/day	PC 14	0.031	0.206	99.907
Brix's value	PC 15	0.014	0.093	100.000

Scree plot graph depicted in Figure 1 explains the percentage of variance associated with each principal component obtained by drawing a graph between Eigen values and principal component numbers. PC1 showed 34.165% variability with Eigen value 5.12 and latter declined gradually. Semi

curve line is obtained after two PC, tended to become straight with little variance observed in each PC. From the graph, it is clear that the maximum variation was observed in PC1 as compared to other PCs. Hence, selection from these PCs will be rewarding.

Rotated component matrix presented in table 4.9 and 4.10 revealed that the PC1 accounted for the highest variation (34.165%) and was mostly related with traits such as plant height, green fodder yield per plant, green fodder yield per plant per day, dry matter yield per plant, dry matter yield plant per day, crude protein yield per plant and brix's value.

PC2 dominated with days to 50 per cent tasseling, days to 50 per cent silking, inter nodal length. PC3 dominated with leaf area. PC4 dominated with number of leaves per plant. PC5 dominated with stem girth. PC6 dominated with crude protein per plant per day. PC7 dominated with leaf stem ratio.

On the basis of PCA, most of the important yield and yield attributing traits were present in PC1, PC2, PC3, PC4, PC5, PC6 and PC7. Rotated component matrix revealed that these seven PCs are representing maximum variability (91.917%). Hence, the traits falling to these seven PCs may be given due weightage in maize improvement programme.

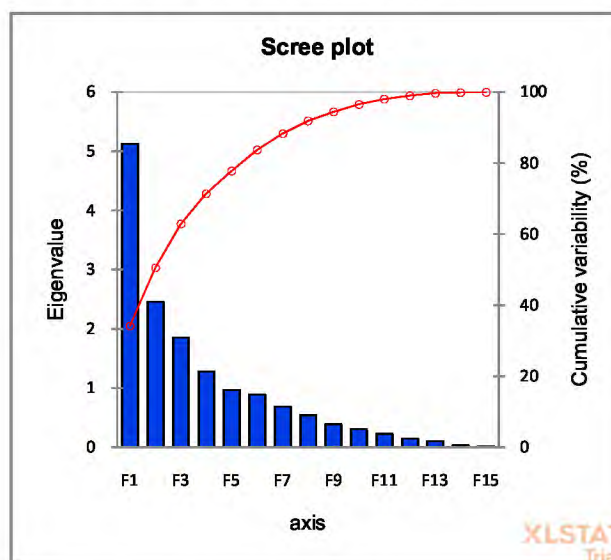


Figure1. Scree plot graph

**Table 4.9 Rotated component matrix for different traits of fodder maize
(Kharif 2018)**

Characters	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
DFT	-0.086	0.686	-0.592	0.202	-0.213	-0.063	0.050
DFS	-0.059	0.601	-0.495	0.442	-0.117	-0.128	-0.098
PH	0.555	0.455	-0.552	0.144	-0.088	-0.081	0.107
NLPP	-0.325	0.302	-0.280	0.572	0.277	0.316	0.329
SG	0.045	-0.506	0.191	-0.208	0.736	0.034	-0.289
INL	0.196	0.673	-0.539	0.083	0.063	0.056	0.016
LA	-0.014	-0.090	0.669	0.498	0.249	-0.225	0.235
LSR	0.394	0.356	0.192	-0.426	0.058	-0.373	0.551
GFYPP	0.808	0.066	-0.002	0.201	-0.025	0.076	-0.085
GFYPD	0.921	-0.230	0.159	0.021	-0.019	0.136	0.108
DMYPP	0.770	-0.116	0.103	-0.098	0.357	-0.196	0.041
DMYPD	0.890	0.088	0.039	-0.097	-0.152	0.275	-0.023
CPYPP	0.918	0.036	0.064	-0.040	-0.136	0.247	-0.009
CPYPD	-0.488	-0.041	0.382	-0.274	0.105	0.604	0.290
BV	0.733	-0.352	0.273	0.274	0.168	0.073	-0.066

PC scores of fodder Maize genotypes

In 31 genotypes of fodder maize, high Principal Component scores (PC score) for all the traits were estimated in these seven components and are presented in Table 4.11. These scores can be utilized to propose precise selection indices whose intensity can be decided by variability explained by each of principal component. High PC score for a particular line in a particular component denotes high values for the variables in that particular genotype.

Table 4.10 Interpretation of rotated component matrix for the traits having highest value in each PC (*kharif* 2018)

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
C H A R E C T R S	Plant height	Days to 50% tasseling	Leaf area	Number of leaves per plant	Stem girth	Crude protein yield per plant per day	Leaf stem ratio
	Green fodder yield per plant	Days to 50% silking					
	Green fodder yield per plant per day	Inter nodal length					
	Dry matter yield per plant						
	Dry matter yield per plant per day						
	Crude protein yield per plant						
	Brix's value						

In Table 4.12 list of selected genotypes are categorized. Where, high PC1 score obtained in genotypes Sugar-75 (4.438) was followed by DFH-8 (3.615), ADV-759 (2.900), TSFM-16-10 (2.882), JM-216 (2.691), Jawahar baby corn-1 (2.470), ADV-6781 (2.453), Bioseed-9544 (2.009), African Tall (1.713), JM-218 (1.571) and Star-111 (1.538) indicate that these genotypes possess high value of trait for plant height, green fodder yield per plant, green fodder yield per plant per day, dry matter yield per plant, dry matter yield plant per day, crude protein yield per plant and brix's value.

High PC2 scores obtained in African Tall (3.436) followed by IMHBG-18KF2 (2.517), BAI Fmaize-6 (1.863), Jawahar baby corn-1 (1.527), Sugar-75 (1.450), AH-8071R (1.267), ADV-759 (1.262) and J-1006 (1.108) indicate that these genotypes possess high value of trait for days to 50 per cent tasseling, days to 50 per cent silking, stem girth and inter nodal length.

High PC3 scores obtained in Jawahar baby corn-1 (3.028) followed by IMHBG-18KF2 (2.290), Bioseed-9544 (1.842), AH-8071R (1.705) and ADV-759 (1.452) indicate that these genotypes possess high value of trait for days to 50 per cent tasseling and days to 50 per cent silking.

High PC4 scores obtained in DFH-8 (2.276) followed by ADV-6781 (1.840), PFM-10 (1.670), PFM-9 (1.396), BAI Fmaize-6 (1.268), African Tall (1.249) and IMHBG-18KF1 (1.073) indicate that these genotypes possess high value of trait for number of leaves per plant.

High PC5 scores obtained in MF-2018 (1.959) followed by PFM-10 (1.436), PAC-745 (1.349), JM-216 (1.323), AH-8070 (1.293), BAI Fmaize-6 (1.221) and Star-111 (1.074) indicate that these genotypes possess high value of trait for stem girth.

High PC6 scores obtained in HPFM-9 (1.776) followed by JM-218 (1.609), SCH-201 (1.526), VMH-45 (1.210) and AH-8070 (1.127) indicates that this genotype possess high value of traits for crude protein yield per plant per day.

