VARIABILITY STUDIES IN FODDER SORGHUM
(*Sorghum bicolor* (L.) Moench)

BINI.K

Thesis submitted in partial fulfillment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2003

Department of Plant Breeding and Genetics
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

DECLARATION

I hereby declare that this thesis entitled **"Variability Studies in Fodder Sorghum (*Sorghum bicolor* (L.) Moench)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,
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CERTIFICATE

Certified that this thesis entitled **"Variability Studies in Fodder Sorghum (*Sorghum bicolor* (L.) Moench"** is a record of research work done independently by Ms. Bini. K (2001-11-66) under my guidance `and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Dedicated to

Puthuchirakavilamma

&

My Parents

ACKNOWLEDGEMENT

I consider it a privilege to express my sincere gratitude to:

"God almighty for his grace and blessings in every walk of my life"

Dr. D. I. Suma Bai, Associate Professor, Department of Plant Breeding and Genetics, Chairman of the advisory committee for her able guidance and care bestowed upon me for the past two years. I will be always indebted to her for the timely advice, inspiration, patience, affection, motherly care and blessings, which I value the most. I am ever full of her.

Dr. D. Chandramony, Professor and Head Department of Plant Breeding and Genetics who was always a source of encouragement, guidance, care and support throughout the course period.

Dr. P. Saraswathi, Professor and Head Department of Agricultural Statistics, who had taken much pain in going through the manuscript inspite of her busy schedule, and for her valuable suggestions and timely advices.

Dr. V. L. Geetha Kumari, Associate Professor, Department of Agronomy who had helped me during the chemical analysis and for the love and affection.

All the teachers of the Department of Plant Breeding and Genetics, whom I could approach at any stage of the completion of this work.

Sri. C. E. Ajith Kumar, Junior Programmer, Department of Agricultural Statistics for his immense help during the analysis of my data.

Dr. C. Gokulapalan, Department of Plant Pathology who had helped in taking the photographs inspite of his tight schedule. I express my sincere gratitude towards him.

The non-teaching staff of the Department of Plant Breeding and Genetics and farm labourers for their wholehearted cooperation throughout the conduct of the experiment.

All friends Mini chechi, Rajitha, Sangeetha, Serene chechi, Ninitha, Deepthi, Bini, Sherin, Bijily, Beena, Shivamani, Jithesh, Hima, Robi, Ancy to name a few have been a source of inspiration throughout the period of my study. Love to Bini chechi, Sindhumole chechi, Lovely chechi, Vrinda chechi, Usha chechi and Anu chechi for their whole hearted affection, love and passion during my stay in the campus.

Poornima chechi, Soumia (IARI), Premna and Lekha who were always with me in my happiness and adversaries. My sincere gratitude and indebtedness are above words for all of them.

My father and mother who are the greatest gifts of God to me, Arun for his flawless love, chechi, Prasanth chettan, Unnikuttan, Ashok uncle and Dileep uncle, Sunil who had always provided me the inner strength, love, care and affection.

The patience and perseverance of Kishore who had helped in preparing the manuscript in its present form.

Kerala Agricultural University for awarding me the Junior Fellowship.

BINI.K

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ABBREVIATIONS

%	Per cent
µm	Micro metre
ºC	Degree Celcius
ANOVA	Analysis of variance
Cm	Centimeters (s)
Et al.	And others
Fig.	Figure
g	Gram (s)
Ha	Hectare
i.e.	That is
Kg	Kiogram
Ml	Millilitre
MSE	Error mean square
SS	Sum of squares
T	Tonne (s)
Viz.	Namely
PCV	Phenotypic Coefficient of variation
GCV	Genotypic Coefficient of variation
ECV	Environmental Coefficient of variation
ICRISAT	International Centre and Research Institute for Semi Arid Tropics

Introduction

1. INTRODUCTION

India holds a leading position in the bovine resources of the world. Livestock enterprises are important features of rural India and the economic sustainability has its main stay on judicious feeding through out the year. Eventhough there is large population of livestock in India, there is low productivity, which is attributed to chronic shortages of feed both in quantity and quality. At present the deficit is too high that we are able to meet only 40 per cent of the animal feed.

Kerala today accounts for about 1.18 per cent of the total livestock population in India. Forage production has only been incidental to the production of food crops. Only 2024 ha (0.07 %) of the state's cropped area is under forage crops and there is hardly any scope for expansion. Pressure of large population, food shortages and small farm units has necessitated concentration on food crops such as cereals, pulses and high value crops. So it is imperative to maximize forage production in space and time, identifying new forage resources and increase the forage production within the existing farming systems.

Sorghum is an important millet crop with high fodder value. Fodder sorghum is characterized by quick growth, high yield, high dry matter content, leafiness, better palatability and excellent material for silage purpose. Eventhough sorghum is widely cultivated in our country, its importance as an excellent fodder is less valued. Identification of the most dependable characters contributing to fodder yield is essential for improvement in this aspect. The present project is undertaken to study the variability, its genetic parameters, correlation among the characters, path coefficient analysis and to derive a selection index for forage yield and quality in sorghum.

Review of Literature

2. REVIEW OF LITERATURE

The available literature on various aspects of the present investigation is reviewed here.

2.1 VARIABILITY

Sindhagi *et al.* (1970) estimated variability in F_1 progenies of intervarietal crosses of fodder sorghum and reported maximum GCV for green fodder yield.

Variability in protein content ranged from 4.81 to 7.44 per cent in a variability study reported by Arora *et al*. (1975).

In fodder sorghum, Rana *et al*. (1976) reported that the width of the fourth leaf from the top was positively correlated with stem girth and fresh fodder yield which accounted for 32 per cent of variability in yield.

In a study of variability between hybrids and varieties in fodder sorghum, Lodhi *et al.* (1977) reported considerable amount of variability with respect to plant height, number of tillers per plant, leaf: stem ratio and green fodder yield per plant.

Mathur and Patil (1982) observed considerable variation among 20 varieties of fodder sorghum for plant height, number of leaves per plant, number of tillers per plant and dry matter yield. The leaf number showed the highest heritability followed by dry matter yield, plant height and number of tillers per plant.

Based on their studies in fodder pearl millet under single and double cut systems, Mohan and Dua (1984) reported GCV values ranging from 9.71 to 21.23 per cent for plant height, 0.87 to 4.34 per cent for tiller number, 16.56 to 17.82 per cent for green fodder yield and 13.46 to 23.66 per cent for dry matter yield.

In fodder bajra, Kunjir and Patil (1986) reported high genotypic and phenotypic variability for tiller number.

Kulkarni and Shinde (1987) reported high genetic variability for plant height and dry fodder yield in sorghum.

Maiti *et al*. (1989) evaluated 90 pearl millet germplasm collections and reported that large phenotypic variability was found between genotypes for plant height, leaf number, leaf width and stem thickness.

High genotypic variance for plant height in fodder sorghum was reported by Kaushik and Grewal (1991).

On evaluation of 53 genotypes of napier grass, Amirthadevarathinam and Dorairaj (1994) reported that GCV was highest for leaf weight followed by green fodder yield, stem weight, crude protein content, dry matter yield and leaves per tiller.

Ramasamy *et al*. (1994) reported high genotypic and phenotypic coefficients of variation for green fodder yield per plant. Days to 50 per cent flowering recorded the lowest phenotypic and genotypic coefficients of variation.

Based on studies in twelve grain and fodder related traits in twenty genotypes of sorghum, Raut *et al*. (1994) reported that variability was highest for fodder yield.

Fifty six genotypes of fodder sorghum were evaluated by Sabharwal *et al*. (1995) and concluded that both genotypic and phenotypic coefficients of variation were high for stem weight, number of leaves, number of tillers and leaf weight.

Sreekumar and Bai (1995) in fodder maize reported high genotypic coefficient of variation for plant height and plant population.

Borad *et al*. (1996) observed wide range of variation for all the nine characters studied in 49 genotypes of fodder sorghum. Green fodder yield, dry matter yield and HCN showed high variability. Highest coefficient of variation was observed for HCN followed by crude protein content, green fodder yield and dry matter yield.

On evaluation of 100 genotypes of sorghum, Patil *et al*. (1996) reported that variability was greatest for green fodder yield followed by plant height.

Bai (1988) evaluated 15 guinea grass clones and reported maximum phenotypic coefficient of variation (35.8 %) for green fodder yield per hill followed by leaf area index (28.72 %) and number of panicles per plot (25.86 %)

On analysis of 350 plants of fodder bajra, Sharma *et al*. (1999) reported that significant differences existed between families for fresh weight and dry weight per plant, plant height, leaf: stem ratio and leaf area in the first cutting.

In pearl millet, Berwal and Khairwal (2000) reported highly significant variation among accessions for plant height, tiller number per plant, stem thickness, leaf length, leaf width, fodder yield and grain yield per plant.

Desai *et al*. (2000) reported high variability for dry fodder yield followed by green fodder yield, plant height and total leaf area in sorghum genotypes.

Singh and Dash (2000) in fodder maize reported considerable and significant variation for all the characters except leaf: stem ratio and plant population.

Sharma (2002) reported significantly high variability for fresh weight per plant, dry matter per plant, days to 50 per cent flowering, plant height, tillers per plant, leaves per plant, stem thickness, leaf: stem ratio, leaf area and green fodder yield per plant in fodder bajra.

2.2 HERITABILITY AND GENETIC ADVANCE

Sindhagi *et al*. (1970) studied parents, F_1s and F_2s of two intervarietal crosses of fodder sorghum and reported high heritability and genetic advance for plant height (82.14 and 37.62 %) and for green fodder yield (86.05 and 72.47 %) respectively. The number of leaves recorded a heritability estimate of 59.03 per cent and genetic advance of 26.81 per cent.

Low heritability estimates were observed for leaf weight, stem weight and green fodder yield and medium heritability for number of tillers per plant in a diallel cross involving six crosses of fodder sorghum by Sainy and Paroda (1975).

Jhorar and Paroda (1976) estimated high heritability values for leaf area (93.32%), number of tillers per plant (88.63%), plant height (87.93 %) green fodder yield (87.50%) and dry matter yield (86.93 %) in forage sorghum.

High heritability estimates were recorded for green fodder yield and plant height in forage sorghum by Rana *et al*. (1976)

Singhania *et al*. (1977) reported low heritability estimates for green fodder yield per plant, leaf: stem ratio and leaf area in forage sorghum.

Moderate heritability was recorded by Vaithialingham (1979) in forage sorghum for leaf: stem ratio, green fodder yield and dry fodder yield.

Sidhu and Mehinderetta (1980) reported high heritability estimates for leaf length and plant height in fodder sorghum.

On evaluation of 20 genotypes of fodder sorghum, Mathur and Patil (1982) reported high heritability for leaf number per plant, number of tillers per plant, dry matter yield and plant height. The highest genetic advance was reported for number of leaves per plant.

Singh (1982) reported high genetic advance for leaf yield per plant from a study on 21 varieties of sorghum for forage characters. Plant height, leaf number, leaf yield and forage yield per plant had high heritability estimates.

Kunjir and Patil (1986), based on studies in pearl millet reported high heritability and high genetic advance for tiller number and plant height indicating additive gene action.

Amirthadevarathinam *et al.* (1990) evaluated 30 genotypes of sorghum and reported high heritability estimates for plant height, leaf length and grain yield.

Patil *et al.* (1993) reported high heritability and genetic advance for green folder yield per plant, plant height and number of leaves per plant.

Thirumeni and Das (1993) evaluated 15 genotypes of fodder pearl millet and reported high estimates of heritability for plant height, leaf area per clump, green fodder yield, dry matter yield and leaf: stem ratio. High heritability coupled with high genetic advance was observed for leaf: stem ratio, dry fodder yield, leaf area per clump, green fodder yield and crude protein content.

