GENETIC VARIABILITY IN FODDER BAJRA

By

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THESIS

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1997

DECLARATION

I hereby declare that this thesis entitled **"Genetic Variability in Fodder Bajra"** 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 of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellayani,
6-3-1997.

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CERTIFICATE

Certified that this thesis entitled **"Genetic Variability in Fodder Bajra"** is a record of research work done independently by **Sri. S. Suresh,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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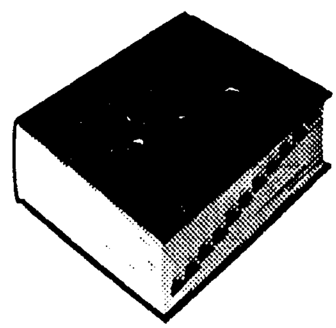
INTRODUCTION

INTRODUCTION

India accounts for 15 per cent of total world's livestock population with only two percent of world's geographical area (Hazra, 1995). This is an indicative of tremendous animal pressure on this limited land resources. Against the projected need of 990 million tonnes of green fodder and 830 million tonnes of dry fodder in India, the present availability is only 370 and 550 million tonnes respectively.

In Kerala, the availability of roughage is only 4.2 million tonnes against the requirement of 6.2 million tonnes needed for feeding 3.4 million adult cattle showing a deficit 41 per cent (Shamsudeen *et al.*, 1985). The area under cultivated fodder crops in Kerala is only 0.1 per cent of the net area sown (Anonymous, 1991). The opportunities for increasing area under cultivated forages are remote because of the preferential need for human food. So the only possibility is to identify and develop superior fodder varieties.

Fodder bajra is a quick growing, short duration, high tillering, drought resistant, high photosynthetic efficient crop suited for the dry farming areas. Eventhough varietal testing has been carried out for identifying high yielding fodder bajra varieties under the AICRP on Forage crops, no systematic effort has been done for analysing the yield and its components. Identification of the most dependable components contributing to fodder yield is a must for the planning of crop improvement programme in bajra. The present work is undertaken to study the genetic parameters and to derive a selection index for forage yield and quality in bajra.



REVIEW OF LITERATURE

REVIEW OF LITERATURE

Fodder bajra (**Pennisetum americanum (L.) K. Schum**) is an annual diploid (2n = 14) fodder crop of the arid and semi arid tracts of India. It can be fed to cattle without harm at any stage of growth. Large amount of diversity present in this crop provides ample chances for improvement. Selection of genotypes suited to a particular soil and climatic condition from the diverse population forms the basic step in any forage breeding programme for getting appreciable fodder yield coupled with good quality. The estimation of genetic variability, heritability, genetic advance, correlation coefficients, discriminant function analysis and path analysis help in the selection of superior genotypes from genetically diverse population. A brief account of work done on these aspects which forms the basis for a critical evaluation and planning of future strategies in fodder bajra breeding is given below.

2.1. Variability

2.1.a. Bajra

Gupta and Gupta (1971) reported high genetic variability for stem thickness, plant height and leaf size and medium for leaf number and green fodder yield.

Gupta and Nanda (1971) studied 176 lines of fodder bajra including Indian varieties and inbreds, African varieties and American inbreds and reported that Indian varieties were variable for leaf number, stem thickness and plant height. The

African varieties were most variable for yield, leaf size, leaf number and stem thickness. The American inbreds recorded maximum variability for plant height.

Sangha and Singh (1973) studied six fodder bajra varieties and reported that fodder yield had maximum phenotypic (14.4%) as well as genotypic (18.72%) coefficient of variation. The PCV and GCV values were 12.77 and 12.22 per cent respectively for tiller number. The least estimates of PCV (4.08%) and GCV (3.85%) were observed for ear length.

Tyagi **et al.** (1980) studied 30 strains of fodder pearl millet and reported maximum GCV value for green fodder yield (14.71%). This was followed by number of leaves (11.77%), leaf breadth (11.18%), dry matter yield and stem girth (9.94%), number of tillers (7.80%), plant height (5.57%) and leaf length (4.67%).

Prakash (1983) reported high genotypic coefficient of variation for plant height, forage yield per plant and dry matter yield per plant in fodder bajra.

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

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

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

Thirumeni and Vijendra Das (1993) evaluated 15genotypes of fodder pearlmillet and reported high genotypic and phenotypic coefficient of variation for leaf area per clump and dry matter yield.

Suthamathi and Dorairaj (1995) studied variability in twenty eight genotypes of fodder pearlmillet and reported that characters stem weight (28.91%), green fodder yield per plant (23.64%), leaf weight (23.21%), number of tillers per plant (22.45%) and number of leaves per plant (22.03%) showed high genotypic coefficients of variation.

2.1.b. Sorghum

Swarup and Chaugale (1962 a) studied seventy divergent collections of fodder sorghum and reported high phenotypic variability for plant height, panicle length, panicle weight and HCN content. Characters like plant height, (53.11%) leaf number (56.27%) and green fodder yield (95.88%) recorded high GCV.

Sindagi *et al.* (1970) estimated variability in F_2 progenies of intervarietal crosses of fodder sorghum and reported maximun GCV for green fodder yield (65.40%).

Arora *et. al* (1975) reported variability in protein content from 4.81 to 7.44 per cent in fodder sorghum.

Rana *et al.* (1976) reported that in forage sorghum the GCV for plant height was 15 per cent and for green fodder yield it was 30 per cent

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

Mathur and Patil (1982) reported GCV estimates of 7.66 per cent, 26.08 per cent 6.76 per cent respectively for plant height, number of tillers per plant and dry matter yield per plant in fodder sorghum.

High genotypic variance for plant height in fodder sorghum was reported by Kaushik (1987).

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

Amirthadevarathinam *et. al.* (1990) studied 30 genotypes of fodder sorghum and reported large genotypic variability for plant height, plant stand, total soluble solids and leaf length. Highest genotypic coefficient of variation was observed for fodder yield (49.65%) followed by total soluble solids (45.23%).

2.1.c. Ragi

Patnaik (1968) reported high phenotypic variation for number of tillers and high genotypic variation for plant height in finger millet.

Kempanna *et. al.* (1971) reported genotypic coefficient of variation exceeding 30 per cent for number of productive tillers less than 15 per cent for plant height in fodder ragi.

Mahudeswaran and Murugasan (1973) reported GCV values of 13.7 per cent for plant height, 29.2 per cent for straw yield, 24.6 per cent for number of productive tillers and 7.2 per cent for number of fingers.

Patnaik and Jana (1973) evaluated eighteen fodder ragi varieties and reported genotypic coefficient of variation of less than 15 per cent for plant height, number of tillers and number of panicles.

Appadurai *et. al.* (1977) reported genotypic coefficient of variation of 9.8 per cent for plant height, 27.1 per cent for number of productive tillers and 44.1 per cent for straw weight.

Mishra *et. al.* (1978) in fodder ragi reported genotypic coefficients of variation values less than 13 per cent for plant height and number of effective tillers.

In fodder ragi, Dhanakodi (1980) reported maximum genotypic variance for fodder yield. The lowest phenotypic as well as genotypic variances were reported for leaf-stem ratio. The highest phenotypic coefficient of variation (91.59%) was observed for

for plant height followed by fodder yield (36.03%), leaf-stem ratio (21.24%) and tiller number (19.53%). Fodder yield recorded the highest genotypic coefficient of variation (30.43%). The GCV values were high for plant height (22.15%), leaf-stem ratio (16.56%) and tiller number (14.06%).

Dhanakodi (1994) studied fifty genotypes of fodder ragi and reported high GCV values for fodder yield (30.43%) and plant height (22.15%) followed by leaf-stem ratio (16.56%), leaf number (16.37%) and internodal length (15.32%).