High PC7 scores obtained in Star-111 (1.510) followed by J-1006 (1.258), MF-2018 (1.072) and AH-8070 (1.047) indicate that these genotypes possess high value of trait for leaf stem ratio.

Table 4.11 Principal component scores for fodder maize genotypes (*kharif* 2018)

Genotypes	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
TNFM 131-9	-1.146	0.361	-1.067	0.219	0.029	-0.661	-1.475
PFM-9	-2.145	0.438	-0.945	1.396	0.467	0.365	-0.837
VMH-45	-3.130	0.480	0.891	0.121	0.217	1.210	-1.172
PFM-10	-1.542	-0.699	-0.795	1.670	1.436	-0.616	0.016
HPFM-9	0.317	0.587	-1.376	0.997	-2.273	1.776	-0.222
DFH-8	3.615	-2.272	0.925	2.276	-1.388	0.553	0.174
ADV-6781	2.453	-1.560	-1.968	1.840	-0.265	0.936	0.408
AFH-6	-3.494	-0.198	0.880	0.829	-1.509	-1.265	0.880
IMHBG-18KF1	-1.176	-1.993	-1.238	1.073	-0.173	-0.722	0.731
BAIF,maize-6	-1.224	1.863	-1.157	1.268	1.221	-1.429	-0.473
COHM-6	0.933	0.121	-0.990	-1.039	-0.552	-1.246	0.477
AH-8071 R	-0.743	1.267	1.705	0.537	-0.123	-1.067	0.042
MF-2018	0.514	-2.267	0.273	0.242	1.959	0.183	1.072
Star-111	1.538	0.876	0.600	0.130	1.074	0.997	1.510
TSFM-16-10	2.882	0.847	-2.930	-2.151	-0.208	-0.937	-0.285
SCH-201	-2.966	0.416	0.775	-0.558	-0.416	1.526	0.759
AH-8070	-0.005	0.494	0.754	0.085	1.293	1.127	1.047
IMHBG-18KF2	-2.661	2.517	2.290	0.245	-0.770	-0.033	0.613
CMVLBC-2	-3.024	-1.060	0.612	-1.642	-1.027	-0.469	0.285
KDFM-3	-3.459	0.077	-1.866	-2.054	0.665	0.644	0.313
Bioseed-9544	2.009	-0.422	1.842	-0.648	0.759	-1.023	0.155
ADV-759	2.900	1.262	1.452	-0.963	-0.915	-0.460	0.402
PAC-745	0.263	-0.978	0.241	-0.408	1.349	0.212	-0.881
ADV-9293	-2.022	-1.220	0.461	-1.184	0.029	0.870	-1.484
JM-216	2.691	-0.734	0.279	-0.428	1.323	-0.369	0.100
JM-218	1.571	-1.271	-0.209	-0.983	-0.138	1.609	-1.167
Jawahar pop corn-11	-0.122	-4.450	0.721	-0.617	-1.219	-1.517	-0.522
Sugar-75	4.438	1.450	-0.090	-1.415	-0.606	0.561	0.432
Jawahar baby corn-1	2.470	1.527	3.028	0.375	0.452	-0.090	-1.478
J-1006 (C)	-1.450	1.108	-1.470	-0.462	-0.227	0.021	1.258
African Tall (C)	1.713	3.436	-1.628	1.249	-0.465	-0.688	-0.675

Table 4.12 List of fodder maize genotypes with >1 PC scores (*kharif* 2018)

Genotypes	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
TNFM 131-9							
PFM-9				1.396			
VMH-45						1.210	
PFM-10				1.670	1.436		
HPFM-9						1.776	
DFH-8	3.615			2.276			
ADV-6781	2.453			1.840			
AFH-6							
IMHBG-18KF1				1.073			
BAIF,maize-6		1.863		1.268	1.221		
COHM-6							
AH-8071 R		1.267	1.705				
MF-2018					1.959		1.072
Star-111	1.538				1.074		1.510
TSFM-16-10	2.882						
SCH-201						1.526	
AH-8070					1.293	1.127	1.047
IMHBG-18KF2		2.517	2.298				
CMVLBC-2							
KDFM-3							
Bioseed-9544	2.009		1.842				
ADV-759	2.900	1.262	1.452				
PAC-745					1.349		
ADV-9293							
JM-216	2.691				1.323		
JM-218	1.571					1.609	
Jawahar pop corn-11							
Sugar-75	4.438	1.450					
Jawahar baby corn-1	2.470	1.527	3.028				
J-1006 (C)		1.108					1.258
African Tall (C)	1.713	3.436		1.249			



1 PC common



2 PC common



3 PC common

DISCUSSION

The experimental findings of present study “Genetic Analysis of Fodder Yield and its Components in Maize” have been carried out in 31 genotypes of maize and are discussed on following heads in the light of available literature.

5.1 Parameters of Genetic Variability

5.1.1 Genetic variability

5.1.2 Genotypic and Phenotypic coefficient of variation

5.1.3 Heritability and Genetic advance

5.2 Association analysis

5.2.1 Correlation Coefficient Analysis

5.2.2 Path Coefficient Analysis

5.3 Principal Component Analysis

5.1 Parameters of genetic variability

5.1.1 Genetic variability

Genetic variability is one of the most essential requirements for any crop improvement programme. The ultimate aim of plant breeder is to increase the yield potential of a crop, coupled with its desirable quality. A wide range of variation was observed for almost all the traits in the material under study.

Analysis of variance indicated that the mean sum of squares due to genotypes were highly significant for all the traits under study viz., days to 50 per cent tasseling, days to 50 per cent silking, plant height, number of leaves per plant, leaf area, stem girth, inter nodal length, leaf stem ratio, brix's value, crude protein yield per plant , crude protein yield per plant per day, dry matter yield per plant per day, green fodder yield per plant per day, dry matter yield per plant, green fodder yield per plant. It indicates that sufficient variability has present for most of the important characters among the genotypes. The

exploitation of the present variability helps in developing the potential and suitable genotypes in future.

The genotypes which showed high range of variation namely JM-218 (leaf area), DFH-1 (green fodder yield per plant), African Tall (plant height, inter nodal length), Sugar-75 (dry matter yield per plant, crude protein yield per plant, crude protein yield per plant per day, green fodder yield per plant per day), SCH-201 (brix's value), AH-8070 (number of leaves per plant), IMHBG-18KF1 (stem girth) and ADV-759 (leaf stem ratio). Whereas, the genotype IMHBG-18KF2 took more days to 50 per cent tasseling and days to 50 per cent silking.

Similar findings have been reported by Aminon *et al.* (2015) for days to 50% flowering and plant height.

Morphological trait, leaf colour was observed viz., dark green colour (DFH-8, Bioseed-9544, ADV-759, Jawahar pop corn-11 and Sugar-75), green colour (TNFM-131-9, PFM-9, PFM-10, AFH-6, IMHBG-18KF1, BAIF, maize-6, AH-8071R, Star-111, SCH-201, KDFM-3, PAC-745, ADV-9293, Jawahar baby corn-1, J-1006 and African Tall) and light green colour (VMH-45, HPFM-9, ADV-6781, COHM-6, MF-2018, TSFM-16-10, AH-8070, IMHBG-18KF2, CMVLBC-2, JM-216 and JM-218). White mid rib colour observed in almost all the genotypes except SCH-201 and IMHBG-18KF2 had brown mid rib colour which decreases the lignin content and improve digestibility. The results in agreement with A. Murigneux *et al.* (2008) for brown mid rib colour.