Shabharwal *et al.* (1995) reported high heritability estimates combined with high genetic advance for plant height, number of leaves per plant, stem weight, tillers per plant, green fodder yield and dry matter yield.

Genetic analysis of fodder yield and its components in fodder maize by Sreekumar and Bai (1995) revealed that plant height and plant population had high genetic advance and heritability.

According to Suthamathi and Dorairaj (1995) high heritability and high genetic advance were shown by crude protein content, stem weight, plant height, green fodder yield per plant, leaf length, dry matter content, leaf weight, days to 50 per cent flowering and leaf: stem ratio.

Borad *et al.* (1996) reported high heritability estimates combined with high genetic advance for HCN, green fodder yield and leaf breadth. Dry matter yield and crude protein yield had high GA but moderate heritability.

Moderate to high heritability estimates were observed for green fodder yield and plant height by Patil *et al.* (1996)

Desai *et al.* (2000) in fodder sorghum reported high heritability estimates for dry fodder yield, green fodder yield, plant height and total leaf area.

2.3 CORRELATION COEFFICIENT

Phenotypic, genotypic and environmental correlations were worked out by Swarup and Chaugale (1962) in sorghum. Fodder yield was positively correlated with plant height and number of leaves.

In fodder sorghum, Naphade (1972) reported that the yield of fodder had significant positive correlation with leaf number and plant height. Plant height and leaf area showed positive but in significant correlation with yield.

Chauhan and Singh (1975) reported that fodder yield had positive phenotypic correlation with plant height and leaf number in fodder sorghum.

Significant and positive correlation with green fodder yield and components like plant height, leaf length, leaf breadth, days to flowering and stem girth were reported in fodder sorghum by Paroda *et al.* (1975).

Jhorar and Paroda (1976) reported negative phenotypic correlation with plant height and tiller number in fodder sorghum.

Chauhan and Singh (1977) reported that plant height was positively correlated with number of leaves and fodder yield and negatively correlated with internode diameter in fodder sorghum.

Rao and Ahluwalia (1977) reported that green fodder yield had significant positive phenotypic correlation with plant height and leaf stem ratio.

In fodder sorghum Singhania *et al.* (1977) reported that plant height, fifth leaf area and stem diameter had positive phenotypic correlation with fodder yield. The above characters showed positive association among themselves.

Gopalan and Balasubramanian (1978) conducted correlation studies in 23 lines of fodder sorghum and reported that length of leaf, breadth of leaf, number of leaves and thickness of stem had positive phenotypic correlation with green fodder yield.

Sainy and Paroda (1978) reported positive correlation of plant height with green fodder yield and dry fodder yield in sorghum.

In fodder sorghum, Vaithialingham (1979) reported positive phenotypic correlation of plant height, fourth leaf area and dry fodder yield with green fodder yield.

In fodder sorghum, Sidhu and Mehinderetta (1980) reported that leaf number, stem thickness, leaf length and leaf width were positively correlated with green fodder yield at phenotypic level.

Mathur and Patil (1982) reported that plant height and number of leaves per plant were positively correlated with dry matter yield both at genotypic and phenotypic levels, whereas number of tillers per plant was correlated at genotypic level.

On evaluation of 21 sorghum varieties, Singh (1982) reported that leaf and stem yields had high coefficients of variation at genotypic and phenotypic levels and were highly correlated with each other.

Positive phenotypic correlation was reported in fodder sorghum by Vaidyanathan (1982), between plant height and green fodder yield and negative correlation between leaf:stem ratio and fodder yield.

Rohewal *et al.* (1984) reported that in fodder sorghum there was significant positive genotypic correlation of fodder yield with stem diameter and plant height. Internode length was positively correlated with fodder yield but not significant.

Mangath (1986) in fodder pearl millet reported that fodder yield was positively correlated with plant height, stem thickness, internode number, leaf width and days to flowering.

In fodder ragi, Dhanakodi and Chandrasekaran (1989) reported positive correlation of plant height, leaf number, leaf length, leaf width, days to flowering and internodal length with green fodder yield. Negative significant correlation between fodder yield and tiller number and insignificant negative correlation between fodder yield and leaf: stem ratio were also reported.

Girija and Natarajan (1989) reported that green fodder yield had positive correlation with dry matter accumulation in fodder sorghum.

In association studies in fodder sorghum, Sood and Ahluwalia (1989) reported that there was significant and positive correlation of green fodder and dry matter yield with each other as well as with stem girth, leaves per plant, days to 50 per cent flowering and leaf breadth. The fodder yield was found to be negatively correlated with plant height and leaf: stem ratio.

Kaushik and Grewal (1991) reported positive correlation between plant height and stem weight in fodder sorghum.

In fodder sorghum, Patil *et al*. (1993) reported that fodder yield had positive phenotypic correlation with plant height, stalk diameter and total leaf area.

Thirumeni and Das (1993) reported high genotypic and phenotypic coefficient of variation for leaf area per clump and dry matter yield in fodder pearl millet.

Sabharwal *et al.* (1995) reported that genotypic and phenotypic coefficients of variation were high for stem weight, number of leaves, number of tillers and leaf weight in fodder sorghum.

Sreekumar and Bai (1995) in fodder maize reported high genotypic correlation between green and dry fodder yield and also between plant population and dry fodder yield. .

Suresh and Bai (1998) in fodder bajra, reported that dry matter had the highest positive and negative genotypic correlations with crude protein content and internode length respectively. A high genotypic correlation for dry matter yield, plant stand after germination, leaf number per plant and leaf area index was present with green fodder yield.

In fodder maize, Basheeruddin *et al*. (1999) reported positive and highly significant correlation coefficient for plant height, number of leaves, leaf area per plant, stem girth, crude protein content and ear height on fodder production.

Desai *et al*. (1999) reported that plant height, number of leaves per plant, leaf length, total leaf area and basal tillering had significant positive correlations with yield.

On analysis of 129 half sib families of fodder bajra, Sharma and Sharma (1999) reported that fresh weight per plant, dry weight per plant, days to heading, plant height, tillers per plant, leaves per plant, stem thickness, leaf: stem ratio, leaf area and green fodder yield per plant showed significant positive correlation among themselves and green fodder yield per plot.

Sukhchain (1999) stated that in guinea grass green fodder yield showed a positive and significant phenotypic correlation coefficient with dry matter yield in all cuts. Tiller number per plant and plant height showed a positive and significant correlation with green fodder yield and dry matter yield in all cuts.

2.4 PATH ANALYSIS

Naphade (1972), reported that number of leaves per plant was the most important component influencing fodder yield followed by plant height and leaf area in fodder sorghum.

In fodder sorghum, Phul *et al*. (1972) reported that length and breadth of leaf and stem girth contributed most to fodder yield.

Jhorar and Paroda (1976) stated that leaf width, plant height and leaf weight were the important factors influencing yield in fodder sorghum.

High positive direct effect on green fodder yield was shown by leaf length and leaf breadth in the findings of Gopalan and Balasubramanian (1978).

In pearl millet, Tyagi *et al*. (1980) reported that dry matter yield, leaf length and number of tillers had direct effect on green fodder yield. Plant height, green fodder yield, stem girth and number of leaves exerted direct effect on dry matter yield too.

According to Mathur and Patil (1982) degree effect of plant height and number of leaves per plant was low and that of number of tillers per plant was high.

Mangath (1986) reported that internode number had the maximum direct effect on yield in fodder bajra.

In fodder maize, Paramathma and Balasubramanian (1986) reported that stem girth and leaf breadth had positive direct effect on yield. Plant height had indirect effect on yield through stem girth and leaf breadth.

In guinea grass, Bai (1988) reported that green fodder yield per hill, leaf: stem ratio on fresh weight basis, number of tillers per hill and plant height exerted positive direct effect on green fodder yield.

Patel and Shelke (1988) reported that leaf area per clump, internode number per plant, stem circumference and percentage of nitrogen content had significant positive direct effect on yield in fodder maize.

Dhanakodi and Chandrasekaran (1989) in fodder ragi reported maximum positive direct effect of days to flowering on yield followed by tiller number and leaf number. Plant height and internodal length showed negative indirect effect on yield.

Sood and Ahluwalia (1989) reported high and positive direct contribution of stem girth towards fodder yield. Leaf breadth, leaf: stem ratio and leaves per plant also exhibited significant positive direct effect on green fodder yield.

Chalapathi (1990) in fodder maize reported that plant height had high positive direct effect on yield followed by leaf number per plant and cob number per plant.

In forage maize, Paramathma *et al*. (1992) reported that plant height had the maximum direct effect on forage yield followed by leaf breadth and stem girth.

Pradhan *et al*. (1993) in bajra napier hybrid reported that number of tillers per hill was the most important character positively influencing the green fodder yield.

Ramasamy *et al*. (1994) in fodder ragi reported that leaf weight per plant showed maximum positive direct effect on yield.

Alikhan *et al*. (1995) reported positive effect of number of leaves and leaf breadth on green fodder yield of yellow grained sorghum.

In fodder maize, Sreekumar and Bai (1995) reported that plant height had positive effect on green fodder yield.

Sharma and Sharma (1999) reported that leaves per plant, dry weight per plant and green fodder yield per plant were the important characters for improving green fodder yield.

2.5 SELECTION INDEX (DISCRIMINANT FUNCTION)

Swarup and Chaugale (1962) in fodder sorghum reported that selection based on the index formulated by including the characters plant height, stalk diameter and leaf number was useful for the improvement of forage yield.

Patel *et al*. (1973) reported that selection of tall plants with thick stalk will improve the fodder yield.

In fodder sorghum, Singh and Singh (1974) reported that selection index developed by including leaf length, stem girth, stem length, number of internodes and fodder yield was very effective for improvement of fodder yield through selection.

Singh (1982) reported that leaf yield per plant showed a high value of genetic advance. Plant height, leaf number, leaf yield and forage yield per plant had high heritability estimates.

In guinea grass Santhipriya (1991) reported that plant height, tiller number per plant, leaf area, leaf: stem ratio and green matter yield were the most important yield contributing parameters. She also suggested that the selection index formulated based on the above characters was useful for population improvement.

Information on variability and yield correlations by Alikhan *et al*. (1995) in fodder sorghum indicated that number of leaves and leaf breadth had to be taken into consideration for increasing the green fodder yield.

Sreekumar and Bai (1995) reported that additive gene action was present in the case of plant height and was a reliable character during selection programme for increasing the yield in fodder maize.

Raveendran *et al*. (1996) reported that selection for biometrical characters, days to flowering, number of tillers, leaf length/breadth ratio and number of leaves will help to identify high fodder yield in sorghum genotypes.

Materials and Methods

3. MATERIALS AND METHODS

The present study on “Variability studies in fodder sorghum [*Sorghum bicolor* (L.) Moench]” was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Thiruvananthapuram during August to November 2002.

3.1 MATERIALS

The experimental material consisted of fifty accessions of fodder sorghum [*Sorghum bicolor* (L.) Moench] collected from ICRISAT, Hyderabad. The details of the accessions are presented in Table 1.

3.2 METHODS

A field experiment was conducted during August to November 2002 with fifty accessions in a randomized block design with two replications. Two hundred and sixty six plants were maintained in a plot size of 12 m^2 with a spacing of 30 x 15 cm. The morphological variability for various accessions are given in Plate 1. The crop was raised as per the technical programme of AICRP on Forage Crops. Ten plants were selected at random from each plot and the data on following characters were recorded and the corresponding means were subjected to statistical analysis.

3.2.1 Observations Recorded

3.2.1.1 Plant Stand after Germination

The number of plants per plot after two weeks of sowing was recorded.

3.2.1.2 Plant Height at Harvest, cm

The plant height was measured in centimeters from the base of the plant to the tip of the longest leaf.