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

2.1.d. Guinea grass

Burton ***et al.*** (1973) studied 158 accessions of guinea grass and reported variation in plant height and fresh plant weight.

Jose ***et al.*** (1978) studied bulk samples of 28 guinea grass populations and reported significant difference for tiller number, plant height, panicle length and days of flowering.

Sreenivasan ***et al.*** (1986) estimated variability in 24 varieties of guinea grass and reported maximum genotypic coefficient of variation for dry fodder yield (74.58%) followed by green fodder yield (71.29%) and leaf area index (63.61%). The crude fibre content recorded the lowest GCV value (7.52%). The highest phenotypic coefficient of variation was recorded for dry fodder yield (72.15%).

In guinea grass, Joseph (1988) reported maximum phenotypic coefficient of variation (33.15%) for dry matter yield. The lowest PCV value was recorded for tiller count (4.88%). Dry matter yield recorded the maximum GCV (24.03%) and the weight of leaves recorded the minimum GCV (2.10%).

Thejasee Bhai (1988) evaluated 15 guinea grass clones and reported maximum phenotypic coefficient of variation of 35.80 per cent for green fodder yield per hill followed by leaf-area index (28.72%), number of panicles per plot (25.86%) and green fodder yield per hill (26.22%) followed by number of panicles per plot (23.49%) and leaf-area index (22.93%) •

Santhipriya (1991) studied six varieties of guinea grass and reported high phenotypic coefficient of variation for the characters, inflorescence count (241.16%), leaf area (41.32%), leaf-stem ratio (39.33%) and root length (38.4%). High genotypic coefficients of variation were reported for inflorescence count (212.27%), leaf area (33.78%), root length (33.61%) and leaf-stem ratio (29.54%).

Shajan (1993) evaluated 30 guinea grass clones and reported high GCV estimates for number of panicles per hill (89.50%), weight of seeds per hill (56.10%) and leaf-stem ratio (45.22%) . The characters, number of panicles per hill (91.57%), weight of seeds per hill (60.42%) and leaf-stem ratio (48.10%) recorded high PCV values.

2.1.e. Other fodder crops

Vijendra Das (1994) studied 22 genotypes of napier grass accessions and reported high GCV estimates for the characters number of tiller (40.9%), leaf area (35.4%) and leaf length (36.4%). Number of tillers (43.3%), leaf length (36.4%) and leaf area (36.2%) recorded high PCV value.

Amirthadevarathinam and Dorairaj (1994) evaluated 53 genotypes of napier grass and reported that the GCV was the highest in leaf weight (80.69%) followed by green fodder yield, stem weight, crude protein content, dry matter yield and leaves per tiller.

Sreekumar and Suma Bai (1995) evaluated nine fodder maize genotypes and reported that plant height (195.30%) and plant population (58.65%) recorded high genotypic coefficient of variation . The phenotypic coefficient of variation was maximum for plant height (291.76%) and minimum for leaf-stem ratio (0.03%).

2.2. Heritability and genetic advance

2.2.a. Bajra

Gupta and Gupta (1971) in fodder bajra reported high heritability values for leaf number (97.91%), leaf size (72.74%) , plant height (62.78%) and green fodder yield (61.10%).

Gupta and Nanda (1971) studied 176 lines of bajra germplasm consisting of Indian varieties, African varieties, Indian inbreds and American inbreds. Indian varieties recorded high heritability values for leaf number (87.60%) and stem thickness (55.95%) while the Indian inbreds recorded high heritability values for plant height (61.72%) and leaf size (53.11%) . In African varieties heritability was high for leaf number (72.68%) , green fodder yield (61.28%) and stem thickness (60.0%). In American inbreds , higher heritability was estimated for plant height (93.24%) and green fodder yield (63.12%).

Sangha and Singh (1973) evaluated six bajra varieties and reported that the maximum heritability of 93.0 per cent was recorded by fodder yield followed by number of tillers (92.0%). Genetic advance as percentage of mean for fodder yield and number of tillers were 37.18 per cent and 24.08 per cent respectively.

Heritability values of 74.28 per cent for dry fodder yield and 31.72 per cent for green fodder yield were observed in pearl millet by Hooda ***et al*** **.** (1978).

In fodder bajra Tyagi ***et al.*** (1980) reported high heritability values for fodder yield (66.48%), plant height (65.05%) and stem girth (56.09%) . The dry fodder yield (22.01%) and leaf breadth (25.56%) recorded low estimate of heritability. Genetic advance as percentage of mean was reported to be low for all the characters and medium for green fodder yield.

Kumar (1982) reported high heritability and expected genetic advance for green and dry matter yield per plant, leaf weight and stem weight in fodder pearl millet.

Prakash (1983) reported that plant height, forage yield per plant and dry matter yield per plant had high broad sense heritability values in pearl millet.

In fodder bajra Mohan and Dua (1984) reported high heritability value for leaf breadth (63.66%) followed by plant height (52.69%) and leaf length (44.68%). . Green fodder yield (21.16%) recorded the lowest value of heritability. Genetic advance was reported to be high for plant height (37.75%) followed by leaf number (24.88%) and green fodder yield (17.11%).

Kunjir and Patil (1986) based on their studies on pearl millet reported high heritability estimates for tiller number (64.80%) and plant height (56.09%) and the genetic advance for these characters was also high indicating additive gene action.

Thirumeni and Vijendra 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. Low estimate of heritability was noticed for number of tillers per clump. High heritability coupled with high genetic advance estimates were observed for leaf-stem ratio, dry fodder yield, leaf area per clump, green fodder yield, crude protein and calcium content.

Suthamathi and Dorairaj (1995) evaluated 28 genotypes of fodder pearl millet and reported high heritability estimates for crude protein content (99.05%), stem weight (97.95%), plant height on 30th day (96.69%), green fodder yield per plant (94.50%), leaf length (88.77%), dry matter content (85.07%), leaf weight (81:84%), days to 50 per cent flowering (77.54%) and leaf -stem ratio (71.43%). The highly heritable characters like stem weight (58.94%), green fodder yield per plant (47.32%), leaf weight (43.29%), leaf - stem ratio (33.33%), plant height on the 30th day (29.28%), plant height at harvest (27.14%), crude protein content (26.54%) and dry matter content (26.07%) had high genetic advance as percentage of mean indicating that these characters were under the influence of additive gene action.

2.2.b. Sorghum

Swarup and Chaugale (1962 a) observed high heritability values for plant height (98.36%), leaf number (98.18%) and green fodder yield per plant (84.83%) in fodder sorghum. The genetic advance for these traits were 108.53 per cent, 114.88 per cent and 181.31 per cent respectively.

Sindagi *et al.* (1970) studied parents, F_1's and F_2's of two intervarietal crosses of fodder sorghum and reported high heritability and genetic advance for plant height, 82.14 per cent and 37.62 per cent respectively and for green fodder yield, the values of heritability and genetic advance were 86.05 per cent and 72.47 per cent respectively. The number of leaves recorded a heritability estimate of 59.03 per cent and genetic advance of 26.81 per cent.

Sainy and Paroda (1975) reported low estimate of heritability (below 30%) for the characters leaf weight, stem weight and green fodder yield and medium heritability (30 to 40%) for number of tillers in 6x6 diallel cross involving six types of sorghum .

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.

Rana *et al.* (1976) reported high heritability estimates for green fodder yield (64.5%) and plant height (62.7%) in forage sorghum.

Singhania *et al* . (1977) reported low heritability estimates for green forage yield per plant (11.00%) , leaf -stem ratio (14.84%) and leaf area (16.2%) in forage sorghum.