The analysis of variance estimates of various parameters for assessment of genetic variability viz., mean, range, GCV and PCV coefficient of variation, heritability and genetic advance (as % of mean) help the breeders in bringing improvement in quantitatively inherited traits, which directly affects the fodder yield and allied traits.

5.1.2 Genotypic and phenotypic coefficient of variation

The PCV was observed higher in magnitude than its corresponding GCV for all the characters under studied. However, the differences are narrow indicating little influence of environment on the expression of the characters.

Phenotypic coefficient of variation

High magnitude of PCV was observed in green fodder yield per plant per day, crude protein yield per plant per day, crude protein yield per plant, dry matter yield, green fodder yield per plant, dry matter yield per plant per day. Moderate magnitude of PCV was observed in brix's value, leaf area, number of leaves per plant inters nodal length. Whereas, low magnitude of PCV was observed in leaf stem ratio, stem girth, plant height, days to 50 per cent tasseling, days to 50 per cent silking.

Genotypic coefficient of variation

High magnitude of GCV was observed in crude protein yield per plant per day, crude protein yield per plant, green fodder yield per plant per day, dry matter yield per plant. Moderate magnitudes of GCV was observed in green fodder yield per plant, dry matter yield per plant per day, brix's value, number of leaves per plant and inter nodal length. Whereas, low magnitude of GCV was observed leaf area, stem girth, leaf stem ratio, plant height, days to 50 per cent tasseling, days to 50 per cent silking. This implies the importance of genetic variability in improvement through selection.

Similar findings have been observed by Bai and Rani (2000) and Srivas and Singh (2004) for green fodder yield, Kapoor *et al.* (2015) for plant height, leaf length, stem girth, dry matter yield and green fodder yield, Rana *et al.* (2016) for dry matter content and Ranjith *et al.* (2017) for high GCV for green fodder yield.

However, contradictory result was reported Malik *et al.* (2015) for inter node length, stem girth and protein content and Singh *et al.* (2016) for leaf area, plant height and leaf stem ratio.

5.1.3 Heritability in broad sense and genetic advance

The coefficient of variation reveals only the extent of variability existing for various characters but does not give any information regarding heritable portion of it. Heritability permits greater effectiveness of selection by separating out the environmental influence from the total variability and to indicate accuracy with which a genotype can be identified phenotypically. Heritability estimates along with the genetic advance are normally more helpful in predicting the genetic gain under selection than heritability estimates alone. However, it is not necessary that the character showing high heritability will also exhibit high genetic advance.

High or moderate heritability accompanied with high or moderate genetic advance indicate additive gene action involved in the inheritance of concerned traits and hence selection may be effective. And if high or moderate heritability coupled with low genetic advance or vice versa indicates predominance of non-additive gene action.

Dry matter yield per plant, crude protein yield and green fodder yield showed high heritability and PCV, these characters will be useful in the selection of meaningful genotypes. Similar results were also obtained by Rohman and Hussain (2003).

High magnitude of broad sense heritability observed in internodal length, number of leaves per plant, crude protein yield per plant, crude protein yield per plant per day, stem girth, dry matter yield per plant per day, plant height, brix's value, dry matter yield per plant. Moderate magnitude of heritability was observed in leaf stem ratio, leaf area, green fodder yield per plant per day and green fodder yield per plant. Low magnitude of heritability was observed in days to 50 per cent tasseling and days to 50 per cent silking.

High magnitude of genetic advance as percentage of mean was observed in crude protein yield per plant, crude protein yield per plant per day, dry matter yield per plant, green fodder yield per plant per day, dry matter yield per plant per day, green fodder yield per plant.

Moderate magnitude of genetic advance as percentage of mean was observed in inter nodal length, leaf area, stem girth, leaf stem ratio and plant height. Low magnitude of genetic advance as percentage of mean was observed in days to 50 per cent tasseling and days to 50 per cent silking.

High magnitude of broad sense heritability with high magnitude of genetic advance was exhibited by inter nodal length, number of leaves per plant, crude protein yield per plant, crude protein yield per plant per day, stem girth, dry matter yield per plant per day, plant height, brix's value, dry matter yield per plant, green fodder yield per plant per day, green fodder yield per plant. This indicates lesser influence of environment in expression of these characters and preponderance of additive gene action; hence their characters are amenable for direct selection.

These results are in agreement with finding of Singh *et al.* (2004) for stem girth, green fodder yield per plant per day, brix's value and crude protein yield. Warked *et al.* (2008) for dry matter yield, Jain *et al.* (2009) for plant height, Kapoor and Batra (2015) for number of leaves per plant.

Moderate magnitude of heritability with high magnitude of genetic advance was exhibited by leaf stem ratio, leaf area, brix's value, number of leaves per plant, green fodder yield per plant per day, green fodder yield per plant, crude protein yield per plant, crude protein yield per plant per day, dry matter yield per plant, dry matter yield per plant per day. This also indicates the presence of additive gene action and selection of these characters may be rewarding.

Moderate magnitude of heritability with low magnitude of genetic advance was exhibited by leaf stem ratio, leaf area, green fodder yield per plant per day, green fodder yield per plant, days to 50 per cent tasseling, days to 50 per cent silking. This indicates that non-additive gene action play major role in the inheritance of these characters and selection of these characters may not be effective.

Similar results are reported by Fekadu (2014) observed for the trait days to 50 per cent silking had low value of genetic advance as per cent of mean.

5.2 Association analysis

5.2.1 Correlation Coefficient Analysis

Yield is a complex quantitative character governed by number of genes and is highly influenced by environment. Hence, the selection of superior genotypes based on yield as such is not effective. For a rational approach towards improvement of yield, selection has to be made for the components of yield. Association of yield components and yield assumes special importance on the basis of indirect selection. Genetic correlation between different characters of plant often arises because of linkage or pleiotropy.

Analysis of correlation coefficient revealed that the degree of association between yield and its components given the mutual relationship between yield and its components. It helps in direct selection of associated characters for the improvement of desirable traits.

Most of the characters are associated with each other but the extent of correlation varies with different characters pairs. A positive or negative correlation between the desired characters is favorable to the breeder as it helps in selection. However, a negative correlation hinders the recovery of the recombinants in both characters. In such a situation any strong selection applied to a character also brings about change in other character.

Days to 50 per cent tasseling was highly significant and showed positive correlation with days to 50 per cent silking.

Days to 50 per cent silking showed no significant positive or negative association with other characters under study.

Plant height observed highly significant and positive correlation with internodal length, green fodder yield per plant per day, crude protein yield per plant per day, crude protein yield per plant, dry matter yield per plant and dry matter

yield per plant per day. Plant height was highly significant negative correlation with brix's value.