Table 1. Details of fodder sorghum evaluated

Sl. No.	Name	Source	Sl. No.	Name	Source
1	Acc.No. 23	ICRISAT	26	11098	ICRISAT
2	118	”	27	11105	”
3	164	”	28	11106	”
4	172	”	29	11109	”
5	186	”	30	11119	”
6	237	”	31	11120	”
7	472	”	32	11122	”
8	603	”	33	11128	”
9	633	”	34	11161	”
10	670	”	35	10299	”
11	680	”	36	11150	”
12	698	”	37	11238	”
13	821	”	38	11241	”
14	846	”	39	11244	”
15	902	”	40	11283	”
16	914	”	41	11296	”
17	927	”	42	11298	”
18	1005	”	43	11302	”
19	10046	”	44	11311	”
20	11003	”	45	11357	”
21	11026	”	46	11394	”
22	11049	”	47	11446	”
23	11074	”	48	11456	”
24	11075	”	49	11693	”
25	11079	”	50	11745	”

Plate 1. Morphological variability for various accessions

3.2.1.3 Leaf:Stem Ratio

Ten plants selected at random from each plot were harvested and each plant separated into leaf and stem. Weight of leaf and stem was recorded separately for each plant and leaf: stem ratio was worked out.

3.2.1.4 Internode Length, cm

The length of the fourth internode from top was measured in centimeters.

3.2.1.5 Tiller Number per Plant

The total number of tillers from a random sample of ten plants per plot was counted at harvest and the mean was calculated.

3.2.1.6 Leaf Number per Plant

The total number of leaves from a random sample of ten plants per plot was counted at harvest and the mean was recorded.

3.2.1.7 Leaf Weight per Plant, g

Ten plants were selected at random from each plot, harvested, leaves separated, the mean leaf weight per plant was estimated and expressed in g.

3.2.1.8 Leaf Area Index (LAI)

The total leaf area (cm^2) was calculated by multiplying the total number of leaves with actual area of the 4^{th} leaf from top of the stem. The actual leaf area of the 4^{th} leaf was estimated as its length x breadth x 0.71 which is the leaf product constant.

The leaf area index was computed by using the formula suggested by William (1946).

$$LAI = \frac{\text{Total leaf area of the plant}}{\text{Ground area occupied}}$$

3.2.1.9 Green Fodder Yield, t ha^{-1}

The green fodder yield for observational plants were recorded at harvest and mean weight calculated and multiplied with number of plants in one hectare and expressed in tonnes per hectare.

3.2.1.10 Crude Protein Content, %

Dried plant samples collected at the time of harvest was subjected to nitrogen analysis by the modified microkjeldahl method (Jackson, 1967). The crude protein was calculated by multiplying the nitrogen percentage with a factor 6.25 (Simpson *et al*., 1965).

3.2.1.11 Crude Fibre Content, %

Dried plant samples collected at the time of plant harvest were utilized for the estimation of crude protein by acid and alkali digestion method (Sadasivam and Manickam, 1992).

From the dried plant materials, two grams were taken and boiled with 200 ml of sulphuric acid for 30 minutes. Then it was filtered through a muslin cloth and the filtrate was washed with boiling water until the washings were no longer acidic. The residue obtained was again boiled with 200 ml of sodium hydroxide solution for 30 minutes. It was again filtered through muslin cloth and washed with 25 ml of 1.25 per cent boiling sulphuric acid, three 50 ml portions of water and 25 ml alcohol. The residue was transferred to ashing dish which was pre weighed (w_1). The residue was then dried for two hours at 130 $\pm$ 2^0C.The dish was cooled and weighed (w_2). Then the residue was ignited for 30 minutes, cooled and weighed in a dessicator and weighed (w_3). Percentage crude fibre in the sample was estimated as:

$$\frac{\text{Loss of weight on ignition}}{\text{Weight of sample}} \times 100$$

$$= \frac{(w_2 - w_1) - (w_3 - w_1)}{\text{Weight of sample}} \times 100$$

3.2.1.12 Palatability

Weighed quantity of each accession was fed to the cattle and it was consumed fully.

3.3 STATISTICAL ANALYSIS

The data collected were subjected to the following statistical analyses. Analysis of variance and covariance were done:

i) to test varietal difference if any,with respect to various traits

ii) to estimate variance components and other parameters like correlation coefficients ,heritability ,genetic advance etc.

Format of analysis of variance / covariance is given below.

Table 2. Analysis of variance / covariance

Source	df	Observed mean square (X)	Expected mean square (XX)	Observed mean sum of products (XY)	Expected mean sum of products (XY)	Observed mean square (YY)	Expected mean square (YY)
Block	(r-1)	B_{xx}		B_{xy}		B_{yy}	
Genotype	(v-1)	G_{xx}	$\sigma^2_{ex} + r\sigma^2_{gx}$	G_{xy}	$\sigma_{exy} + r\sigma_{gxy}$	G_{yy}	$\sigma^2_{ex} + r\sigma^2_{gx}$
Error	(v-1) (r-1)	E_{xx}	σ_{ex}	E_{xy}	σ_{exy}	E_{yy}	σ^2_{ey}
Total	(rv-1)	T_{xx}		T_{xy}		T_{yy}	

3.3.1.The Genetic and Environmental Components of Phenotypic Variance

Genotypic variance / covariance	Environmental variance / covariance	Phenotypic variance / covariance
$\sigma^2_{g\,(x)} = (G_{xx} - E_{xx})/r$	$\sigma^2_{e\,(x)} = E_{xx}$	$\sigma^2_{p\,(x)} = \sigma^2_{gx} + \sigma^2_{ex}$
$\sigma^2_{g\,(y)} = (G_{yy} - E_{yy})/r$	$\sigma^2_{e\,(y)} = E_{yy}$	$\sigma^2_{p\,(y)} = \sigma^2_{gy} + \sigma^2_{ey}$
$\sigma_{g\,(xy)} = (G_{xy} - E_{xy})/r$	$\sigma_{e\,(xy)} = E_{xy}$	$\sigma_{p\,(xy)} = \sigma_{gxy} + \sigma_{exy}$

3.3.2 Coefficient of Variation

Phenotypic and genotypic coefficients of variation (PCV and GCV) were estimated as

$$GCV = \frac{\sigma_{gx}}{\bar{x}} \times 100$$

$$PCV = \frac{\sigma_{px}}{\bar{x}} \times 100$$

where σ_{gx} = genotypic standard deviation

σ_{px} = phenotypic standard deviation

$\bar{x}$ = mean

3.3.3 Heritability (Broad sense)

$$H^2 = \frac{\sigma^2_{gx}}{\sigma^2_{px}} \times 100$$

where H^2 is the heritability expressed in percentage (Jain,1982)

3.3.4 Genetic Advance as Percentage of Mean

$$GA = \frac{kH^2\sigma_p}{\bar{x}} \times 100$$

(Miller *et al.*, 1958)

k= selection differential = 2.06 at 5 per cent selection

3.3.5 Correlation Coefficient

Genotypic correlation coefficient (r_{gxy}) = $\frac{\sigma_{gxy}}{\sigma_{gx} \times \sigma_{gy}}$

Phenotypic correlation coefficient (r_{pxy}) = $\frac{\sigma_{pxy}}{\sigma_{px} \times \sigma_{py}}$

Environmental correlation coefficient (r_{gxy}) = $\frac{\sigma_{exy}}{\sigma_{ex} \times \sigma_{ey}}$

3.3.6 Path Analysis

The path coefficient analysis developed by Wright (1921) was applied to study the direct and indirect effects of each variable under study on green fodder yield. The simultaneous equations which give the estimates of path coefficients are as follows:

$\underline{Ry} = \underset{\sim}{Rx} . \underline{P}$

So that $\underline{P} = \underset{\sim}{Rx}^{-1} . \underline{R_y}$

$\underset{\sim}{Rx}$ is the kxk genotypic intercorrelation matrix of 'k' dependant traits

$\underline{Ry}$ is the vector representing correlation of y with x_i, i= 1,2,…….k

$\underline{P}$ is the vector representing path coefficients

The residual factor (R) which measures the contribution of other factors not defined in the casual scheme was estimated by the formula

$$R = (1-\sum_{i=1}^{k} P_i r_{iy})^{1/2}$$

Indirect effect of i^{th} character via j^{th} character on yield was estimated as $P_j r_{ij}$, i + j = 1, 2….k.

3.4 SELECTION INDEX (DISCRIMINANT FUNCTION)

The Fisher's discriminant function based on a number of variables was used for the formulation of selection index to discriminate the 50 genotypes on the basis of their merit. The genetic worth of a plant is defined by Smith (1936) as:

$$H = a_1G_1 + a_2G_2 + \ldots\ldots\ldots + a_nG_n$$

where $G_1, G_2 \ldots G_n$ are the genotypic values with respect to n characters of the individual genotypes and $a_1, a_2, \ldots\ldots a_n$. the economic weight assigned to each character. As G values are not measurable, another function I, which describes the phenotypic performance of an individual based on 'n' characters $x_1, x_2, \ldots\ldots x_n$ is defined as:

$$I = b_1x_1 + b_2x_2 + \ldots\ldots, b_nx_n$$

where b_1, b_2,……….,b_n are the corresponding coefficients. The ‘b’ coefficients are calculated such that the correlation between H and I is maximum and the selection of genotypes using I gives maximum gain.

The genetic advance that can be expected at a selection intensity of 5 per cent was calculated as follows.

$$GA = \frac{i\underline{a}^{1}\tilde{G}\,\underline{b}}{\sqrt{\underline{b}^{1}\tilde{P}\,\underline{b}}}$$

Where,

$\underline{a}$ is the vector of weights attached to each other character, which is taken as unity in the present case.

$\underline{b}$ is the vector of b- coefficient in the discriminant function,

$\tilde{G}$ is the genotypic variance/ covariance matrix,

$\tilde{P}$ is the phenotypic variance/ covariance matrix, and

i is the selection differential at a given selection intensity, which at 5 per cent is 2.06

Results

4. RESULTS

The data collected from the experiment were statistically analysed and the results are presented below

4.1 ANALYSIS OF VARIANCE

Analysis of variance revealed that all the 11 characters were significant and is presented in Table 2. The mean value along with the F value, standard error and critical difference are presented in Table 3.

4.1.1 Varietal Effect

The plant stand after germination varied from 264.0 (Acc. No. 11446) to 231.5 (Acc. No.172 and 186). The Acc. Nos. 11298, 11079, 11026, 11003, 680, 670 and 902 were on par with the Acc.No.11446.

Plant height at harvest varied from 99.0 cm to 299.0 cm. The maximum height was recorded for Acc.No.11456 (299.0 cm) and it was on par with the Acc.No.11446 (297.0 cm). Minimum plant height at harvest was recorded for the Acc. No. 927 (99.0 cm).

The maximum internodal length was recorded for the Acc. No. 11302 (23.5 cm) and the minimum was recorded for the Acc. No.172 (12.0 cm). The accessions on par with the Acc.No.11302 were Acc. Nos. 698, 821, 914, 11026, 11105, 10299, 11119, 11456, 11745 and 11296.

No significant difference between accessions was noticed for number of tillers per plant.

Leaf stem ratio varied from 0.22 (Acc. Nos.11106 and 670) to 0.51 (Acc. No.11296). There was no significant difference between accessions for this character.

The leaf weight per plant varied from 202.0 to 37.0 g. Maximum leaf weight per plant was recorded for the Acc.No.11079 (202.0 g) and minimum leaf weight per plant for the Acc. No. 11106 (37.0 g). No accessions were found on par with the Acc. No. 11079.