Vaithialingam (1979) reported moderate heritability values for leaf-stem ratio, green fodder yield and dry fodder yield in forage sorghum.

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

Sood and Ahluwalia (1980) reported heritability estimates exceeding 30 per cent for plant height , number of leaves per plant , leaf length, green fodder yield per plant and dry matter yield per plant in fodder sorghum.

In fodder sorghum Mathur and Patil (1982) observed high heritability estimates for leaf number (88.88%) followed by dry matter yield (70.52%), plant height (54.70%) and number of tillers per plant (49.22%). The genetic advance was high for number of leaves per plant (165.28%).

In fodder sorghum Singh (1982) reported high heritability estimates for plant height , leaf number , leaf yield and forage yield. Genetic advance was reported to be high for leaf yield per plant.

Amirthadevarathinam *et al.* (1990) evaluated 30 genotypes of fodder sorghum and reported high heritability estimates for the characters plant height (98.07%), leaf length (97.40%), total soluble salts (96.85%) and grain yield (93.60%). The genetic advance of these characters were 29.31 per cent, 4.61 per cent, 91.77 per cent and 59.28 per cent respectively.

Patil *et al.* (1993) evaluated 45 genotypes of fodder sorghum and reported that green forage yield per plant , plant height and number of leaves per plant recorded higher estimates of heritability and genetic advance .

2.2.c. Ragi

Kempanna and Thirumalachar (1968) reported medium heritability of 32.28 per cent for number of tillers per plant in fodder ragi.

Patnaik (1968) reported high heritability for plant height (68.4%) and low value for number of tillers (15.0%) in fodder finger millet.

Patnaik and Jana (1973) evaluated 18 fodder ragi varieties and reported a heritability value of 37.69 per cent for plant height and 27.82 per cent for number of tillers. Genetic advance as percentage of mean 93.65 per cent and 13.29 per cent for plant height and number of tillers respectively.

Mahudeswaran and Murugasan (1973) observed heritability estimates of 90.30 per cent for plant height, 78.10 per cent for productive tiller number and 67.60% for straw yield in fodder ragi. The maximum genetic gain was shown by straw yield (33.90%) followed by plant height (19.50%) and number of productive tillers (2.30%).

Appadurai ***et al.*** (1977) observed heritability values of 72.50 per cent for straw weight, 51.40 per cent for number of productive tillers and 37.02 per cent for plant height in fodder ragi. The corresponding values of genetic advance were 36.29 per cent, 1.55 per cent and 10.0 per cent respectively.

High heritability was recorded for plant height in finger millet by Shankar (1982).

Dhanakodi (1994) evaluated 50 genotypes of fodder ragi and reported high heritability estimates for the characters days to flowering (99.08%), leaf number (79.67%), leaf length (73.94%) and fodder yield (71.31%). The corresponding values of genetic advance as percentage of mean were 286.68 per cent, 66.69 per cent, 42.90 per cent and 98.79 per cent respectively.

Ramasamy ***et al.*** (1994) evaluated 40 diverse genotypes of fodder ragi and reported high heritability values for days to 50% flowering (96.07%), green fodder yield per plant (84.58%), plant height (72.89%) and number of tillers per plant (72.79%). The corresponding values of genetic advance as percentage of mean were 28.56 per cent, 74.27 per cent, 25.63 per cent and 47.47 per cent respectively.

2.2.d. Guinea grass

Joseph (1988) in guinea grass reported high estimate of heritability for crude protein content (56.98%) followed by inflorescence content (56.16%), dry matter yield (55.56%) and green fodder yield (51.81%). Moderate heritability estimates of 43.67 per cent , 39.37 per cent and 36.59 per cent were recorded for tiller count, leaf-stem ratio and crude fibre content respectively. Low estimate of heritability was recorded for width of leaves (13.95%) and plant height (11.7%) . High genetic advance of 21.51 per cent for inflorescence count was recorded.

Thejasee Bhai (1988) reported high heritability estimates for number of panicles per plant (82.45%) followed by leaf-stem ratio on dry weight basis (66.32%), leaf -stem ratio on fresh weight basis (59.98%) and plant height (54.65%) in guinea grass. Green fodder yield per hill recorded the highest estimate of genetic advance (184.59%).

Santhipriya (1991) in guinea grass reported high estimate of heritability for height of grass (77.59%) followed by inflorescence count (77.48%), leaf area (66.88%) and leaf-stem ratio (56.43%). She has also reported high genetic advance for inflorescence count (384.91) followed by leaf area (56.91) and leaf-stem ratio (45.72). The genetic advance was low for green fodder yield.

2.2.e. Other fodder crops

Vijendra Das (1994) evaluated 32 genotypes of napier grass and reported high heritability values for leaf length (81.5%), green fodder yield (79.9%), number of tillers (79.6%), plant height (79.5%) and stem girth (77.3%). The genetic advance was high for all the characters studied. Number of tillers recorded the maximum genetic advance (81.7%) followed by leaf area (72.1%) and plant height (70.0%).

Amirthadevarathinam and Dorairaj (1994) evaluated 53 genotypes of napier grass and reported high heritability estimate for plant height (99.74%) followed by stem thickness (99.51%), leaf breadth (97.99%) and tillers per clump (97.44%). High genetic advance was recorded for green fodder yield (92.19%) followed by stem weight (80.40%).

Sreekumar and Suma Bai (1995) evaluated nine fodder maize genotypes and reported high heritability estimates for plant height (66.94%), green fodder yield (56.95%), dry fodder yield (54.99%) and plant population (50.55%). Leaf-stem ratio (9.59%) recorded low heritability estimate. The genetic advance was high for plant height (23.55%). Dry fodder yield recorded low genetic advance (0.38 %).

2.3. Correlation Studies

2.3. a. Bajra

Gupta and Athwal (1966) in fodder bajra reported positive phenotypic correlation of leaf size, leaf number, leaf length and tillering with green fodder yield.

Sangha and Singh (1973) in fodder bajra reported that green fodder yield had significant positive phenotypic correlation with number of tillers.

Phul ***et al.*** (1974) in fodder pearl millet reported significant positive correlation between plant height and tiller number.

Tyagi ***et al.*** (1980) in fodder bajra reported that dry matter showed significant positive association with fodder yield both at genotypic and phenotypic levels. They have also observed negative correlation between fodder yield and days to flower. Plant height showed significant positive association with number of leaves and leaf length. Positive significant correlation was observed between stem girth and leaf breadth and also between stem girth and number of tillers. Leaf breadth had positive significant association with number of tillers.

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 flower.

2.3.b. Sorghum

Rohewal *et al.* (1964) in fodder sorghum reported significant positive genotypic correlation of fodder yield with stem diameter and height. Internode number was positively correlated with fodder yield but not significant.

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

Hussain and Khan (1973) in fodder sorghum reported positive and significant phenotypic correlation of fodder yield with tiller number, plant height and leaf number.

Patel *et al.* (1973) reported that fodder yield had positive phenotypic correlation with plant height, stalk diameter and total leaf area in fodder sorghum.

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

Sood (1975) observed negative correlation between plant height and fodder yield in fodder sorghum.

Paroda *et al.* (1975) in fodder sorghum reported that plant height, leaf length, leaf breadth, days to flower and stem girth were significantly and positively correlated with green fodder yield both at genotypic and phenotypic level.

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

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

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

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

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 that plant height was positively correlated with green and dry fodder yield in Eu-sorghum.

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

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

In fodder sorghum Mathur and Patil (1982) reported positive and significant phenotypic correlation between dry matter yield and plant height and also between number of leaves per plant and number of tillers per plant.