Number of leaves per plant had significant and positive correlation with inter nodal length. While, it showed highly significant and negative correlation with dry matter yield per plant followed by significant negative correlation dry matter yield per plant per day, crude protein yield per plant, crude protein yield per plant per day and leaf stem ratio.

Leaf area showed positive correlation and significant association with inter nodal length.

Inter nodal length showed highly significant and negative correlation with stem girth, significant negative association with brix's value, significant positive correlation with crude protein yield per plant.

Stem girth observed significant and positive association with green fodder yield per plant.

Leaf stem ratio had highly significant and positive correlation with dry matter yield per plant per day followed by significant positive correlation with crude protein yield per plant, green fodder yield per plant per day, crude protein yield per plant per day and dry matter yield per plant.

Green fodder yield per plant per day had highly significant and positive correlation with dry matter yield per plant, green fodder yield per plant, crude protein yield per plant, crude protein yield per plant per day and dry matter yield per plant per day. While, significant and negative association was observed with brix's value.

Dry matter yield per plant exhibited highly significant and positive correlation with crude protein yield per plant per day, crude protein yield per plant, green fodder yield per plant and dry matter yield per plant per day. It was also observed that dry matter yield per plant had significant negative correlation with brix's value.

Dry matter yield per plant per day had highly significant and positive correlation with crude protein yield per plant per day, crude protein yield per plant, green fodder yield per plant and highly significant negative association with brix's value.

Highly significant and positive correlation was observed for crude protein yield per plant with crude protein yield per plant per day, green fodder yield per plant and highly significant negative association with brix's value.

Crude protein yield per plant per day recorded highly significant and positive correlation with green fodder yield per plant. However, it had highly significant and showed negative correlation with brix's value.

Brix's value was significant and showed negative correlation with green fodder yield per plant.

These findings are in agreements with the results of Kumar and Kumar (1997) significant positive correlations were reported for plant height. Srivas and Singh (2004) for dry fodder yield per plant, green fodder yield. Patel *et al.* (2005) for green and dry matter. Borad *et al.* (2007) for stem girth and crude protein yield with green fodder as well as dry matter yields. Bhoite *et al.* (2007) for dry matter yield and crude protein yield. Icoz and Kara (2009) for green fodder yield and dry matter yield. Prakash *et al.* (2014) for crude protein yield, plant height, stem girth and number of leaf per plant. Vendruscolo *et al.* (2016) for dry matter yield per plant and green fodder yield per plant per day.

However, contradictory result was reported by Srivas and Singh (2004) for days to 50 per cent silking.

5.2.2 Path coefficient analysis

In the present study, path coefficient analysis was carried out using green fodder yield per plant as a dependent variable. The genotypic path coefficient analysis of different traits on green fodder yield per plant revealed that high positive direct effect on green fodder yield per plant was exerted by crude protein yield per plant per day, days to 50 per cent tasseling, stem girth,

green fodder yield per plant per day, dry matter yield per plant per day. Low positive direct effect exerted by leaf area, dry matter yield per plant. Whereas, negligible positive direct effect was exhibited by brix's value.

On the other hand, highly negative direct effect exerted by crude protein yield per plant and days to 50 per cent silking. Moderate negative effect exerted by leaf stem ratio. The traits showed their negligible effect are plant height, number of leaves per plant, inter nodal length. This indicates that, the indirect effect seems to be cause of correlation and indirect casual effects are to be considered simultaneously for selection.

Days to 50 per cent tasseling imparted low positive indirect effect on green fodder yield per plant via leaf area. Whereas, low negative indirect effect on green fodder yield per plant via days to 50 per cent silking and low negative indirect effect on green fodder yield per plant via stem girth.

Days to 50 per cent silking imparted high positive indirect effect on green fodder yield per plant via days to 50 per cent tasseling, leaf area.

Plant height imparted moderate positive indirect effect on green fodder yield per plant via crude protein yield per plant per day and low positive indirect effect on green fodder yield per plant via green fodder yield per plant per day, dry matter yield per plant per day. Plant height had low negative indirect effect on green fodder yield per plant via crude protein yield per plant and stem girth.

Number of leaves per plant imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant and low negative indirect effect on green fodder yield per plant via crude protein yield per plant per day and dry matter yield per plant per day.

Leaf area imparted low positive indirect effect on green fodder yield per plant via days to 50 per cent tasseling, dry matter yield per plant per day and green fodder yield per plant per day. Whereas, low negative indirect effect on green fodder yield per plant via stem girth and days to 50 per cent silking.

Inter nodal length imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant per day and low negative indirect effect on green fodder yield per plant via stem girth.

Stem girth imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant followed by leaf stem ratio, days to 50 per cent silking, dry matter yield per plant per day and dry matter yield per plant. However, it also imparted low negative indirect effect on green fodder yield per plant via days to 50 per cent tasseling.

Leaf stem ratio imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant per day, dry matter yield per plant per day, days to 50 per cent tasseling and negative indirect effect on green fodder yield per plant via crude protein yield per plant, stem girth.

Green fodder yield per plant per day imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day and low positive indirect effect on green fodder yield per plant via dry matter yield per plant, dry matter yield per plant per day. Green fodder yield per plant per day imparted moderate negative indirect effect on green fodder yield per plant via crude protein yield per plant.

Dry matter yield per plant imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day and moderate indirect effect on green fodder yield per plant via green fodder yield per plant per day and dry matter yield per plant per day. Dry matter yield per plant imparted highly negative indirect effect on green fodder yield per plant via crude protein yield per plant.

Dry matter yield per plant per day imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day and low positive indirect effect on green fodder yield per plant via green fodder yield per plant per day and dry matter yield per plant. Dry matter yield per plant per day imparted moderate negative indirect effect on green fodder yield per plant via

crude protein yield per plant and low negative indirect effect on green fodder yield per plant via leaf stem ratio.

Crude protein yield per plant imparted highly positive indirect effect on green fodder yield per plant via crude protein yield per plant per day and moderate positive indirect effect on green fodder yield per plant via green fodder yield per plant per day. Crude protein yield per plant imparted low positive indirect effect on green fodder yield per plant via dry matter yield per plant per day, dry matter yield per plant.

Crude protein yield per plant per day imparted highly negative indirect effect on green fodder yield per plant via crude protein yield per plant. The moderate positive indirect effect on green fodder yield per plant via green fodder yield per plant per day, dry matter yield per plant per day and low positive indirect effect on green fodder yield per plant via dry matter yield per plant.

Brix's value imparted low positive indirect effect on green fodder yield per plant via crude protein yield per plant followed by days to 50 per cent tasseling, leaf stem ratio and low negative indirect effect on green fodder yield per plant via crude protein yield per plant per day, green fodder yield per plant per day and dry matter yield per plant per day.

These findings are in agreements with the results of Kumar and Singh (2004) for days to 50 per cent silking, Bini and Bai (2005) for leaf area index. Shelake *et al.* (2005) for days to 50 per cent tasseling, Patel *et al.* (2005) for dry matter yield per plant, Bhoite *et al.* (2007) for dry matter yield. Jain and Patel (2012) for leaf area, number of leaves per plant, days to 50 per cent flowering and plant height, Jain and Patel (2013) for green fodder yield per plant and dry matter yield, Sadish *et al.* (2014) for plant height and sugar with days to 50 per cent silking and tasseling and Singh *et al.* (2016) for leaf area had direct effect on fodder yield

While, its negative direct effects were observed by Borad *et al.* (2007) for plant height, inter nodal length and leaf stem ratio.