Table 2. Analysis of variance for various characters

Sl. No.	Characters	Mean squares			F value
		Replication	Treatment	Error	
1	Plant stand after germination	0.000	206.00	9.8878	20.83**
2	Plant height at harvest	13.00	5658.745	39.2245	144.56**
3	Internodal length	2.2500	11.8165	2.7194	4.345**
4	Tiller number per plant	0.0400	0.2906	0.1012	2.870**
5	Leaf: stem ratio	0.0018	0.0218	0.0003	40.420**
6	Leaf weight per plant	299.2813	1858.6050	15.9432	116.57**
7.	Leaf area index	0.4209	26.5467	0.3386	78.390**
8	Leaf number per plant	6.2500	34.4549	0.7602	45.32**
9.	Green fodder yield	72.2188	1433.9640	89.3119	16.05**
10	Crude fibre content	10.2383	12.6604	1.3625	9.292**
11	Crude protein content	0.0122	2.0673	0.0328	63.00**

** Significant at 1% level of probability

Table 3. Mean value of various characters

Sl. No.	Treatment (Acc.No.)	Plant stand after germination	Plant height at harvest, cm	Internodal length, cm	Tillers per plant	Leaf: stem ratio	Leaf weight per plant, g	Leaf area index	Leaf number per plant	Green fodder yield, tha^{-1}	Crude fibre content,%	Crude protein content,%
1	.23	245.5	161.0	15.0	1.0	0.32	83.5	7.25	9.0	71.5	23.5	6.30
2	118	239.5	181.5	17.5	1.0	0.37	87.0	5.70	11.0	67.5	27.5	6.00
3	164	251.0	194.0	14.0	1.5	0.29	74.5	8.20	19.5	75.5	25.5	6.35
4	172	231.5	103.5	12.0	1.0	0.29	61.0	8.65	10.0	39.5	24.0	4.85
5	186	231.5	138.5	19.5	1.0	0.49	62.0	6.55	11.5	39.0	21.5	4.35
6	237	241.5	108.5	15.5	1.5	0.34	50.5	8.85	14.5	49.0	22.5	5.05
7	472	237.0	160.0	17.5	1.0	0.35	57.0	6.30	13.0	40.5	23.5	4.55
8	603	239.5	186.0	12.5	1.0	0.27	46.0	6.95	13.5	45.0	24.5	5.10
9	633	233.5	164.5	17.5	1.5	0.28	43.5	3.75	9.5	35.5	21.5	4.75
10	670	263.5	275.5	19.5	1.5	0.22	88.5	13.40	21.0	114.0	22.5	7.80
11	680	261.5	263.5	16.0	1.0	0.28	123.5	12.65	20.5	121.0	32.0	7.60
12	698	237.0	222.5	21.0	1.0	0.31	58.5	5.85	11.5	49.5	24.0	4.95
13	821	248.0	194.5	20.0	1.0	0.30	54.0	9.00	15.0	57.5	29.0	5.95
14	846	255.0	179.0	18.5	1.0	0.24	56.0	4.55	10.5	66.0	28.0	6.50
15	902	259.5	240.0	18.5	2.0	0.24	76.5	13.40	25.0	89.5	27.5	7.05
16	914	232.5	206.5	20.0	1.5	0.26	80.0	8.95	20.5	34.0	26.5	6.65
17	927	250.0	99.0	17.0	1.0	0.47	50.5	9.85	14.5	63.5	23.5	4.55
18	1005	256.0	272.0	13.5	1.0	0.35	75.0	15.10	19.0	63.0	28.5	5.90
19	10046	256.5	210.5	16.5	1.0	0.39	60.0	6.45	14.5	61.5	27.5	5.80
20	11003	261.5	169.5	16.5	1.0	0.34	58.5	7.00	16.0	51.5	24.5	5.55
21	11026	263.5	278.0	21.0	1.0	0.45	154.0	15.30	14.0	154.5	26.5	7.90
22	11049	242.5	235.0	14.5	1.0	0.33	68.0	8.75	20.5	60.0	26.5	6.25
23	11074	238.5	176.5	18.0	1.0	0.28	49.5	6.30	11.5	48.5	27.5	5.00
24	11075	244.0	201.0	16.5	1.0	0.25	50.5	6.10	13.0	54.0	27.0	5.75
25	11079	261.0	266.0	19.5	2.0	0.48	202.0	20.50	22.0	132.0	27.5	8.05
26	11098	232.5	114.5	16.5	1.0	0.41	55.0	6.55	12.5	40.5	23.0	4.80
27	11105	240.5	210.5	20.5	1.5	0.41	69.0	9.80	14.0	53.5	24.0	5.20
28	11106	234.5	184.0	15.5	1.0	0.22	37.0	5.10	10.0	40.0	22.5	4.25
29	11109	240.5	211.0	17.5	1.0	0.50	66.5	11.75	15.5	43.5	24.0	4.60

Table 3. continuing…

Sl.No.	Treatment (Acc. No.)	Plant stand after germination	Plant height at harvest, cm	Internodal length, cm	Tillers per plant	Leaf: stem ratio	Leaf weight per plant, g	Leaf area index	Leaf number per plant	Green fodder yield, t ha^{-1}	Crude fibre content,%	Crude protein content,%
30	11119	251.0	243.0	21.5	1.5	0.29	88.0	6.80	13.5	54.0	23.0	5.30
31	11112	250.0	192.5	15.5	1.0	0.27	85.0	11.80	14.5	59.0	22.5	5.70
32	11128	257.5	261.0	17.5	2.0	0.33	104.0	16.35	22.5	87.5	26.0	6.90
33	11130	243.0	116.0	16.5	1.0	0.34	55.5	8.00	11.0	37.5	22.5	4.55
34	11161	249.5	254.0	18.5	1.0	0.30	64.5	9.65	13.0	62.0	26.0	6.00
35	10299	252.5	285.0	20.5	2.0	0.27	52.0	11.20	20.0	71.0	28.0	6.05
36	11150	244.0	274.0	19.5	1.5	0.43	59.5	9.80	19.5	42.0	21.5	4.70
37	11238	244.5	217.5	16.0	1.0	0.44	61.0	12.75	15.5	42.5	24.5	4.05
38	11241	234.0	198.5	18.5	1.5	0.42	50.5	11.40	12.5	40.0	23.5	4.65
39	11244	232.5	267.0	20.0	2.0	0.44	75.5	13.50	22.0	51.0	23.5	4.65
40	11283	249.5	184.5	20.5	1.5	0.32	61.5	8.05	12.5	60.0	23.5	5.55
41	11298	262.5	192.5	19.5	2.0	0.41	145.0	14.50	22.0	111.0	30.5	6.65
42	11302	253.5	284.0	23.5	1.0	0.25	59.5	19.75	16.5	69.5	24.5	6.25
43	11311	238.5	179.5	18.5	2.0	0.32	53.0	7.25	17.0	42.0	24.5	4.95
44	11357	250.5	180.5	17.5	1.0	0.26	56.5	8.20	13.0	59.5	23.5	6.50
45	11394	254.5	230.5	18.0	2.0	0.36	82.5	8.10	14.0	62.5	23.0	6.10
46	11446	264.0	297.0	18.5	1.0	0.23	101.0	17.50	23.0	111.5	28.0	7.80
47	11456	255.5	299.0	20.5	1.0	0.32	109.0	15.50	21.0	82.5	24.5	7.05
48	11693	237.0	138.5	19.5	1.0	0.34	49.5	9.65	13.0	44.0	22.5	4.80
49	11745	242.0	211.5	20.5	1.0	0.40	65.5	11.95	17.0	57.5	23.0	5.55
50	11296	232.5	218.0	21.0	1.0	0.51	75.0	8.70	13.5	46.0	29.5	5.25
	F-value	20.8338**	144.2656**	4.3453**	2.8709**	40.4203**	116.5763**	78.3903**	45.3232**	16.0557**	9.2921**	63.00**
	SE	2.2234	4.4285	1.1660	0.2249	0.0126	2.8234	0.4114	0.6165	6.6825	0.8253	0.1281
	CD	6.3204	12.5885	3.3146	0.6394	0.0358	8.0257	1.1696	1.7525	18.9955	2.3461	0.3641

**Significant at 1 % level of probability

The maximum leaf area index was recorded for the Acc. No. 11079 (20.50) and minimum was recorded for the Acc. No. 633 (3.75). The Acc. No.11302 was found on par with the Acc.No.11079.

Leaf number per plant varied from 9.0 to 25.0. The maximum leaf number was observed for the Acc. No. 902 (25.0) and minimum for the Acc. No. 23 (9.0). There was significant difference between all the accessions for this character.

Green fodder yield was maximum (154.5 t ha^{-1}) for the Acc. No. 11026 and minimum (34.0 t ha^{-1}) was recorded for the Acc. No. 914. There was significant difference between all the accessions for this character.

The crude fibre value ranged from 32 per cent (Acc.No.680) to 21.5 per cent (Acc. Nos. 186, 633 and 11150). The accession 11298 was on par with the accession 680.

Crude protein value was highest for the Acc.No.11079 (8.05 %) and minimum value was recorded for 11238 (4.05 %). The accessions 11446, 670 and 11026 were on par with the accession 11079 while others differed significantly.

4.2 GENETIC PARAMETERS

Genetic parameters were estimated for all the eleven characters. These include genotypic, phenotypic and environmental variances, genotypic, phenotypic, and environmental coefficients of variation, heritability and genetic advance.

4.2.1 Coefficients of Variation

The values of phenotypic, genotypic and environmental coefficients of variation are given in Table 4.

4.2.1.1 Phenotypic Coefficient of Variation

The maximum PCV was recorded for green fodder yield (43.77 %) followed by leaf weight per plant (42.62 %), leaf area index (37.49 %),

Table 4. Components of variation of eleven characters

Character	GCV (%)	PCV (%)	ECV (%)	Genotypic Variance σ^2_g	Phenotypic Variance σ^2_p	Environmental Variance σ^2_e
Plant stand after germination	4.01	4.21	1.27	98.06	107.94	9.888
Plant height at harvest	25.65	25.83	3.03	2809.76	2848.99	39.225
Internodal length	11.89	15.04	9.20	4.55	7.27	2.719
Tiller number per plant	24.42	35.13	25.22	0.10	0.20	0.101
Leaf: stem ratio	23.49	24.07	16.59	0.01	0.01	0.003
Leaf weight per plant	42.25	42.62	5.56	921.33	937.27	15.943
Leaf area index	37.01	37.49	5.95	13.10	13.44	0.339
Leaf number per plant	26.29	26.88	4.87	16.85	17.61	0.761
Green fodder yield	41.12	43.77	14.98	672.33	761.64	89.312
Crude fibre content	9.48	10.56	4.66	5.65	7.01	1.362
Crude protein content	17.49	17.77	0.72	1.02	1.050	0.033

number of tillers per plant (35.13 %) and leaf number per plant (26.88 %). The minimum PCV was observed for plant stand after germination (4.21 %).

4.2.1.2 Genotypic Coefficient of Variation

Leaf weight per plant showed the maximum GCV (42.25 %) followed by green fodder yield (41.12 %), leaf area index (37.01 %), leaf number per plant (26.29 %) and plant height at harvest (25.65 %). Minimum GCV was observed for plant stand after germination (4.01 %).

4.2.1.3 Environmental Coefficient of Variation

Maximum ECV was observed for number of tillers per plant (25.22 %) followed by leaf: stem ratio (16.59 %), green fodder yield (14.98 %), internodal length (9.20 %) and leaf area index (5.95 %). Crude protein content recorded the minimum ECV (0.72 %).

Number of tillers per plant and leaf: stem ratio showed maximum environmental variability. Crude protein content was least influenced by environment. Green fodder yield was variable at phenotypic, genotypic and environmental levels. Low environmental influence was shown by crude protein content, plant stand after germination and plant height at harvest.

At phenotypic level, green fodder yield was the most variable trait closely followed by leaf weight per plant, while at genotypic level leaf weight per plant was the most variable trait followed by green fodder yield (Fig. 1).

4.2.2 Heritability and Genetic Advance

The value of heritability coefficient (%) and genetic advance (as percentage of mean) at five per cent selection for different characters are presented in Table 5 and Fig. 2.