In fodder sorghum Vaidyanathan (1982) reported positive phenotypic correlation between height and green fodder yield and negative correlation between leaf-stem ratio and fodder yield.

Girija and Natarajarathinam (1989) reported that green matter yield was found to be correlated with dry matter accumulation in fodder sorghum.

Sood and Ahluwalia (1989) reported significant positive relationship of green fodder yield with dry matter yield, stem girth, leaves per plant, days to 50 per cent flowering and leaf breadth in single cut fodder sorghum. Plant height showed a significant negative association with green fodder yield while leaf length exhibited a significant and positive association with green fodder yield only in second cut in double cut forage sorghum.

Amirthadevarathinam ***et al.*** (1990) evaluated 30 genotypes of fodder sorghum and reported that plant height and total soluble salts showed high positive correlation with fodder yield.

Kaushik and Grewal (1991) evaluated 54 genotypes of fodder sorghum and reported positive correlation between plant height and stem weight.

2.3.c. Ragi

Patnaik (1968) in fodder ragi reported negative correlation of plant height with number of tillers.

Narasimha Rao and Parthasarathi (1968) reported positive correlation of plant height with tiller number in fodder ragi.

Mahudeswaran and Murugasan (1973) evaluated 20 varieties of ragi and reported that plant height was positively and significantly correlated with straw yield.

Appadurai *et al.* (1977) in ragi reported that straw yield was positively and significantly correlated with plant height while number of leaves per culm showed negative and significant correlation with straw yield.

Goud and Lakshmi (1977) observed negative correlation between plant height and tiller number in ragi.

Dhanakodi (1980) in fodder ragi reported significant positive correlation between green fodder yield and plant height and also between days to flower and internodal length. Non significant negative correlation between leaf-stem ratio and plant height and positive correlation between tiller number and leaf-stem ratio were also reported.

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

Ramasamy ***et al.*** (1994) evaluated 40 diverse genotypes of fodder ragi and reported that green fodder yield per plant was positively and significantly correlated with days to 50 per cent flowering, plant height, number of tillers per plant, number of leaves per plant and leaf weight.

2.3.d. Guinea grass

Joseph (1988) in guinea grass reported that green fodder yield had positive significant correlation with dry matter yield and positive non significant phenotypic correlation with leaf breadth, inflorescence count and tiller count and negative non significant correlation with leaf-stem ratio and protein percentage. Protein percentage showed positive non significant correlation with dry fodder yield.

Thejasee Bhai (1988) in guinea grass reported that the genotypic correlation coefficients were slightly higher than the phenotypic correlation coefficients . Plant height was positively correlated with leaf area index, leaf-stem ratio, number of tillers per hill and dry matter yield at the genotypic level.

Phenotypic correlation of number of panicles per hill with dry matter yield was reported to be positive, but not significant.

In guinea grass, Shajan (1993) reported high positive genotypic correlation and significant positive phenotypic correlation of green fodder yield with dry fodder yield, plant height, leaf length and leaf-area index.

2.3.e. Other fodder crops

Achutha Kumar (1982) in fodder maize reported that forage yield was significantly and positively correlated with leaf length, leaf number, leaf breadth and plant height.

In fodder maize Paramathma and Balasubramanian (1986) reported that plant height, stem girth, leaf breadth and leaf number had highly significant positive association with green fodder yield.

Patel and Shelke (1988) in fodder maize reported positive significant association of forage yield with plant height, leaf area per plant, stem girth and internode number per plant.

Chalapathi (1990) in fodder maize reported positive and significant genotypic correlation between plant height with green fodder yield.

Pradhan *et al.* (1993) in bajra-napier hybrid reported that number of tillers per hill was positively associated with green fodder yield and dry fodder yield.

Ramasamy *et al.* (1993) in bajra-napier hybrid reported that regrowth rate and tiller number were not significantly associated with yield.

Amirthadevarathinam and Dorairaj (1994) reported that green fodder yield was significantly and positively correlated with plant height, leaves per tiller, leaf weight, stem weight, dry matter and crude protein yield.

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

2.4. Path analysis

2.4.a. Bajra

Sankaran and Kaliappa (1974) reported that plant height exerted maximum direct effect on straw yield in fodder bajra.

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. They also reported that plant height, green fodder yield, stem girth and number of leaves exerted direct effect on dry matter yield.

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

2.4.b. Sorghum

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.

Patel *et al*. (1973) reported that stalk diameter had large positive direct effect on fodder yield followed by plant height. They also reported that leaf area had indirect effect on yield through plant height and stalk diameter.

Paroda *et al.* (1975) reported that in fodder sorghum stem girth had positive direct effect on green fodder yield but exerted negative direct effect on dry matter yield. Leaf breadth showed high positive effect on both green and dry matter yield. Direct effect of leaf length was high on dry matter yield. Plant height exerted negative direct effect on both green and dry fodder yield.

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

Gopalan and Balasubramanian (1978) reported that leaf length and leaf breadth showed high positive direct effect on green fodder yield in fodder sorghum.

Mathur and Patil (1982) in fodder sorghum reported that number of tillers per plant had positive direct effect on plant height and number of leaves had negative direct effect on dry fodder yield.

2.4.c. Guinea grass

Sreenivasan *et al.* (1986) reported that plant height exerted maximum direct contribution towards forage yield followed by girth of internode and number of days to 50 per cent flowering. Girth of internode and length of panicle showed indirect contribution towards fodder yield.

In guinea grass Thejasee Bhai (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.

Shajan (1993) in guinea grass reported that leaf area index had the maximum direct effect on green fodder yield followed by plant height and leaf-stem ratio. Number of tillers per hill exerted negative direct effect on green fodder yield.

2.4.d. Other fodder crops

In fodder ragi Dhanakodi (1980) reported positive direct effect of days to flowering, number of tillers and leaf number towards fodder yield.

Achuthakumar (1982) reported that leaf length and cob weight had maximum contribution to forage yield in fodder maize.

Patel and Shelke (1984) reported that leaf area per plant , internode number per plant, stem circumference and percentage of nitrogen content had significant positive direct effect on yield in fodder maize.

Paramathma and Balasubramanian (1986) in fodder maize 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.

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) in forage maize reported positive direct contribution of stem girth towards green fodder yield. Other characters such as leaf breadth, leaf-stem ratio and leaves per plant also exhibited positive direct effects on green fodder yield.

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

Paramathma ***et al.*** (1992) in forage maize inbreds 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.

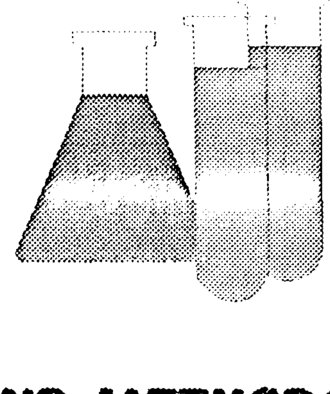
2.5. Selection index (Discriminant function)

Swarup and Chaugale (1962b) 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 fodder yield.

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

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

Shajan (1993) in guinea grass reported that selection index based on plant height, leaf area index, number of tillers per hill, leaf-stem ratio, number of panicles per hill and weight of seeds per hill was useful for the improvement of fodder yield through selection.



MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Thiruvananthapuram during May to August 1995.

3.1. Materials

The experimental material consisted of twenty varieties of fodder bajra ***(Pennisetum americanum (L.) K. Schum)***. supplied by Indian Grassland and Fodder Research Institute (IGFRI), Jhansi. The details of the varieties are presented in Table 1.