On the basis of correlation and path coefficient analysis it is revealed that stem girth, green fodder yield per plant per day, dry matter yield per plant per day and crude protein yield per plant per day had significant correlation and higher direct effect. This indicated that these characters will enhance the effectiveness of selection for higher fodder yield in Maize.

However, contradictory result was reported by Kumar and Singh (2004) for days to 50 per cent silking, Srivas and Singh (2004) for plant height, leaf area and number of leaves per plant, Borad *et al.* (2007) for inter nodal length and leaf stem ratio, Sadish *et al.* (2014) for sugar content. While, Shelake *et al.* (2005) observed that crude protein yield had highest negative direct effect.

5.3 Principal Component Analysis

Principal Component Analysis (PCA) is important for the reflection of the highest contributor to the total variation at each axis of differentiation. It is basically a data reduction technique, offers solution to the complex problem of large and unmanageable data by transforming the original set of variables into a smaller set of linear combinations that account for most of the variability of the original set. This technique is an ordination method often used to simultaneously describe the relationships between sets of variables. It tends to reduce the dimension of multivariate data by removing inter-correlation among variables and allows a multi-dimensional relationship to be plotted on two or three principal axes. As a result, PCA allows visualization of the differences among the individuals, identification of possible groups and finding relationships among individuals and variables.

Its main objective is to identify the minimum number of components, which can explain maximum variability out of the total variability (Anderson, 1972 and Morrison, 1982) and also to rank genotypes on the basis of PC scores.

Principal Components Analysis was performed using yield and quality attributing traits in maize genotypes include two checks. Out of fifteen, only 8

Principal Components (PCs) exhibited more than 0.5 eigen value and showed 94.496% variability among the traits studied.

The first Principal Component *i.e.*, PC1 accounted for maximum proportion of total variability in the set of all variables and remaining components accounted for progressively lesser and lesser amount of variation. The PC-1 accounted for 34.165% of total variability, whereas, PC-2, PC-3, PC-4, PC-5, PC-6, PC-7 and PC-8 exhibited 16.393%, 12.324%, 8.501%, 6.430%, 5.940%, 4.562% and 3.601% respectively for the traits under study.

Rotated component matrix revealed that the PC1 which accounted for the highest variability (34.165%) and was mostly related yield traits such as plant height, green fodder yield per plant, green fodder yield per plant per day, dry matter yield per plant, dry matter yield plant per day, crude protein yield per plant and brix's value.

PC2 dominated with days to 50 per cent tasseling, days to 50 per cent silking, inter nodal length. PC3 dominated with leaf area. PC4 dominated with number of leaves per plant. PC5 dominated with stem girth. PC6 dominated with crude protein per plant per day. PC7 dominated with leaf stem ratio.

The results are in agreement with the findings of Ahmed *et al.* (2011) for having yield contributing traits were present in PC1 and PC2 was dominating by morphological traits in oat. Vikas *et al.* (2013) observed similar finding for spikelets per panicle and seed yield present in PC1. While, days to 50% flowering present in PC2. Chikuta *et al.* (2015) reported first four PCs had 89% of total variation. Muhammad *et al.* (2015), studied 54 genotypes of maize, PCA showed that the first six components with eigen values more than 1 contributed 82.30% of variability among the genotypes. Jain and Patel (2016) showed first three PCs explaining 70.89% of total variation and Kamara *et al.* (2017) for dry matter and green fodder yield.

From this study, it was clear that PC1 score is mostly related with yield and quality traits like green fodder yield per plant, green fodder yield per plant per day, dry matter yield per plant, dry matter yield plant per day, crude protein

yield per plant, plant height. The putative genotypes are Sugar-75 was followed by DFH-8, ADV-759, TSFM-16-10, JM-216, Jawahar baby corn-1, ADV-6781, Bioseed-9544, African Tall, JM-218 and Star-111.

PC2 score obtained in African Tall followed by IMHBG-18KF2, BAI Fmaize-6, Jawahar baby corn-1, Sugar-75, AH-8071R, ADV-759 and J-1006 indicates that these genotype possess high value of trait for days to 50 per cent tasseling, days to 50 per cent silking, stem girth and inter nodal length.

PC3 scores obtained in Jawahar baby corn-1 followed by IMHBG-18KF2, Bioseed-9544, AH-8071R and ADV-759 indicated that these genotypes possess high value for days to 50 per cent tasseling and days to 50 per cent silking.

PC4 scores obtained in DFH-8 followed by ADV-6781, PFM-10, PFM-9, BAI Fmaize-6, African Tall and IMHBG-18KF1 indicated that these genotypes possess high value for number of leaves per plant.

PC5 scores obtained in MF-2018 followed by PFM-10, PAC-745, JM-216, AH-8070, BAI Fmaize-6 and Star-111 indicated that these genotypes possess high value of trait for stem girth.

PC6 scores obtained in HPFM-9 followed by JM-218, SCH-201, VMH-45 and AH-8070 indicated that these genotypes possess high value for crude protein yield per plant per day.

PC7 scores obtained in Star-111 followed by J-1006, MF-2018 and AH-8070 indicated that these genotypes possess high value for leaf stem ratio.

Based on the results of PCA, promising genotypes are Sugar-75, DFH-8, IMHBG-18KF2, Bioseed-9544 and Adv-6781 which were found in PC1, PC2, PC3 and PC4 dominated by yield as well as quality associated traits. Thus these genotypes should be used for development of promising genotypes.

SUMMARY, CONCLUSIONS AND SUGGESTION FOR FURTHER WORK

6.1 Summary

The present investigation entitled “Genetic Analysis of Fodder Yield and its Components in Maize” was carried during *Kharif* season of 2018-19 at the Seed Breeding Farm, Department of Genetics & Plant Breeding and College of Agriculture, JNKVV, Jabalpur (MP). The experimental material for the present investigation consisted of 31 maize genotypes along with checks. These genotypes were planted in Randomized Completely Block Design (RCBD) with three replications to estimate the genetic variability, heritability, genetic advance, correlation coefficient, path analysis and principal components for fodder yield and its components.

The observations were recorded for fodder and allied traits, the randomly selected and tagged five plants of plot size $4 \times 0.9 \text{ m}^2$ area. Data were recorded for morphological traits such as days to 50 per cent tasseling, 50 per cent silking, plant height, number of leaves per plant, leaf area, leaf colour, leaf mid rib colour, stem girth and inter nodal length and agronomical traits *viz.*, leaf stem ratio, green fodder yield per plant, green fodder yield per plant per day, dry matter yield per plant and dry matter yield per plant per day. And biochemical traits such as crude protein yield per plant, crude protein yield per plant per day and brix's values were evaluated as per standard procedure.