Number of tillers per plant showed medium heritability (48.33 %). Maximum heritability was observed for plant height at harvest

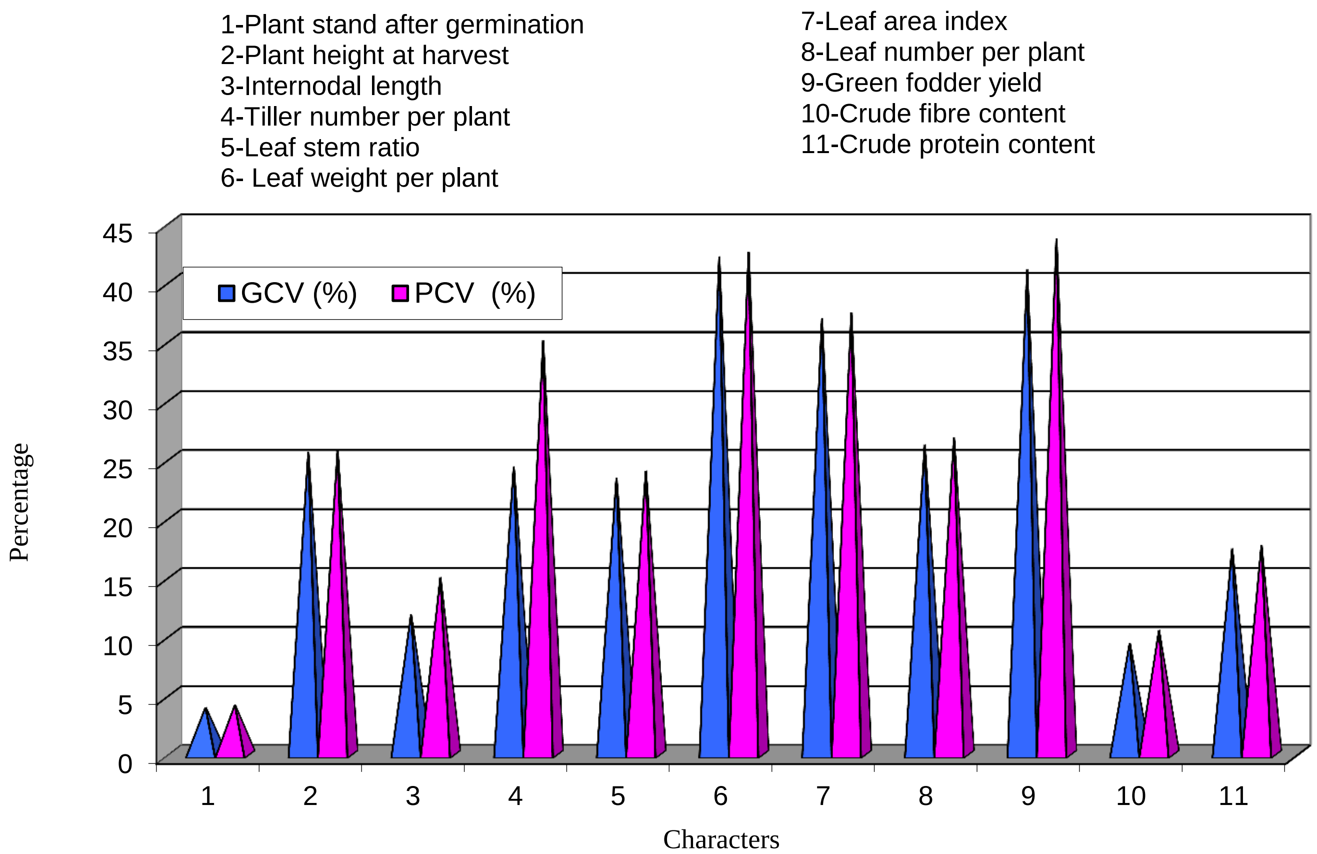

Fig. 1. Genotypic and phenotypic coefficients of variation for eleven characters

Table 5. Heritability and genetic advance (as percentage of mean) of eleven characters

Sl. No.	Character	Heritability (broad sense), %	Genetic advance at 5 % intensity of selection
1	Plant stand after germination	90.83	19.44
2	Plant height at harvest	98.62	108.44
3	Internodal length	62.58	3.47
4	Tiller number per plant	48.33	0.44
5	Leaf: stem ratio	95.17	0.16
6	Leaf weight per plant	98.29	61.99
7	Leaf area index	97.48	7.36
8	Leaf number per plant	95.68	8.27
9	Green fodder yield	88.27	50.18
10	Crude fibre content	80.56	4.39
11	Crude protein content	96.87	2.04

Table 6. Phenotypic and genotypic correlation coefficients of green fodder yield with other characters

Sl. No.	Characters	Correlation coefficients	
		G	P
1	Plant stand after germination	0.8551**	0.7618**
2	Plant height at harvest	0.5668**	0.5308**
3	Internodal length	0.2550	0.1715
4	Tiller number per plant	0.2704*	0.1746
5	Leaf: stem ratio	-0.0493	-0.0296
6	Leaf weight per plant	0.8691**	0.8155**
7	Leaf area index	0.7132**	0.6516**
8	Leaf number per plant	0.5386**	0.4910**
9	Crude fibre content	0.5471**	0.4570**
10	Crude protein content	0.9155**	0.8384**

* significant at 5 % level of probability
** significant at 1 % level of probability

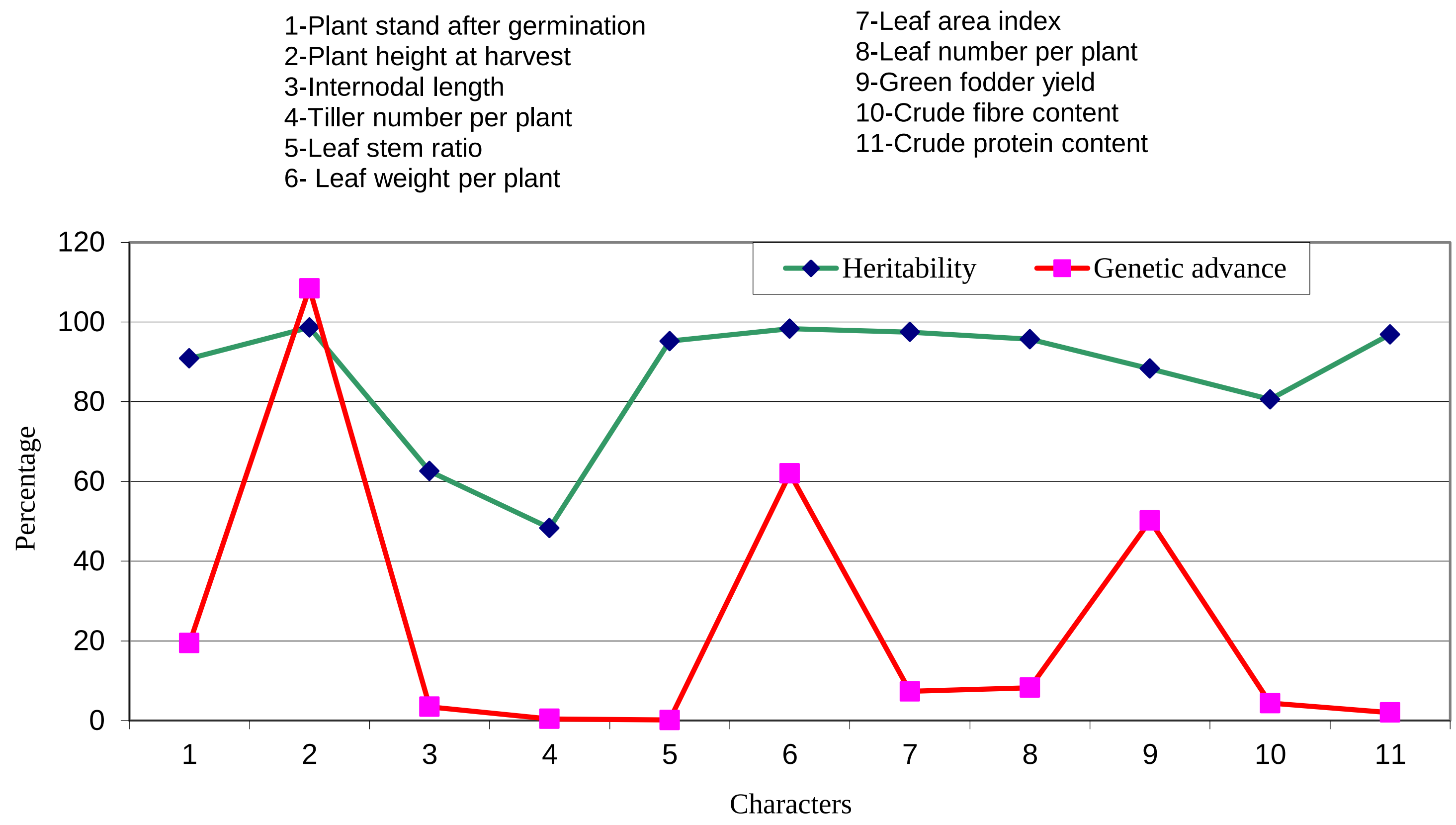

Fig. 2. Heritability and genetic advance for eleven characters

(98.62 %) followed by leaf weight per plant (98.29 %), leaf area index (97.48 %), crude protein content (96.87 %), leaf number per plant (95.68 %), leaf: stem ratio (95.17 %), plant stand after germination (90.83 %) and green fodder yield (88.27 %).

Genetic advance as a percentage of mean was highest for plant height at harvest (108.44 %). Apart from this high genetic advance was shown by leaf weight per plant (61.99 %) and green fodder yield (50.18 %). Moderate genetic advance was shown by plant stand after germination (19.44 %). The characters, leaf:stem ratio (0.16 %), number of tillers per plant (0.44 %), crude protein content (2.04 %), internodal length (3.47 %), leaf area index (7.36 %) and leaf number per plant (8.27 %) showed low genetic advance.

Plant height at harvest, leaf weight per plant and green fodder yield recorded high heritability coupled with high genetic advance. High heritability coupled with low genetic advance was observed for leaf: stem ratio, leaf area index, crude protein content and leaf number per plant. Medium heritability and low genetic advance was observed for number of tillers per plant.

4.2.3 Correlation Analysis

Phenotypic and genotypic correlation between yield and other ten characters were worked out (Table 6) and the inter-correlations between all the pairs were also found out.