3.2. Methods

A field experiment was conducted during May to August 1995 with twenty varieties in a randomised block design with three replications. Two hundred plants were maintained in a plot size of 12 m^2 with a spacing of 30x20 cm. 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 the following characters were recorded and the corresponding means were subjected to statistical analysis.

3.2.1. Plant stand after germination

Table 1. Details of fodder bajra evaluated

SL. NO.	NAME	SOURCE
1.	AFB-9-2-2	IGFRI , Jhansi
2.	AFB-48-1	IGFRI , Jhansi
3.	AFB-65-14	IGFRI , Jhansi
4.	UUJ-1	IGFRI , Jhansi
5.	UUJ-2	IGFRI , Jhansi
6.	UUJ-IV-M	IGFRI , Jhansi
7.	HTGPK-1993	IGFRI , Jhansi
8.	FMH-2	IGFRI , Jhansi
9.	FMH-3	IGFRI , Jhansi
10.	FMH-4	IGFRI , Jhansi
11.	L-74	IGFRI , Jhansi
12.	SSG-59-3	IGFRI , Jhansi
13.	MBFH-7	IGFRI , Jhansi
14.	LSGP-1995	IGFRI , Jhansi
15.	C-1	IGFRI , Jhansi
16	C-8	IGFRI , Jhansi
17.	GK-1005	IGFRI , Jhansi
18.	EGP-1995	IGFRI , Jhansi
19.	IP-3486	IGFRI , Jhansi
20	IP-5714	IGFRI , Jhansi

IGFRI - Indian Grassland and Fodder Research Institute

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

3.2.2. Plant height

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

3.2.3. Leaf - stem ratio

Ten plants selected at random from each plot was harvested and each plant was seperated into leaf and stem. Weight of leaf and stem was recorded seperately for each plant and leaf-stem ratio was worked out.

3.2.4. Internodal length

The internodal length was recorded in centimetres at the time of harvest from a random sample of ten plants per plot and the mean was estimated.

3.2.5. 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 recorded.

3.2.6. 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 .

3.2.7. Leaf weight per plant

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

3.2.8. Leaf area index (LAI)

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

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

3.2.9. Green fodder yield

The green fodder yield per plot was recorded at harvest and estimated in tonnes per hectare.

3.2.10. Dry matter yield

At harvest random sample was taken from each plot, weighed, dried to a constant weight and the dry matter percentage was computed. Based on this estimate the total dry matter yield was computed and expressed in tonnes per hectare.

3.2.11. Crude protein

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

3.2.12. Crude fibre

Dried plant samples collected at the time of harvest was utilised for the estimation of crude fibre content by acid and alkali digestion method (Sadasivam and Manickam, 1992).

3.3. Statistical analysis.

The data collected were subjected to the following statistical analyses.

3.3.1. Analysis of variance and covariance

Analysis of variance and covariance were done

i) to test varietal effect with respect to various traits

ii) to estimate variance components and other parameters like correlation coefficients, heritability, genetic advance etc (Singh and Choudhary, 1979).

Table 2 represents the analysis of variance/ covariance. From this table other genetic parameters were estimated as follows.

Table 2. Analysis of variance / covariance

Source	df	observed mean square XX	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)	Bxx		Bxy		Byy	
Genotype	(v-1)	Gxx	$\sigma^2ex+r\sigma^2gx$	Gxy	$\sigma exy+r\sigma gxy$	Gyy	$\sigma^2ex+r\sigma^2gx$
Error	(v-1)(r-1)	Exx	σ^2x	Exy	σexy	Eyy	σ^2ey
Total	(rv-1)	T_{xx}		T_{xy}		T_{yy}	

Hence we have the following estimate

$\sigma^2g(x) = (G_{xx} - E_{xx}) / r$ $\qquad\qquad$ $\sigma^2ex = E_{xx}$

$\sigma^2g(y) = (G_{yy} - E_{yy}) / r$ $\qquad\qquad$ $\sigma^2ey = E_{yy}$

$\sigma g(xy) = (G_{xy} - E_{xy}) / r$ $\qquad\qquad$ $\sigma e(xy) = E_{xy}$

Variance

	X	Y
Environmental variance ($\sigma^2 e$)	$= \sigma^2 ex = E_{xx}$	$\sigma^2 ey = E_{yy}$
Genotypic variance ($\sigma^2 g$)	$= \sigma^2 gx = \dfrac{G_{xx} - E_{xx}}{r}$	$\sigma^2 gy = \dfrac{G_{yy} - E_{yy}}{r}$
Phenotypic variance ($\sigma^2 p$)	$= \sigma^2 px = \sigma^2 gx + \sigma^2 ex$	$\sigma^2 py = \sigma^2 gy + \sigma^2 ey$

3.3.2 Coefficient of variation

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

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

$$PCV = \frac{\sigma gx}{\bar{x}} \times 100$$

where σgx = genotypic standard deviation

σpx = phenotypic standard deviation.

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

$$GA = \frac{kh^2\, \sigma p}{\bar{x}} \times 100 \qquad \text{(Miller } et\ al.\text{, 1958)}$$

[where k= selection differential = 2.06 at 5 percent selection]

3.3.5. Correlation

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

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

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

3.3.6. Path analysis

The path coefficients were worked out by the method suggested by Wright (1921). The simultaneous equations which give the estimates of path coefficients are as follows.

$$\begin{vmatrix} r_{1y} \\ \\ r_{iy} \\ r_{ky} \end{vmatrix} = \begin{vmatrix} 1 & r_{12} & r_{13} \ldots\ldots r_{1j} \ldots\ldots r_{1k} \\ & 1 & r_{23} \ldots\ldots\ldots\ldots r_{2k} \\ & & r_{ij} \ldots\ldots r_{ik} \\ & & 1 \end{vmatrix} \times \begin{vmatrix} P_1 \\ P_2 \\ P_i \\ P_k \end{vmatrix}$$

ie, $\underline{Ry} = Rx.\underline{P}$

So that $\underline{P} = Rx^{-1} . \underline{Ry}$

where r_{ij} is the genotypic correlation between x_i and x_j.

$$i, j = 1,2, \ldots\ldots k$$

r_{iy} is the genotypic correlation between x_i and Y and P_i is the path coefficient of x_i.

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 different characters on yield obtained as $p_i \ r_{ij}$ for the i^{th} character via j^{th} character.

3.3.7. Selection index

The character index developed by Smith (1937) using discriminant function of Fisher (1936) was used to discriminate the genotypes based on seven characters viz. plant height, leaf weight per plant, tiller number per plant, leaf area index, green fodder yield, crude protein and crude fibre. The selection index is described by the function

$$I = b_1x_1 + b_2 x_2 + \ldots\ldots + b_7 x_7$$

and the merit of a plant is described by the function

$$H = a_1G_1 + a_2 G_2 + \ldots\ldots + a_7 G_7$$

where x_1 , x_2 , ... , x_7 are the phenotypic values and G_1, G_2 , ... G_7 are the genotypic worth of the plant with respect to characters x_1, x_2, ... x_7.

The b coefficients are determined such that the correlation between H and I is maximun. It is also assumed that the economic weight assigned to each character is equal to unity

i.e., a_1 , a_2, ... a_7 = 1

The expected genetic advance was also estimated at a given intensity of selection.

RESULTS

RESULTS

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

4.1. Analysis of variance

Analysis of variance of twelve characters revealed the significance of all the characters (Table 3). The mean value of these characters along with their standard error and critical difference are presented in Table 4.

4.2. Variability

Plant stand after germination of the crop ranged from 188.33 (C-8, IP-3486, IP-5714) to 196.67 (LSGP-1995)

Plant height ranged from 140.67 to 210.00 cm. The variety SSG-59-3 recorded the maximum height (210.00 cm.) and was on par with the variety HTGPK-1993.