The mean data estimated for fodder and associate traits were subjected to analysis of variance revealed that mean sum of squares due to genotypes were highly significant for all the characters indicating the presence of sufficient amount of genetic variability amongst the material under study. Thus, some of the promising genotypes were selected based on *per se performance* of mean values *viz.*, JM-218, DFH-1, African Tall, Sugar-75, SCH-201, AH-8070, IMHBG-18KF1 and ADV-759 were found to have high value for different traits along with the green fodder yield per plant.

Morphological trait, leaf colour was observed as dark green colour (DFH-8, Bioseed-9544, ADV-759, Jawahar pop corn-11 and Sugar-75), green colour (TNFM-131-9, PFM-9, PFM-10, AFH-6, IMHBG-18KF1, BAIF, maize-6, AH-8071R, Star-111, SCH-201, KDFM-3, PAC-745, ADV-9293, Jawahar baby corn-1, J-1006 and African Tall) and light green colour (VMH-45, HPFM-9, ADV-6781, COHM-6, MF-2018, TSFM-16-10, AH-8070, IMHBG-18KF2, CMVLBC-2, JM-216 and JM-218). White mid rib colour observed in almost all the genotypes except SCH-201 and IMHBG-18KF2 had brown mid rib colour, it possessed low lignin content and therefore had better digestibility.

The PCV was significantly higher in magnitude than its corresponding GCV for all the characters under study. This indicates that influence of the environment on the expression of these characters is effective.

High magnitude of PCV was recorded for green fodder yield per plant, green fodder yield per plant per day, crude protein yield per plant, crude protein yield per plant per day, dry matter yield per plant per day. Moderate magnitude of PCV recorded for brix's value, leaf area, number of leaves per plant, inter nodal length. Low magnitude of PCV was observed in leaf stem ratio, stem girth, plant height, days to 50 per cent tasseling, days to 50 per cent silking. While, in case of GCV traits showed high magnitude was observed in crude protein yield per plant, crude protein yield per plant per day, green fodder yield per plant per day, dry matter yield per plant. Moderate magnitude of GCV was observed in green fodder yield per plant, dry matter yield per plant per day, brix's value, number of leaves per plant, inter nodal length. Low magnitude of GCV was observed leaf area, stem girth, leaf stem ratio, plant height, days to 50 per cent tasseling, days to 50 per cent silking.

Heritability and genetic advance was estimated for all the characters under study and it varied for different yield and yield attributing traits. High magnitude of broad sense heritability with high magnitude of genetic advance was exhibited by inter nodal length, number of leaves per plant, crude protein yield per plant, crude protein yield per plant per day, stem girth, dry matter yield

per plant per day, plant height, brix's value, dry matter yield per plant, green fodder yield per plant per day, green fodder yield per plant. Moderate magnitude of heritability with high magnitude of genetic advance was exhibited by leaf stem ratio, leaf area, brix's value, number of leaves per plant, green fodder yield per plant per day, green fodder yield per plant, crude protein yield per plant, crude protein yield per plant per day, dry matter yield per plant, dry matter yield per plant per day. These characters are governed by additive gene action and their selection will be effective.

Moderate magnitude of heritability with low magnitude of genetic advance was exhibited by leaf stem ratio, leaf area, green fodder yield per plant per day, green fodder yield per plant, days to 50 per cent tasseling, days to 50 per cent silking. While, low heritability with low genetic advance was reported for days to 50 per cent tasseling, days to 50 per cent silking. Such characters are governed by non-additive gene action and their selection may not be effective.

Correlation and path coefficient studies investigate the most important traits such as green fodder yield per plant per day, dry matter yield per plant, dry matter yield per plant per day, crude protein yield per plant, crude protein yield per plant per day. Hence, direct selection may be effective for the improvement of these characters and enhancement in the yielding potential of future genotypes of maize may be achieved.

Direct selection and correlation showed significant and positive effects on green fodder yield per plant per day, dry matter yield per plant per day, crude protein yield per plant per day and stem girth their selection will be rewarded for the development of fodder maize genotypes. While, brix's value has negligible direct effect. Hence, indirect selection *viz.*, crude protein per plant may be made through.

Principal Components Analysis was performed using yield and quality attributing traits in maize genotypes include two checks. Out of fifteen, only 8

Principal Components (PCs) exhibited more than 0.5 eigen value and showed 94.496% variability among the traits studied.

Rotated component matrix revealed that the PC1 accounted for the highest variability (34.165%) was mostly related with traits such as plant height, green fodder yield per plant, green fodder yield per plant per day, dry matter yield per plant, dry matter yield plant per day, crude protein yield per plant and brix's value.

PC2 dominated with days to 50 per cent tasseling, days to 50 per cent silking, inter nodal length, PC3 with leaf area, PC4 with number of leaves per plant, PC5 with stem girth, PC6 with crude protein per plant per day and PC7 with leaf stem ratio.

PC1 score is mostly related with yield and quality traits like green fodder yield per plant, green fodder yield per plant per day, dry matter yield per plant, dry matter yield plant per day, crude protein yield per plant, plant height responsible genotypes are Sugar-75 was followed by DFH-8, ADV-759, TSFM-16-10, JM-216, Jawahar baby corn-1, ADV-6781, Bioseed-9544, African Tall, JM-218 and Star-111.

PC2 score obtained in African Tall followed by IMHBG-18KF2, BAIFmaize-6, Jawahar baby corn-1, Sugar-75, AH-8071R, ADV-759 and J-1006 indicate that these genotypes possess high value of trait for days to 50 per cent tasseling, days to 50 per cent silking, stem girth and inter nodal length.

PC3 scores obtained in Jawahar baby corn-1 followed by IMHBG-18KF2, Bioseed-9544, AH-8071R and ADV-759 indicate that these genotypes possess high value of trait for days to 50 per cent tasseling and days to 50 per cent silking.

PC4 scores obtained in DFH-8 followed by ADV-6781, PFM-10, PFM-9, BAIF maize-6, African Tall and IMHBG-18KF1 indicate that these genotypes possess high value of trait for number of leaves per plant.

PC5 scores obtained in MF-2018 followed by PFM-10, PAC-745, JM-216, AH-8070, BAI Fmaize-6 and Star-111 indicate that these genotypes possess high value of trait for stem girth.

PC6 scores obtained in HPFM-9 followed by JM-218, SCH-201, VMH-45 and AH-8070 indicate that these genotypes possess high value of trait for crude protein yield per plant per day.

PC7 scores obtained in Star-111 followed by J-1006, MF-2018 and AH-8070 indicate that these genotypes possess high value of trait for leaf stem ratio.