4.2.4 Correlation between Green Fodder Yield and Other Characters

At phenotypic level, green fodder yield had positive correlation with all the characters except leaf: stem ratio (Fig. 3). The correlation was significant in the case of plant height at harvest, leaf weight per plant, leaf area index, leaf number per plant, crude fibre content, crude protein content and plant stand after germination at five per cent and one per cent levels of significance. The highest positive correlation was shown by

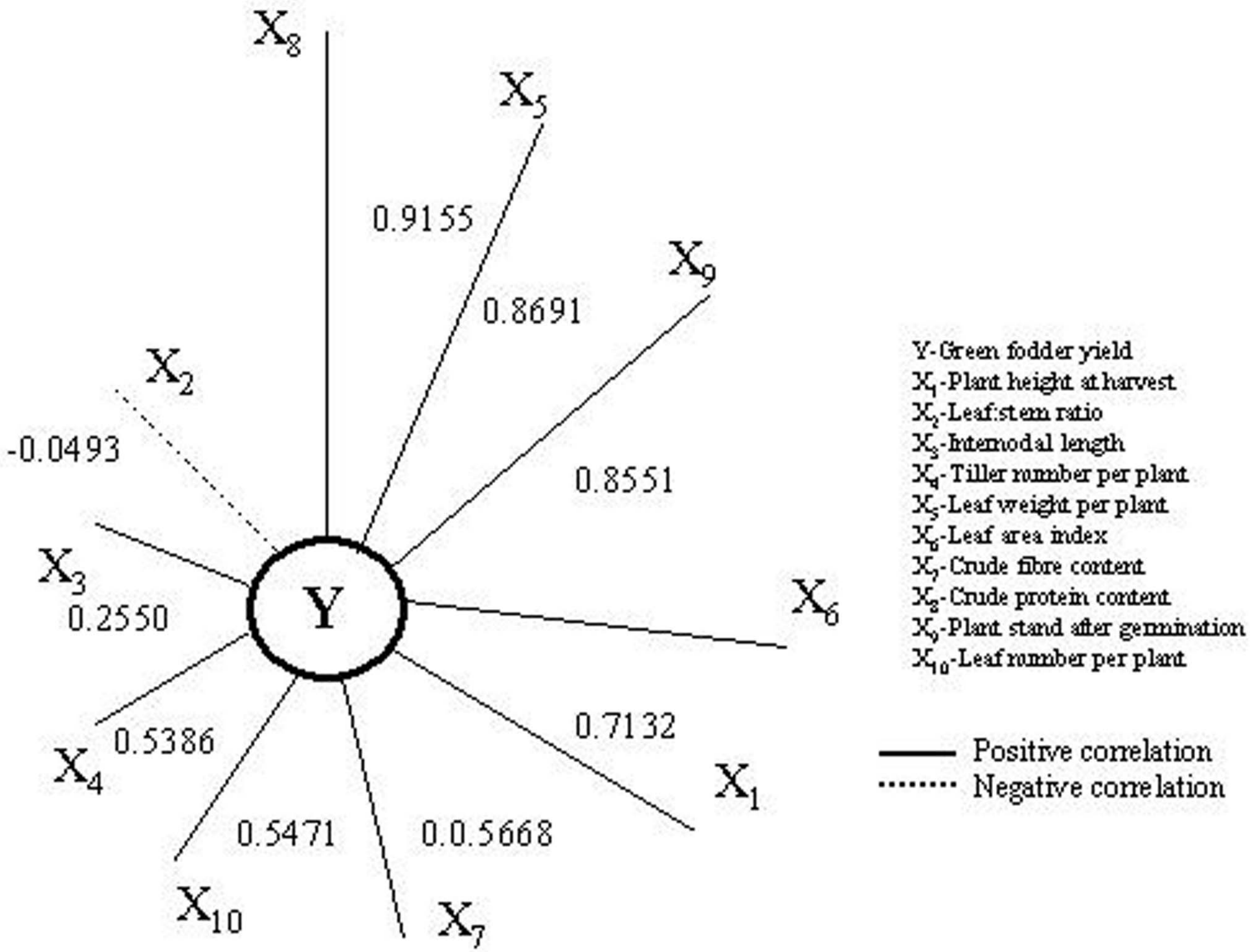

Fig. 3. Correlation diagram showing genotypic correlation between green fodder yield and other characters

crude protein content (0.8384) followed by leaf weight per plant (0.8155), leaf area index (0.6516) and leaf number per plant (0.4910).

Genotypic correlation coefficient was positive for all other characters except leaf: stem ratio. The highest genotypic correlation was exhibited by crude protein content (0.9155) followed by leaf weight per plant (0.8691), plant stand after germination (0.8551), leaf area index (0.7132) and plant height at harvest (0.5668). Plant height at harvest, leaf weight per plant, leaf area index, crude fibre content, crude protein content, plant stand after germination and leaf number per plant were significant both at five per cent and one per cent levels of probability.

There was significant environmental correlation only between plant height at harvest and plant stand after germination, internodal length and number of tillers per plant, leaf area index and leaf number per plant (Table 8).

4.2.5 Correlation Among the Eleven Characters

Plant height at harvest had significant positive correlation with all other characters except leaf: stem ratio, which was insignificant at phenotypic and genotypic levels (Table 7).

Negative significant correlation existed between leaf:stem ratio and crude protein content at genotypic level while negative correlation with plant stand after germination, green fodder yield and crude fibre content were insignificant both at genotypic and phenotypic levels.

Internodal length had positive significant phenotypic correlation with plant height at harvest and number of tillers per plant while with all other characters there was positive correlation, which was insignificant. At genotypic level, internodal length had significant positive correlation only with plant height at harvest while the positive correlation with all other characters were insignificant.

At phenotypic level, number of tillers per plant had significant positive correlation with all the characters, internodal length, leaf weight

Table 7. Genotypic and phenotypic correlation coefficients of eleven characters

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	-	-0.0971	0.4974**	0.3260*	0.4691**	0.5668**	0.6103**	0.3947**	0.6441**	0.5391**	0.6476**
X_2	-0.0955	-	0.2005	0.0461	0.2748*	-0.0493	0.2265	-0.0808	-0.2665*	-0.2180	-0.0072
X_3	0.3974**	0.1457	-	0.2506	0.2443	0.2550	0.2027	0.0498	0.2326	0.1257	0.2215
X_4	0.2331	0.0389	0.2866*	-	0.3800**	0.2704*	0.4041**	0.0597	0.2930*	0.1794	0.6434**
X_5	0.4628**	0.2652*	0.1985	0.2635*	-	0.8691**	0.7337**	0.4856**	0.7633**	0.5794**	0.5169**
X_6	0.5308**	-0.0296	0.1715	0.1746	0.8155**	-	0.7132**	0.5471**	0.9155**	0.8551**	0.5386**
X_7	0.5983**	0.2182	0.1689	0.2803*	0.7167**	0.6516**	-	0.3312*	0.6333**	0.5731**	0.7507**
X_8	0.3421*	-0.0726	0.0277	0.0136	0.4356**	0.4590**	0.2866*	-	0.5912**	0.4608**	0.4018**
X_9	0.6319**	-0.2577	0.1774	0.1969	0.7430**	0.8384**	0.6182**	0.5153**	-	0.7970**	0.6175**
X_{10}	0.5205**	-0.1958	0.1264	0.1816	0.5460**	0.7618**	0.5340**	0.4111**	0.7437**	-	0.5274**
X_{11}	0.6280**	0.0016	0.1827	0.4430**	0.5051**	0.4910**	0.7365**	0.3518*	0.5959**	0.5002**	-

Upper diagonal values-Genotypic correlation Lower diagonals values-Phenotypic correlation

* Significant at 5 % level of probability ** significant at 1 % level of probability

X_1 -Plant height at harvest
X_2 - Leaf:stem ratio
X_3 -Internodal length
X_4 -Tiller number per plant
X_5 -Leaf weight per plant
X_6 -Green fodder yield
X_7 -Leaf area index
X_8 -Crude fibre content
X_9 -Crude protein content
X_{10}-Plant stand after germination
X_{11}-Leaf number per plant

Table 8. Environmental correlation coefficients of eleven characters

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	-										
X_2	-0.0575	-									
X_3	0.0918	-0.0675	-								
X_4	0.0944	0.0483	0.3384*	-							
X_5	0.0598	-0.0225	0.0869	0.0167	-						
X_6	0.0476	0.2071	-0.0861	-0.0081	-0.1319	-					
X_7	-0.0045	0.0015	0.1089	0.0254	-0.0747	-0.1828	-				
X_8	-0.1884	-0.0191	-0.0286	-0.0747	0.0607	-0.0163	-0.0986	-			
X_9	0.1119	-0.0456	-0.0344	-0.0284	-0.0813	-0.1355	0.0984	-0.0893	-		
X_{10}	0.2886*	0.1043	0.1733	0.2885	-0.0388	-0.0382	-0.1108	0.1265	-0.0728	-	
X_{11}	-0.0430	0.1841	0.0887	0.0368	0.1392	-0.0563	0.3469*	-0.0100	0.0382	0.1358	-

*Significant at 5 % level of probability

X_1 -Plant height at harvest
X_2 - Leaf:stem ratio
X_3 -Internodal length
X_4 -Tiller per plant
X_5 -Leaf weight per plant
X_6 -Green fodder yield
X_7 -Leaf area index
X_8 -Crude fibre content
X_9 -Crude protein content
X_{10}-Plant stand after germination
X_{11}-Leaf number per plant

harvest, leaf:stem ratio, crude fibre content, crude protein content, green fodder yield and plant stand after germination. At genotypic level, significant positive correlation were obtained for all characters except leaf:stem ratio, internodal length, crude fibre content and plant stand after germination.

Leaf weight per plant showed significant positive correlation with all characters except internodal length, both at genotypic and phenotypic levels.

Significant positive correlation existed between green fodder yield and characters other than internodal length, leaf: stem ratio and number of tillers per plant. Negative correlation exhibited between green fodder yield and leaf: stem ratio which was insignificant both at genotypic and phenotypic levels.

Leaf area index had significant positive correlation with all other characters except internodal length and leaf:stem ratio at phenotypic and genotypic levels.

There was significant positive genotypic correlation between crude fibre content and characters other than internodal length and number of tillers per plant. Leaf: stem ratio had insignificant negative correlation both at phenotypic and genotypic levels.

Crude protein content had high positive phenotypic correlation with characters other than internodal length and number of tillers per plant, which were insignificant. Negative insignificant correlation existed between leaf: stem ratio and crude protein content. At genotypic level there existed a positive genotypic correlation, with all other characters except leaf:stem ratio.

At phenotypic and genotypic levels high positive correlation existed between plant stand after germination and all other characters except internodal length and number of tillers per plant; while negative insignificant correlation existed with leaf: stem ratio.

Leaf number had positive significant phenotypic correlation with all the characters other than leaf: stem ratio and internodal length. At genotypic level, only leaf: stem ratio had insignificant and negative correlation while all other characters had significant positive correlation.

4.2.6 Path Coefficient Analysis

Path coefficient analysis was carried out using five characters *viz*. plant height at harvest, leaf: stem ratio, leaf area index, leaf weight per plant and number of tillers per plant. Green fodder yield was taken as the effect. The direct and indirect effects are presented in Table 9.

4.2.6.1 Direct Effect

Leaf weight per plant exhibited the maximum direct effect (0.7745) on green fodder yield and its genotypic correlation with green fodder was 0.8691.The genotypic correlation, which was near to the direct effect reveals that this character had maximum effect on yield.

Second highest direct effect on green fodder yield was shown by leaf area index (0.1120) and the total genotypic correlation was 0.7132.This high correlation was due to the positive indirect effect via other characters on green fodder yield.

Plant height at harvest showed positive direct effect on green fodder yield (0.0991) with genotypic correlation of 0.5668.

Direct effect of leaf: stem ratio (-0.2471) and number of tillers per plant (-0.0744) was negative. The maximum negative direct effect was shown by leaf: stem ratio.

4.2.6.2 Indirect Effect

Leaf weight per plant exhibited maximum indirect effect via leaf area index (0.5551) followed by plant height at harvest (0.3584), leaf: stem ratio (0.2054) and number of tillers per plant (0.2041)

Leaf area index showed maximum indirect effect via leaf weight per plant (0.0803) followed by plant height at harvest (0.0670).