The maximum leaf number of 11.67 was recorded by the variety HTGPK-1993 and the minimum of 7.07 by GK-1005. The varieties on par with this were FMH-2 and UUJ-2.

The maximum leaf weight per plant (49.37 g) was recorded by the variety IP-5714 and it was on par with variety HTGPK-1993. The minimum leaf weight (12.40g) was recorded by the variety C-8.

Table 3 . Analysis of variance for twelve characters in fodder bajra

Sl. no.	Character	Mean sum of square			F value (for treatments)
		Replication df = 2	Treatment df = 19	Error df = 38	
1.	Plant stand after germination	12.75	23.21	6.07	3.826**
2.	Plant height (cm)	892.81	797.80	283.84	2.811**
3.	Leaf number per plant	1.25	4.72	0.59	8.031**
4.	Leaf weight per plant (g)	258.33	279.80	46.96	5.958**
5.	Tiller number per plant	0.0471	0.1797	0.0698	2.575**
6.	Internodal length (cm)	53.93	108.36	25.22	4.296**
7.	Leaf area index	0.1655	2.48	0.1551	15.958**
8.	Leaf-stem ratio	0.0294	0.0526	0.0084	6.295**
9.	Green fodder yield (t/ha)	56.82	191.63	38.36	4.996**
10.	Dry matter yield (t/ha)	3.55	14.39	3.56	4.046**
11.	Crude fibre (%)	1.55	10.67	2.02	5.280**
12.	Crude protein (%)	0.0363	5.14	0.1656	31.007**

** Significant at 1% level of probability

Table 4. Mean value of twelve characters in fodder bajra

Sl. no.	Varieties	Plant stand after germin ation	Plant height (cm)	Leaf number per plant	Leaf weight per plant (g)	Tiller number per plant	Interno dal length (cm)	Leaf area index	Leaf-stem ratio	Green fodder yield (t/ha)	Dry matter yield (t/ha)	Crude fibre (%)	Crude protein (%)
1.	AFB -9-2-2	188.67	166.33	9.53	14.90	2.43	26.17	1.77	0.36	23.00	6.43	28.90	7.07
2.	AFB-48-1	190.33	140.67	9.60	19.63	2.07	26.07	1.27	0.60	28.00	7.87	28.83	7.10
3.	AFB-65-14	189.33	168.00	8.20	17.50	2.43	33.13	1.20	0.48	25.00	6.93	29.27	7.00
4.	UUJ-1	189.33	182.00	9.93	14.20	1.73	24.27	1.37	0.41	30.00	8.73	29.20	6.10
5.	UUJ-2	190.67	178.33	10.40	18.53	2.53	24.13	2.33	0.40	21.00	5.90	30.50	7.20
6.	UUJ-IV-M	189.33	180.67	9.53	15.47	2.23	23.77	2.03	0.44	23.00	7.00	27.80	8.57
7.	HTGPK-1993	196.33	195.67	11.67	39.13	2.90	23.90	4.13	0.66	47.00	12.83	30.93	6.37
8.	FMH-2	194.67	187.33	10.50	20.43	2.40	24.33	1.50	0.45	35.00	9.43	32.33	5.03
9.	FMH-3	194.00	171.00	10.23	26.57	2.30	22.70	2.20	0.53	38.00	9.97	31.23	6.10
10.	FMH-4	194.67	167.67	9.77	23.77	2.47	29.83	1.67	0.57	36.67	10.60	33.40	5.47
11.	L-74	189.33	161.00	9.47	15.93	2.63	23.63	1.47	0.47	25.00	6.13	32.20	5.27
12.	SSG-59-3	192.33	210.00	8.30	23.13	2.43	26.73	3.93	0.49	27.00	7.87	27.90	6.70
13.	MBFH-7	191.67	147.33	7.60	29.00	2.33	36.37	1.93	0.55	24.00	7.10	28.93	6.50
14.	LSGP-1995	196.67	167.67	10.13	38.23	2.63	29.73	3.10	0.60	43.33	11.17	27.60	7.20
15.	C-1	189.00	168.67	8.53	30.70	2.30	35.60	1.90	0.63	25.00	8.40	26.77	10.83
16.	C-8	188.33	170.33	7.43	12.40	2.60	24.83	1.23	0.45	22.00	6.00	31.73	6.07
17.	GK-1005	190.33	156.67	7.07	17.13	2.17	26.47	1.43	0.46	24.33	6.27	26.93	8.60
18.	EGP-1995	188.67	151.33	7.30	20.17	2.50	31.77	1.50	0.55	19.00	4.43	28.50	6.47
19.	IP-3486	188.33	161.33	8.13	26.33	2.47	22.07	2.30	0.71	17.33	4.50	28.70	6.37
20.	IP-5714	188.33	161.00	9.67	49.37	2.20	46.20	3.63	0.94	29.67	8.07	29.80	6.60
	F value (19,38)	3.826**	2.811**	8.031**	5.958**	2.575**	4.296**	15.958**	6.295**	4.996**	4.046**	5.280**	31.007**
	SE	1.422	9.727	0.442	3.957	0.153	2.900	0.227	0.053	3.576	1.089	0.821	0.235
	CD	4.072	27.856	1.267	11.331	0.437	8.304	0.651	0.151	10.241	3.118	2.351	0.673

Tiller number per plant was maximum for the variety HTGPK-1993 (2.90). The varieties on par with this were L-74, LSGP-1995, C-8 and UUJ-2. The variety UUJ-1 recorded the minimum value (1.73) •

The maximum internodal length (46.20 cm) was recorded by the variety IP-5714 and none of the varieties was found to be on par with this variety. The variety IP-3486 recorded the minimum value (22.07 cm) .

The maximum leaf area index was recorded by the variety HTGPK-1993 (4.13) and the varieties on par with this were SSG-59-3 and IP-5714. The maximum value was recorded by the variety AFB-65-14 (1.20).

Leaf-stem ratio ranged from 0.36 to 0.94. The maximum value was recorded by the variety IP-5714 and none of the varieties was found to be on par with this variety.

The variety HTGPK-1993 recorded the maximum green fodder yield per hectare (47.06 t) and it was on par with LSGP-1995 and FMH-3. The minimum value was recorded by the variety IP-3486 (17.33 t)

Dry matter yield per hectare was maximum for the variety HTGPK-1993 (12.83 t) and was on par with LSGP-1995 , FMH-3 and FMH-4. The variety EGP-1995 recorded the minimum value (4.43 t).

Crude fibre content was maximum for the variety FMH-4 (33.40%) and minimum for the variety C-1 (26.77%). The varieties FMH-2, L-74, C-8 and FMH-3 were on par with the variety FMH-4.

Crude protein content was maximum for the variety C-1 (10.83%) and minimum for the variety FMH-2 (5.03%). None of the varieties was found to be on par with the variety C-1.

4.3. Genetic parameters

Genetic parameters were estimated for all the twelve characters Table 5 and Figure 1 indicate phenotypic and genotypic variances and coefficient of variation. Heritability and genetic advance are presented in Table 6 and Figure 2.

4.3.a. Phenotypic and genotypic coefficient of variation

Maximum phenotypic coefficient of variation was recorded for leaf weight per plant (47.24) followed by leaf area index (46.00), dry matter yield (34.40), green fodder yield (33.58), leaf-stem ratio (28.26) and internodal length (25.91). Plant stand after germination recorded the minimum value (1.80).

Maximum genotypic coefficient of variation was recorded for leaf weight per plant (37.29) followed by green fodder yield (25.38), dry matter yield (24.42), leaf- stem ratio (22.58), crude protein content (18.85) and internodal length (18.74). Plant stand after germination recorded the minimum genotypic coefficient of variation (1.25).