6.2 Conclusions

1. Analysis of variance revealed highly significant difference for all the traits indicating sufficient variability in the existing material.
2. Leaf colour *viz.*, dark green colour (DFH-8, Bioseed-9544, ADV-759, Jawahar pop corn-11 and Sugar-75), green colour (TNFM-131-9, PFM-9, PFM-10, AFH-6, IMHBG-18KF1, BAIF, maize-6, AH-8071R, Star-111, SCH-201, KDFM-3, PAC-745, ADV-9293, Jawahar baby corn-1, J-1006 and African Tall) and light green colour (VMH-45, HPFM-9, ADV-6781, COHM-6, MF-2018, TSFM-16-10, AH-8070, IMHBG-18KF2, CMVLBC-2 and JM-216 and JM-218).
3. Leaf mid rib colour *viz.*, white mid rib colour observed in almost all the genotypes except SCH-201 and IMHBG-18KF2 has brown mid rib these have low lignin content and improve digestibility.
4. High magnitude of PCV and GCV was recorded for green fodder yield per plant per day, crude protein yield per plant, crude protein yield per plant per day, dry matter yield per plant per day. Moderate magnitude of PCV recorded for brix's value, leaf area, number of leaves per plant, inter nodal length. Moderate magnitude of PCV and GCV recorded for brix's value, leaf area, number of leaves per plant, inter nodal length. Whereas, low magnitude of PCV and GCV was observed in leaf stem ratio, stem

girth, plant height, days to 50 per cent tasseling and days to 50 per cent silking.

5. High magnitude of broad sense heritability coupled with high magnitude of genetic advance was observed in inter nodal length, number of leaves per plant, crude protein yield per plant, crude protein yield per plant per day, stem girth, dry matter yield per plant per day, plant height, brix's value, dry matter yield per plant, green fodder yield per plant per day and green fodder yield per plant. This indicates that additive gene action play major role in the inheritance of these characters and selection of these characters is effective.
6. Moderate magnitude of heritability with low magnitude of genetic advance was exhibited by leaf stem ratio, leaf area, green fodder yield per plant per day, green fodder yield per plant, days to 50 per cent tasseling and days to 50 per cent silking.
7. On the basis of correlation and path coefficient analysis it reveals that stem girth, green fodder yield per plant per day, dry matter yield per plant per day and crude protein yield per plant per day has significant correlation and higher direct effect. This indicated that these characters will enhance the effectiveness of selection for higher fodder yield in Maize.
8. On the basis of mean performance and Principal Component Analysis (PCA) eight PCs showed more than 0.5 eigen value and showed 94.496% variability among the traits studied.
9. Genotypes sorted viz., Sugar-75, DFH-1, IMHBG-18KF2 (responsible for brown midrib colour as well as for late tasseling and silking), TSFM-16-10, Bioseed-9544 and ADV-6781 have been identified as putative genotypes in PC1, PC2, PC3 and PC4 dominated by yield as well as quality associated traits. Thus, these genotypes should be used for development of promising genotype as they possess higher value for fodder yield and quality traits.

6.3 Suggestions for Further work

1. The promising genotypes identified for yield and quality traits shall be tested over years and locations for their stability.
2. The diversity of the genotypes shall be confirmed using molecular markers.
3. Identified superior genotypes shall be involved in future breeding programme to obtained better segregates.

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APPENDICES

Appendices 1. Meteorological information (week-wise) during the entire crop season of the year 2018 at Jabalpur

Month	Week	T max.	Tmin.	Sun Shine hrs.	Rainfall (mm)	RH Mor	RH Eve	Wind Speed	Vapur Presure (MM)		Evapo (mm)	Rainy days
									Mor.	Eve.		
July	27	32.5	24.6	3.9	44.1	86.0	67.4	7.2	23.1	23.4	3.8	3
	28	32.4	24.8	1.8	64.6	92.4	78.1	5.2	23.4	25.2	3.5	6
	29	31.4	24.8	1.8	137.0	95.3	79.9	6.7	23.6	24.1	3.3	2
	30	28.7	23.6	0.0	106.9	95.0	88.4	7.9	21.8	22.5	2.2	4
	31	29.6	24.3	0.5	2.8	89.0	72.9	7.3	21.7	22.7	1.9	0
August	32	29.4	24.3	0.6	187.9	93.3	83.7	6.2	22.5	23.2	3.4	4
	33	30.3	24.6	2.6	86.3	94.0	77.9	5.4	23.6	24.9	2.7	6
	34	28.5	23.3	0.9	138.8	95.1	93.0	6.2	22.1	23.7	2.7	5
	35	26.8	23.4	0.3	193.8	95.3	91.4	6.2	21.9	23.0	2.0	5
September	36	26.8	22.6	0.3	72.2	96.4	84.3	6.4	21.3	22.3	2.1	4
	37	31.2	22.7	8.1	0.0	90.0	69.1	4.4	21.0	22.5	4.3	0
	38	31.1	22.7	6.0	11.8	91.0	72.0	5.8	20.9	23.5	3.6	1
	39	32.8	22.1	8.0	0.0	90.0	61.7	3.5	20.7	22.9	3.8	0
October	40	34.2	19.8	9.2	0.0	88.7	53.9	2.8	18.6	20.7	4.2	0
	41	32.0	18.0	8.1	0.0	86.4	60.7	3.6	17.0	20.4	3.6	0
	42	32.7	17.8	8.7	0.0	85.7	53.3	2.6	16.7	19.7	3.5	0
	43	31.9	14.7	9.2	0.0	84.9	52.9	2.7	14.3	17.8	3.3	0
November	44	30.5	15.1	8.6	0.0	87.7	45.6	3.3	14.1	14.7	2.8	0
	45	29.0	10.9	8.3	0.0	84.9	28.6	2.5	11.0	8.5	2.6	0
	46	30.5	9.0	8.8	0.0	82.4	35.3	2.0	10.6	9.2	2.4	0
	47	29.7	9.9	8.0	0.0	84.3	30.3	2.1	9.9	9.1	2.6	0

**Appendices 2.a Mean performance of morphological traits in fodder
Maize genotypes (Kharif 2018)**

Genotypes	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	No. of leaves/ plant	Leaf area (cm²)
TNFM 131-9	55.83	69.83	170.33	10.77	428.30
PFM – 9	56.10	70.30	173.80	12.40	415.30
VMH – 45	59.03	69.73	156.33	11.27	427.73
PFM – 10	56.57	68.43	165.20	12.57	430.10
HPFM – 9	58.13	69.23	186.93	11.60	318.10
DFH – 1	57.47	69.53	172.80	11.27	321.77
ADV – 6781	54.53	67.03	185.80	12.60	346.67
AFH – 6	59.30	71.20	167.60	10.67	341.67
IMHBG – 18KF1	54.43	68.70	173.07	11.07	342.07
BAIF, Maize 6	58.27	70.10	186.80	12.47	451.07
COHM – 6	56.30	68.27	189.20	10.13	375.03
AH 8071R	60.83	71.87	171.60	11.00	421.90
MF – 2018	55.50	66.50	161.47	12.33	429.07
Star – 11	58.23	69.27	187.80	12.27	433.13
TSFM – 16-10	54.33	65.37	197.37	9.87	419.50
SCH 201	58.60	68.50	155.40	12.07	413.17
AH 8070	57.33	69.97	172.33	12.80	434.00
IMHBG -18KFF2	61.10	74.17	154.60	12.00	413.43
CMVLBC 2	57.83	66.80	149.13	9.87	367.53
KDFM -3	54.17	66.00	168.07	11.27	426.43
Bioseed 9544	57.87	69.80	150.20	10.20	420.00
ADV – 759	59.80	70.07	183.00	8.83	398.17
PAC 745	56.63	67.57	165.07	9.67	460.07
ADV 9293	56.10	68.07	155.93	10.40	427.67
JM 216	56.87	68.20	178.83	9.40	437.03
JM 218	55.67	66.73	166.40	10.00	403.47
Jawahar Pop Corn 11	55.43	66.67	156.53	8.20	317.73
Sugar 75	57.03	69.03	190.30	9.50	430.03
Jawahar babycorn-1	60.13	73.80	174.23	9.80	491.73
J 1006 (C)	57.30	67.43	181.33	12.60	384.33
African tall (C)	59.03	70.57	200.93	12.33	434.40
SEm ±	0.95	1.06	4.41	0.30	17.36
C.D. at 5% level	2.70	3.01	12.47	0.86	49.12