Table 9. Direct and indirect effects of five characters on green fodder yield

Sl. No.	Character	Plant height at harvest	Leaf:stem ratio	Tiller number per plant	Leaf weight per plant	Leaf area index	Total correlation
1	Plant height at harvest	**0.0991**	0.0236	-0.0173	0.3584	0.0670	0.5308
2	Leaf:stem ratio	-0.0095	**-0.2471**	-0.0029	0.2054	0.0244	-0.0297
3	Tiller number per plant	0.0231	-0.0096	**-0.0744**	0.2041	0.0314	0.1746
4	Leaf weight per plant	0.0459	-0.0655	-0.0196	**0.7745**	0.0803	0.8156
5	Leaf area index	0.0593	-0.0539	-0.0208	0.5551	**0.1120**	0.6517

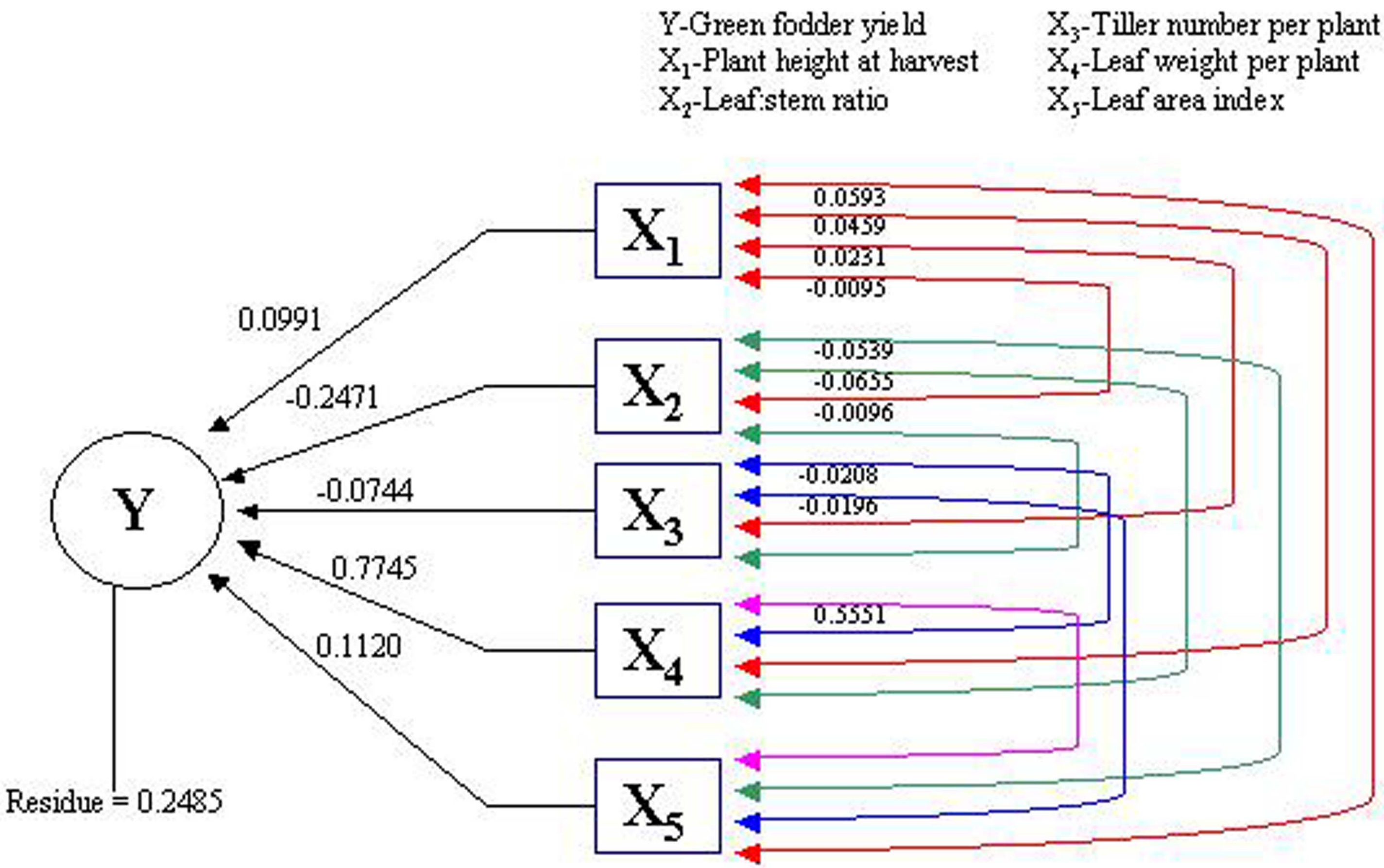

Fig. 4. Path diagram

Plant height at harvest showed maximum indirect effect via leaf area index (0.0593) followed by leaf weight per plant (0.0459).

Number of tillers per plant showed negative indirect effect via all characters and maximum negative indirect effect was shown by leaf area index. (-0.0655).

Residual effect was 0.2485 indicating that 75 per cent contribution was there for selected characters towards green fodder yield.

4.3 SELECTION INDEX (DISCRIMINANT FUNCTION)

A discriminant function was fitted with eleven variables to derive a selection index for 50 accessions based on their performance. The variables used were plant stand after germination (x_1), plant height at harvest (x_2), internodal length (x_3), tillers per plant (x_4), leaf: stem ratio (x_5) leaf weight per plant (x_6), leaf area index (x_7), and leaf number per plant (x_8) contributing towards yield and the quality parameters, crude fibre content (x_9) and crude protein content (x_{10}). The b coefficients of various characters are given below.

Character	b Coefficients
Plant stand after germination	1.1313
Plant height at harvest	0.9655
Internodal length	0.7667
Tiller number per plant	-2.6313
Leaf:stem ratio	6.7209
Leaf weight per plant	1.0926
Leaf area index	2.2862
Leaf number per plant	0.4159
Crude fibre content	1.0554
Crude protein content	11.9603

The index ranged from 2038.42 for accession number 11079 to 1119.72 for accession number 172. The selection index for various

Table 10. Selection index (score) for 50 accessions of fodder sorghum

Sl. No.	Accession number	Selection index	Sl. No.	Accession number	Selection index
1.	11079	2038.42	26	118	1399.22
2.	11026	1951.24	27	11109	1386.95
3.	11446	1850.70	28	821	1386.37
4.	680	1812.86	29	11122	1376.16
5.	11456	1798.09	30	698	1369.38
6.	670	1749.46	31	23	1386.37
7.	11128	1717.25	32	846	1367.60
8.	11298	1703.19	33	11357	1364.26
9.	1005	1624.48	34	11283	1359.01
10.	902	1618.31	35	11075	1349.93
11.	11302	1600.57	36	11003	1341.96
12.	10299	1587.65	37	11241	1304.18
13.	11244	1537.75	38	11302	1274.86
14.	11161	1524.64	39	603	1272.34
15.	11394	1515.26	40	11074	1269.12
16.	11150	1491.06	41	470	1226.08
17.	11049	1482.38	42	11106	1200.65
18.	11119	1453.17	43	11693	1189.10
19.	194	1441.90	44	186	1179.43
20.	10046	1430.16	45	633	1175.88
21.	11745	1426.16	46	927	1160.01
22.	914	1425.80	47	11130	1151.37
23.	11296	1419.97	48	237	1146.16
24.	11238	1409.03	49	11098	1129.68
25.	11105	1404.23	50	172	1119.72

accessions are presented in Table 10. Twenty percent selection was exercised and the superior ones identified were accession numbers 11079 (2038.42), 11026 (1951.24), 11446 (1850.70), 680 (1812.86), 11456 (1798.09), 670 (1749.46), 11128 (1717.25), 11298 (1703.19), 1005 (1624.48) and 902 (1618.31).

Discussion

5. DISCUSSION

Selection of superior genotypes is important for crop improvement programme. For selection there should be good genetic variability in the material chosen. So the preliminary step in crop improvement programme is the search for variability. The phenotypic variance of a crop is the sum of its genotypic and environmental variances. The information on genotypic variance is indispensable because only the genotypic variability is carried through generations and adds to the crop improvement programme.

While evaluating more than one character their intercorrelations also have to be worked out. The parameters like heritability and genetic advance are unavoidable. The phenotypic variance which is due to genotypic variance is expressed by heritability. The magnitude of improvement of selection programme is detected by genetic advance. High heritability together with high genetic advance is an important requirement for selection programme.

The present study was conducted by evaluating 50 accessions of fodder sorghum. Variability and its parameters, correlation coefficient and path analysis were worked out and a selection index was worked out using yield and other contributing factors.

5.1 VARIABILITY

Total variability in a population is due to its genotypic, phenotypic and environmental components. Genetic variability contributes to gain under selection.

Analysis of variance of eleven characters revealed significant differences for all characters *viz*., plant stand after germination, plant height at harvest, internodal length, number of tiller per plant, leaf : stem ratio, leaf area index, leaf weight per plant, number of leaves per plant, green fodder yield, crude fibre content and crude protein content. Borad *et al*.

(1996) reported wide range of variation for almost all the above characters in 49 sorghum genotypes. Similar trend was reported by Desai *et al.* (2000), Patil *et al.* (1996) in sorghum and Sreekumar and Bai (1995) in fodder maize.

High variability was observed for green fodder yield and plant height at harvest. Patil *et al*. (1996) and Borad *et al*. (1996) reported similar results in fodder sorghum.

High variability for green fodder yield was reported by Raut *et al*. (1994). Plant height showed high variability in the studies of Kaushik and Grewal (1991).

In the present study high variability was observed for plant height at harvest, leaf weight per plant and green fodder yield. Similar findings were reported by Patil *et al*. (1996) in fodder sorghum and Berwal and Khairwal (2000) in pearl millet.

The environmental variance recorded was low for all the characters indicating that the phenotypic variance was largely due to genotypic variance and hence it is reliable.

The magnitude of variance can be detected by coefficient of variation which is a unitless measurement and is uniformly applicable for characters with different measurements. The total variation is expressed by PCV which is the summation of GCV and ECV. Only GCV is dependable.

In the present study, all the eleven characters exhibited similar trends for GCV and PCV .The highest PCV and GCV were recorded by the characters, leaf weight per plant, green fodder yield, leaf area index, leaf number per plant and plant height at harvest.

Sabharwal *et al.* (1995) observed high genotypic and phenotypic coefficients of variation for number of leaves per plant and weight of leaves. High genotypic coefficient of variation for green fodder yield was recorded by Sabharwal and Singh (2001) in pearl millet and Borad *et al*. (1996) in fodder sorghum.

Plant height showed high genotypic coefficient of variation in the studies of Sreekumar and Bai (1995) in fodder maize.

The results obtained by Suthamathi and Dorairaj (1995) in fodder pearl millet was in conformity with the present study where high genotypic coefficients of variation was shown by green fodder yield per plant, leaf weight and number of leaves per plant.

Similar findings by Thirumeni and Das (1993) in pearl millet where high genotypic and phenotypic coefficients of variation were recorded for total leaf area per clump.

5.2 HERITABILITY AND GENETIC ADVANCE

The gain from selection of a particular character depends on its heritability estimate which would give the best picture of the extent of genetic advance to be expected by selection. High value of heritability indicates that the phenotype is largely due to the genotypic constitution and hence the character under selection will be effective.

In the present study all the characters, except number of tillers per plant showed high heritability. The number of tillers per plant showed medium heritability (48.33 %). In the evaluation of 50 accessions of fodder sorghum maximum heritability was shown by plant height at harvest, leaf weight per plant, leaf area index, crude protein content, leaf number per plant, leaf:stem ratio and plant stand after germination. This indicates low influence of environment on these characters.

Desai *et al.* (2000) in fodder sorghum observed high heritability for plant height, green fodder yield and total leaf area.

Similar results were reported by Borad *et al.* (1996) in fodder sorghum where green fodder yield had shown high heritability.

In the studies of Sreekumar and Bai (1995) in fodder maize, plant height showed high heritability. The results of Suthamathi and Dorairaj (1995) in fodder maize were also in conformity with the present findings where high heritability was observed for the characters, crude protein content, plant height at harvest, green fodder yield and leaf weight per plant.

Mathur and Patil (1982) in fodder sorghum observed high heritability for number of tillers per plant while in the present study moderate heritability was shown by number of tillers per plant.

High genetic advance was shown by the characters plant height at harvest, leaf weight per plant, green fodder yield and crude protein content. Patil *et al.* (1993) reported high genetic advance for green fodder yield, plant height at harvest and number of leaves per plant..

Similar results were reported by Borad *et al.* (1996) in fodder sorghum and Mitra *et al.* (2001) in pearl millet for green fodder yield

Leaf weight per plant showed high genetic advance in the studies of Singh (1982) in fodder sorghum. Suthamathi and Dorairaj (1995) in fodder maize reported high genetic advance for green fodder yield per plant, plant height and leaf weight which were in agreement with the present findings.