Table 5. Components of variation of twelve characters in fodder bajra

Sl. no.	Characters	Genotypic variance $\sigma^2 g$	Phenotypic variance $\sigma^2 p$	Environm-ental variance $\sigma^2 e$	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)
1.	Plant stand after germination	5.92	11.78	6.07	1.25	1.80
2.	Plant height (cm)	171.32	455.16	283.84	7.72	12.58
3.	Leaf number per plant	1.38	1.96	0.59	12.82	15.31
4.	Leaf weight per plant (g)	77.61	124.58	46.96	37.29	47.24
5.	Tiller number per plant	0.04	0.11	0.07	8.02	13.66
6.	Internodal length (cm)	27.71	52.93	25.22	18.74	25.91
7.	Leaf area index	0.77	0.93	0.16	4.98	46.00
8.	Leaf-stem ratio	0.02	0.02	0.01	22.58	28.26
9.	Green fodder yield (t/ha)	51.09	89.45	38.36	25.38	33.58
10.	Dry matter yield (t/ha)	3.61	7.17	3.56	24.42	34.40
11.	Crude fibre (%)	2.88	4.90	2.02	5.74	7.49
12.	Crude protein (%)	1.66	1.82	0.17	18.85	19.77

FIg. 1. Genotypic coefficient of variation for 12 characters

X1	-	Plant stand after germination
X2	-	Plant height
X3	-	Leaf number per plant
X4	-	Leaf weight per plant
X5	-	Tiller number per plant
X6	-	Internodal length
X7	-	Leaf area index
X8	-	Leaf-stem ratio
X9	-	Green fodder yield
X10	-	Dry matter yield
X11	-	Crude fibre
X12	-	Crude protein

4.4. Heritability and genetic advance

High heritability estimates were observed for crude protein content (90.91%), leaf area index (83.31%), leaf number per plant (70.09%), leaf-stem ratio (65.21%) and leaf weight per plant (62.30%). Medium estimates were obtained for crude fibre (58.79%), green fodder yield (57.12%), internodal length (52.35%), dry matter yield (50.38%), plant stand after germination (48.51%), plant height (37.64%) and tiller number per plant (34.91%).

The genetic advance as percentage of mean was maximum for plant height (16.54%) and minimum for leaf-stem ratio (0.20%). Leaf weight per plant (14.32%) and green fodder yield (11.13%) recorded medium estimates of genetic advance. Internodal length (7.85%), plant stand after germination (3.43%), dry matter yield (2.78%), crude fibre content (2.68%), crude protein content (2.53%), leaf number per plant (2.02%), leaf area index (1.65%) and tiller number per plant (0.23%) recorded low estimates of genetic advance. Leaf weight per plant and internodal length had comparatively higher values for both heritability and genetic advance.

4.5. Correlation

Phenotypic and genotypic correlations between yield and other eleven characters and their ***inter se*** associations were worked out. The results on correlations have been split up under the following catagories.

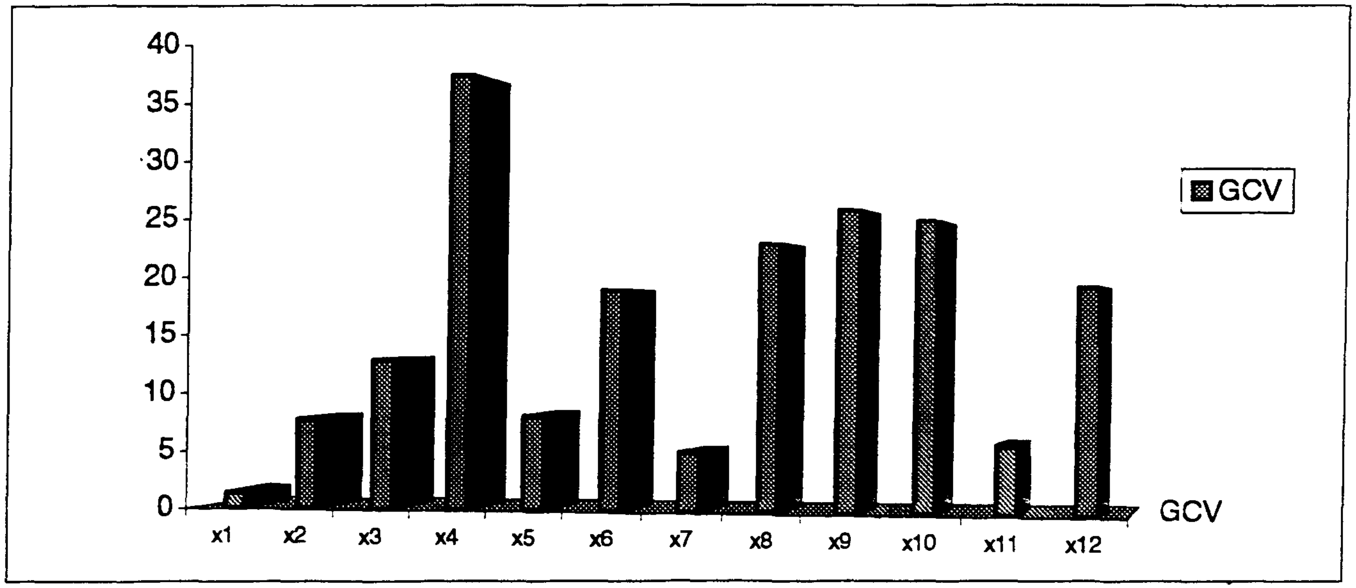


Fig. 1. Genotypic coefficient of variation for 12 characters

Table 6. Heritability and genetic advance (as percentage of mean) of twelve characters in fodder bajra

Sl. no.	Characters	Heritability (broad sense) (%)	Genetic advance at 5% intensity of selection
1.	Plant stand after germination	48.51	3.43
2.	Plant height	37.64	16.54
3.	Leaf number per plant	70.09	2.02
4.	Leaf weight per plant	62.30	14.32
5.	Tiller number per plant	34.91	0.23
6.	Internodal length	52.35	7.85
7.	Leaf area index	83.31	1.65
8.	Leaf-stem ratio	65.21	0.20
9.	Green fodder yield	57.12	11.13
10.	Dry matter yield	50.38	2.78
11.	Crude fibre	58.79	2.68
12.	Crude protein	90.91	2.53

FIg. 2. Heritability and genetic advance for 12 characters

X1	-	Plant stand after germination
X2	-	Plant height
X3	-	Leaf number per plant
X4	-	Leaf weight per plant
X5	-	Tiller number per plant
X6	-	Internodal length
X7	-	Leaf area index
X8	-	Leaf-stem ratio
X9	-	Green fodder yield
X10	-	Dry matter yield
X11	-	Crude fibre
X12	-	Crude protein