**Appendices 2.b Mean performance of agronomical traits in fodder
Maize genotypes (Kharif 2018)**

Genotypes	Internodal length (cm)	Stem girth (mm)	Leaf stem ratio	Green fodder yield/plant (g)	Green fodder yield/ plant/ day (g)
TNFM 131-9	12.20	9.59	0.51	175.67	2.47
PFM – 9	12.20	9.53	0.49	215.67	3.02
VMH – 45	11.67	9.00	0.47	198.67	2.42
PFM – 10	12.00	11.27	0.52	203.00	2.86
HPFM – 9	13.27	9.20	0.46	179.67	2.48
DFH – 1	10.10	10.80	0.53	314.33	4.42
ADV – 6781	12.07	10.50	0.52	280.00	3.92
AFH – 6	10.87	10.70	0.56	167.67	1.79
IMHBG – 18KF1	11.67	11.50	0.53	196.33	2.60
BAIF, Maize 6	12.80	9.80	0.54	184.00	2.80
COHM – 6	11.73	9.17	0.60	203.33	2.16
AH 8071R	11.00	9.77	0.57	185.00	2.59
MF – 2018	9.80	11.17	0.57	230.00	3.21
Star – 11	11.73	9.67	0.60	240.00	3.32
TSFM – 16-10	12.93	8.47	0.62	185.67	3.30
SCH 201	11.00	9.53	0.56	163.33	2.27
AH 8070	11.07	9.63	0.57	207.33	2.83
IMHBG -18KFF2	11.67	9.13	0.59	140.33	1.90
CMVLBC 2	10.20	9.33	0.58	171.67	2.43
KDFM -3	12.20	8.80	0.56	146.00	1.92
Bioseed 9544	11.27	9.67	0.63	273.33	3.13
ADV – 759	12.33	8.77	0.64	262.33	4.27
PAC 745	12.00	10.60	0.52	229.00	3.05
ADV 9293	9.47	9.00	0.48	168.33	2.22
JM 216	12.73	10.93	0.57	266.67	2.47
JM 218	11.33	9.00	0.50	247.33	3.30
Jawahar Pop Corn 11	8.13	10.90	0.52	219.33	2.92
Sugar 75	12.80	9.07	0.64	201.67	4.64
Jawahar babycorn-1	10.57	9.27	0.57	274.33	3.63
J 1006 (C)	12.33	9.03	0.59	163.00	2.24
African tall (C)	13.73	8.47	0.57	185.33	4.46
SEm ±	0.25	0.26	0.01	18.34	0.32
C.D. at 5% level	0.73	0.74	0.04	51.87	0.91

Appendices 2.c Mean performance of biochemical traits fodder Maize genotypes (Kharif 2018)

Genotypes	Dry matter yield/plant (g)	Dry matter yield/plant /day (g)	Crude protein yield/plant (g)	Crude protein yield/plant /day (g)	Brix value (%)
TNFM 131-9	39.97	0.54	5.40	3.80	9.07
PFM – 9	36.67	0.49	3.80	2.70	11.30
VMH – 45	35.00	0.52	3.93	2.73	13.77
PFM – 10	45.67	0.56	4.13	2.93	9.97
HPFM – 9	53.00	0.59	7.73	5.43	11.67
DFH – 1	75.00	0.65	8.07	6.20	9.37
ADV – 6781	63.33	0.62	7.50	5.30	9.53
AFH – 6	34.00	0.42	3.50	2.47	11.90
IMHBG – 18KF1	46.67	0.58	4.63	3.30	11.03
BAIF, Maize 6	32.33	0.67	4.37	2.70	9.00
COHM – 6	54.00	0.73	6.27	4.20	9.67
AH 8071R	47.33	0.66	5.17	3.67	10.77
MF – 2018	61.67	0.73	5.77	4.10	11.63
Star – 11	64.67	0.73	6.27	4.80	13.43
TSFM – 16-10	52.67	0.72	7.93	5.67	7.83
SCH 201	37.67	0.36	5.83	3.53	14.17
AH 8070	51.67	0.74	6.20	4.40	13.60
IMHBG -18KFF2	37.33	0.51	5.40	3.77	12.63
CMVLBC 2	33.33	0.46	3.93	2.77	12.43
KDFM -3	33.33	0.46	3.50	2.47	13.63
Bioseed 9544	58.33	0.81	6.90	4.87	9.90
ADV – 759	68.33	0.69	6.60	4.77	11.63
PAC 745	55.33	0.65	5.77	4.07	11.93
ADV 9293	45.00	0.57	5.27	3.77	12.27
JM 216	62.00	0.85	7.53	5.63	11.17
JM 218	60.00	0.68	7.93	5.13	11.90
Jawahar Pop Corn 11	58.33	0.69	4.93	3.50	10.00
Sugar 75	75.33	0.68	9.73	6.40	11.00
Jawahar babycorn-1	59.67	0.68	7.97	5.53	10.53
J 1006 (C)	40.00	0.57	5.33	3.40	11.43
African tall (C)	51.67	0.59	6.33	4.50	7.53
SEm ±	4.08	0.03	0.40	0.33	0.54
C.D. at 5% level	11.55	0.10	1.14	0.93	1.53

CURRICULUM VITAE

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Place : Bhopal (MP)

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The author of this thesis Ms. Kratika Alawe D/o Shri. Kishore Kumar Alawe Smt. Sharda Alawe born on 31st March 1993 at Bhopal (MP). She has joined following institutions and successfully completed the degree of M.Sc. (Ag.) degree during the year 2018-19.

S. No.	Institutions
1.	JNKVV, Jabalpur (M.P.)
2.	COA, RVSKVV, Gwalior (MP)
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She has got the following degrees,

S. No.	Degrees granted	University/Board	Year
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2.	B.Sc. (Ag.)	RVSKVV, Gwalior	2017
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4.	10 th	BFS, Bhopal	2009

Scientific interests

- Genetics and Plant Breeding
- Molecular Breeding
- Trait improvement breeding

For the partial fulfilment of the master's degree programme she was allotted a research work on "**Genetic Analysis of Fodder Yield and its Components in Maize**" which was successfully conducted by her and being submitted in the form of the thesis.



Field view



Silking



Tasseling

Plate 1. Field view and morphology of Maize crop



Dark green leaf



Green leaf



Light green leaf



White mid rib



Brown mid rib

Plate 2. Leaf and mid rib colour of Maize crop