Heritability and genetic advance have to be evaluated together for a better selection programme. According to Panse (1957), the characters with high heritability and high genetic advance were controlled by additive gene action and enable crop improvement through selection.

Plant height at harvest, leaf weight per plant and green fodder yield observed high heritability together with high genetic advance. This was in conformity with the findings of Patil *et al.* (1993) in fodder sorghum where green fodder yield, plant height and number of leaves per plant showed high heritability and genetic advance.

Similar results were reported by Borad *et al*. (1996) in fodder sorghum and Sreekumar and Bai (1995) in fodder maize.

Suresh and Bai (1998) recorded high heritability and high genetic advance for leaf weight per plant and internodal length in fodder bajra.

High heritability and low genetic advance were shown by the characters leaf: stem ratio, leaf area index, crude protein content and leaf number per plant. Non-additive gene action is predominant here and hence there is less scope for selection and crop improvement through these characters.

Number of tillers per plant showed medium heritability and low genetic advance. This is also a limitation on the scope for improvement based on these characters.

5.3 CORRELATION

Correlation analysis gives information on the extent of association between different characters when more than one character is considered. This association may not be always transferred from one generation to another. There are observable (phenotypic) and inherent (genotypic) associations. This genotypic component has to be evaluated and while selecting one desirable character, the intercorrelated one will also be improved automatically. This facilitates simultaneous improvement of more than one character.

In the present study, correlation between green fodder yield and its contributing characters and their intercorrelations were also evaluated.

5.3.1 Correlation among Green Fodder Yield and Other Components

Green fodder yield was positively correlated with all the characters both at phenotypic and genotypic levels except leaf:stem ratio. High positive correlation was shown by the characters, crude protein content, leaf weight per plant, leaf area index, leaf number per plant, plant stand after germination and plant height at harvest. This is in agreement with the findings of Desai *et al*. (1999) where plant height, total leaf area, number of leaves per plant and basal tillering had significant positive correlation with yield in sorghum.

Negative correlation of green fodder yield with leaf: stem ratio was observed by Sood and Ahluwalia (1989) and Vaidyanathan (1982) in fodder sorghum, which support the present study.

Leaf weight per plant showed high positive correlation with forage yield in the studies of Chand and Goverdhan (2001) and Singh (1982) in forage sorghum.

Vaidyanathan (1982) reported positive association with plant height and green fodder yield. Suresh and Bai (1998) observed high positive correlation of leaf area index with green fodder yield.

The high positive correlation of above characters reveal that they are the most reliable characters for selection for improving the fodder yield. The genotypic correlation was higher than phenotypic correlation for all these characters. This indicates that there is less influence of environment on these characters. They are governed by genotype and hence selection is dependable .The genotypic worth is more reflected in the case of these characters.

5.3.2 Correlation Among Yield Components

Inter correlation among yield components is also important for reliable selection programme.

Plant height had significant positive correlation with all other ten characters except leaf:stem ratio at genotypic and phenotypic levels.

Amirthadevarathinam *et al*. (1990) in fodder sorghum reported that there was high positive correlation between plant height and number of leaves per plant. Similar findings were reported by Chauhan and Singh (1975) where plant height was positively correlated with number of leaves per plant, fodder yield and panicle diameter which supports the present study.

Similar results were reported by Singhania *et al*. (1977) where plant height showed significant positive association with leaf area, stem diameter and forage yield in sorghum.

Suresh and Bai (1998) reported positive correlation between plant height and leaf area index and leaf number in fodder bajra.

Plant height had negative association with leaf stem ratio. Dhanakodi and Chandrasekaran (1989) in ragi reported negative correlation between plant height and leaf: stem ratio.

Negative correlation was observed between leaf stem ratio, crude protein content, plant stand after germination, green fodder yield and crude fibre content. This reveals that they are under the control of different genes and improvement of these characters are not possible through the selection of leaf: stem ratio.

Internodal length had shown positive correlation for all the ten characters with significant correlation only between plant height at harvest at genotypic level. At phenotypic level significant correlation observed with number of tillers per plant too. Suresh and Bai (1998) had similar findings in fodder bajra where positive correlation was there between internodal length, leaf stem ratio, leaf weight per plant and crude protein content.

Number of tillers per plant had significant positive genotypic correlation for all the characters except leaf:stem ratio, internodal length, crude fibre content and plant stand after germination. Tillers per plant and plant height had significant positive correlation in the findings of Jhorar and Paroda (1976) in fodder sorghum.

Leaf weight per plant was positively correlated with all other characters except internodal length. This indicates that through selection of leaf weight per plant other characters can also be improved.

Leaf area index showed significant positive correlation with all other characters except leaf:stem ratio and internodal length at genotypic level. Singhania *et al.* (1977) observed significant positive correlation among plant height, total leaf area and stem diameter.

Significant positive correlation was observed between crude fibre content and all the characters except internodal length and number of tillers per plant. For crude protein content, there was negative correlation with leaf:stem ratio.

Plant stand after germination showed positive correlation with characters other than internodal length and number of tillers per plant. Amirthadevarathinam *et al.* (1990) in fodder sorghum observed positive correlation with plant stand after germination and number of leaves per plant. Similar results were also shown by Suresh and Bai (1998) in fodder bajra having significant positive correlation of plant stand with leaf number, leaf weight per plant, plant height and dry matter yield.

Leaf number per plant showed positive significant correlation with all other characters except leaf:stem ratio at genotypic level. Suresh and Bai (1998) in fodder bajra observed positive correlation of leaf number with crude fibre content, leaf area index and dry matter yield. So simultaneous improvement of major characters are possible through the selection of leaf number.

5.4 PATH COEFFICIENT ANALYSIS

The relative importance of various yield attributes by using path coefficient analysis developed by Wright (1921) is effective for selection. Differential emphasis is laid on the component characters. The total genotypic correlation is partitioned into direct and indirect effects of the component characters on yield (Fig. 4). Selection is possible on the basis of these effects.

In the present study, leaf weight per plant exhibited maximum direct effect on green fodder yield followed by leaf area index and plant height at harvest. Leaf weight per plant also exhibited positive indirect effect via leaf area index, plant height, leaf: stem ratio and number of tillers per plant. Jhorar and Paroda (1976) reported similar results in fodder sorghum showing direct effects of leaf weight and plant height on green fodder yield.

Shajan (1993) reported that in guinea grass leaf area index had the maximum direct effect on green fodder yield followed by plant height and leaf: stem ratio.

To increase grain and yield in fodder sorghum the plant height had to be kept at a desirable level and select for number of leaves and leaf breadth (Alikhan *et al*., 1995).

Sreekumar and Bai (1995) in fodder maize reported similar results where plant height can contribute to fodder yield directly.

Leaf area index and leaf number per plant were the most important characters influencing green fodder yield in the studies of Suresh and Bai (1998) in fodder bajra.

In the present study, both leaf weight per plant and leaf area index had high positive direct effect along with high genotypic correlation. Selection of these characters will be effective for developing high yielding varieties of fodder sorghum.

The residual effect was low indicating that adequate characters were utilized for the studies.

5.5 SELECTION INDEX (DISCRIMINANT FUNCTION)

A selection index was formulated to increase the efficiency of selection by taking into account green fodder yield and its contributing quality and quantity aspects.

Santhipriya (1991) in guinea grass formulated a selection index on yield contributing characters for population improvement.

In fodder sorghum, Singh and Singh (1974) reported that selection index developed by including the component characters of fodder yield would be effective for crop improvement.

Swarup and Chaugale (1962) in fodder sorghum reported that selection based on the index formulated by including the characters, plant height, stalk diameter and leaf number was useful for the improvement in fodder yield.

Shajan (1993) developed a selection index in guinea grass and superior genotypes were selected based on this index.

Suresh and Bai (1998) in fodder bajra selected four high yielding varieties by using the selection index .The elite genotypes, HTGPK-1993, SSG-59-3, FP-5714 and LSGP-1995 were selected by exercising 20 per cent selection.

Basheeruddin *et al*. (1999) reported that crude protein content can be used as a selection criterion for improvement of forage yield in maize.

Prasad and Pandey (2000) reported in durum wheat that a selection index based on harvest index, biomass and gains per ear will improve the yield and productivity.

Summary

6. SUMMARY

The present study was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani from August to November 2002 to assess variability, its genetic parameters, correlation, path coefficient analysis and the scope for selection for forage yield and quality in sorghum.

Fifty accessions of fodder sorghum collected from ICRISAT were evaluated in randomized block design with two replications. Data were collected from ten randomly selected plants from a population of 266 plants per entry on eleven characters namely plant stand after germination, plant height at harvest, leaf: stem ratio, internodal length, number of tillers per plant, leaf area index, leaf weight per plant, green fodder yield, number of leaves per plant, crude fibre content and crude protein content.

Analysis of variance revealed significant differences among the accessions for all the characters.

High phenotypic and genotypic coefficients of variation were recorded for leaf weight per plant, green fodder yield, number of leaves per plant, leaf area index and number of tillers per plant. This indicates that there is immense scope for improvement of these characters through selection.

Heritability estimates were high for all the characters except number of tillers per plant suggesting the meagre influence of environment in the expression of these characters.

High values of genetic advance were recorded for plant height at harvest, leaf weight per plant and green fodder yield.

High heritability coupled with high genetic advance was recorded for plant height at harvest, leaf weight per plant and green fodder yield indicating additive gene action for these characters. This suggests that

permanent improvement could be achieved through pedigree breeding by imparting selection on these traits.

Correlation values were positive for all the characters except leaf: stem ratio. The highest correlation was exhibited by crude protein content followed by leaf weight per plant, plant stand after germination, leaf area index and plant height at harvest. All the correlations were significant both at five per cent and one per cent levels of probability indicating that yield can be improved directly by improving these characters.

Leaf weight per plant exhibited maximum positive direct effect on green fodder yield followed by leaf area index and plant height at harvest. Leaf area index showed the maximum indirect effect on green fodder yield via leaf weight per plant. This clearly indicated that leaf weight per plant and leaf area index were the important characters influencing green fodder yield.

A selection index was formulated to improve the efficiency of selection based on both yield and quality attributes. The accessions were ranked and top ranking ten accessions *viz*., Acc. Nos. 11079, 11026, 11446, 680, 11456, 670, 11128, 11298, 1005 and 902 were selected by exercising 20 per cent selection.

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*Originals not seen

VARIABILITY STUDIES IN FODDER SORGHUM
(*Sorghum bicolor* (L.) Moench

BINI.K

Abstract of the
thesis submitted in partial fulfillment of the requirement
for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2003

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8. ABSTRACT

A research programme was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during August to November 2002 with the objective of estimating the variability in important economic characters and to select superior accessions of fodder sorghum .The experiment was conducted using 50 accessions of fodder sorghum collected from ICRISAT adopting a randomized block design with two replications. Data collected on eleven characters were subjected to statistical analysis. Coefficients of variation, heritability, genetic advance, correlation among the characters, path analysis and selection index were estimated.

Analysis of variance revealed significant difference among the accessions for all the characters. Phenotypic and genotypic coefficients of variation were high for leaf weight per plant, green fodder yield, number of leaves per plant, leaf area index and number of tillers per plant. High heritability coupled with high genetic advance for plant height at harvest, leaf weight per plant and green fodder yield revealed the presence of additive gene action. Hence simple pedigree method will be effective for improvement of these traits.

Correlation studies indicated that crude protein content, leaf weight per plant, plant stand after germination, leaf area index and plant height at harvest exhibited significant positive correlation with green fodder yield.

Leaf weight per plant exhibited the highest positive direct effect on green fodder yield followed by leaf area index and plant height at harvest.

Based on selection index with respect to eleven characters studied, ten superior accessions were selected by exercising 20 per cent selection. They were Acc. Nos.11079, 11026, 11446, 680, 11456, 670, 11128, 11298, 1005 and 902.