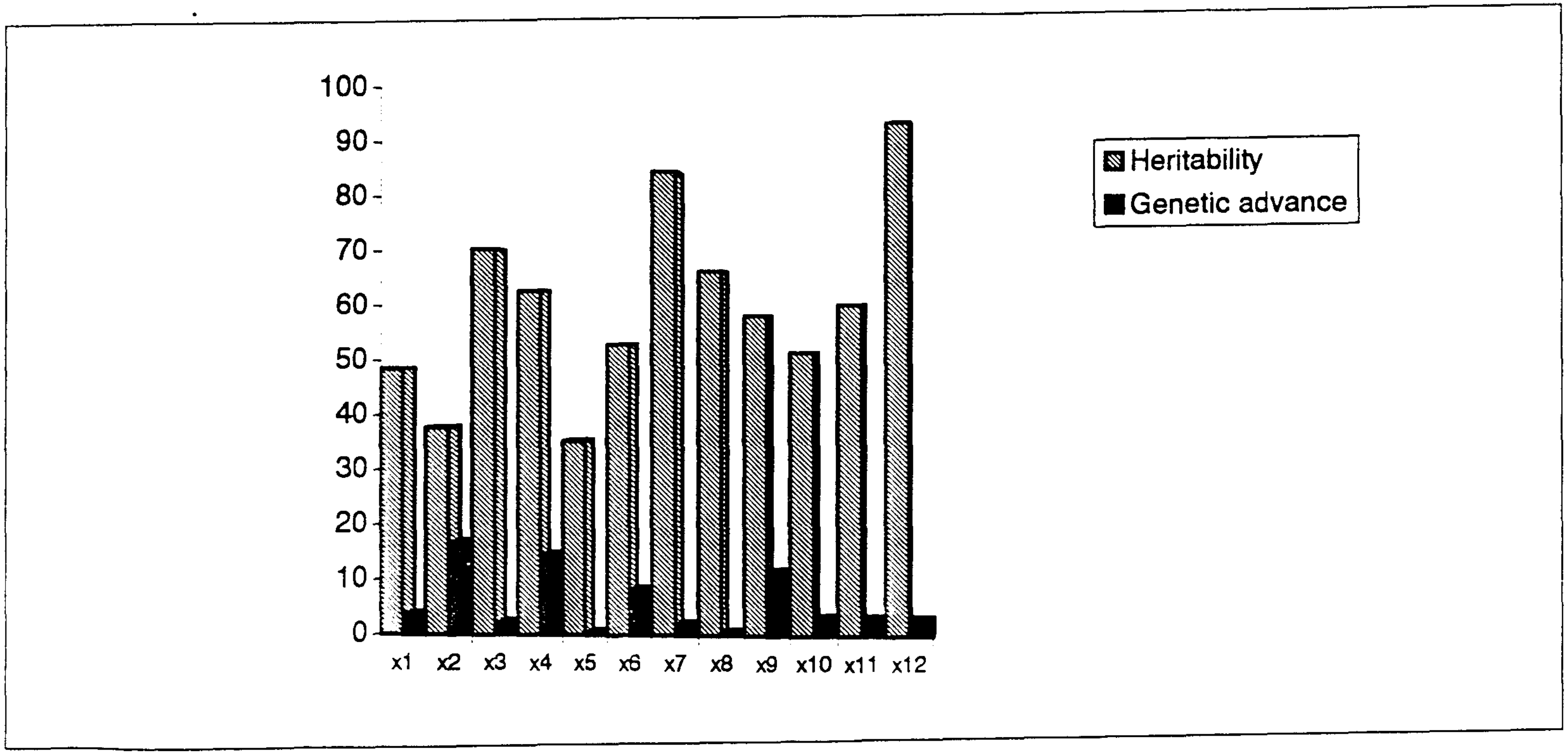


Fig.2. Heritability and genetic advance for 12 characters

4.5.a. Correlation between green fodder yield and other components

The estimate of correlation coefficients between green fodder yield and other components are given in Table 7 and Figure 3.

All the genotypic correlations between green fodder yield and other characters were positive except for those with crude protein content and internodal length. Dry matter yield has the highest positive genotypic correlation with green fodder yield (0.9781) followed by plant stand after germination (0.9739), leaf number per plant (0.8568), leaf weight per plant (0.6364), leaf area index (0.5351), crude fibre content (0.4055) and leaf-stem ratio (0.3011). Crude protein content had the highest negative influence on green fodder yield (- 0.2724).

At the phenotypic level also dry matter yield had the highest significant positive correlation with green fodder yield (0.9560) followed by plant stand after germination (0.7747), and leaf number per plant (0.5194). Plant height, leaf weight per plant, tiller number per plant, internodal length, leaf area index, leaf-stem ratio and crude fibre had positive but non significant correlations with green fodder yield. Crude protein content had non significant negative correlation with green fodder yield (- 0.2158).

4.5.b. Correlation between pair of characters other than those with green fodder yield

Table 8 and Figure 4 depict the correlation among twelve characters in all possible combinations.

Table 7. Phenotypic and genotypic correlation coefficients of green fodder yield with other characters in fodder bajra

Sl. no.	Characters	Coefficient of correlation	
		G	P
1.	Plant stand after germination	0.9739	0.7747 **
2	Plant height	0.3664	0.3448
3.	Leaf number per plant	0.8568	0.5194*
4.	Leaf weight per plant	0.6364	0.3830
5.	Tiller number per plant	0.2624	0.2042
6.	Internodal length	-0.0914	0.0141
7.	Leaf area index	0.5351	0.3607
8.	Leaf-stem ratio	0.3011	0.1238
9.	Dry matter yield	0.9781	0.9560**
10.	Crude fibre	0.4055	0.2193
11.	Crude protein	-0.2724	-0.2158

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 8. Phenotypic and genotypic correlation coefficients of twelve characters in fodder bajra

Character	Plant stand after germination	Plant height	Leaf number per plant	Leaf weight per plant	Tiller number per plant	Internodal length	Leaf area index	Leaf-stem ratio	Green fodder yield	Dry matter yield	Crude fibre	Crude protein
Plant stand after germination	-	0.4838	0.6987	0.4883	0.5204	-0.2503	0.4829	0.1024	0.9739	0.9516	0.3682	-0.3063
Plant height	0.2921	-	0.4784	-0.1024	0.2291	-0.6461	0.6659	-0.3756	0.3664	0.4581	0.1990	-0.0836
Leaf number per plant	0.4207*	0.3618	-	0.3186	0.1679	-0.3030	0.4068	0.0299	0.8568	0.8781	0.4870	-0.2802
Leaf weight per plant	0.2686	0.1261	0.2976	-	0.2471	0.6202	0.8401	0.9324	0.6364	0.6909	-0.0998	0.0803
Tiller number per plant	0.2691	0.2045	0.1215	0.1942	-	-0.2069	0.4586	0.0407	0.2624	0.1383	0.4797	-0.2546
Internodal length	-0.1221	-0.0624	-0.1730	0.5703**	-0.0806	-	0.2175	0.7952	-0.0914	0.0275	-0.3091	0.2934
Leaf area index	0.3615	0.3892	0.3575	0.6115**	0.2877	0.1577	-	0.5900	0.5351	0.5393	-0.1206	0.0178
Leaf-stem ratio	-0.0427	-0.1151	0.1181	0.7732**	0.0893	0.4146	0.3992	-	0.3011	0.3033	-0.1288	0.0525
Green fodder yield	0.7747**	0.3448	0.5194*	0.3830	0.2042	0.0141	0.3607	0.1238	-	0.9781	0.4055	-0.2724
Dry matter yield	0.7199**	0.3707	0.5041*	0.3150	0.1409	0.0023	0.3572	0.1044	0.9560**	-	0.3496	-0.1128
Crude fibre	0.2267	0.0746	0.3421	-0.0693	0.2038	-0.1280	-0.1264	-0.0030	0.2193	0.1644	-	-0.8494
Crude protein	-0.2478	-0.1089	-0.2159	0.0683	-0.1911	0.1725	0.0094	0.0433	-0.2158	-0.1124	-0.6656**	-

Significant at 5% level of probability   Upper diagonal values - Genotypic correlation coefficients
Significant at 1% level of probability   Lower diagonal values - Phenotypic correlation coefficients

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

Y - Green fodder yield (t/ha)

X_1 - Plant stand after germination

X_2 - Plant height (cm)

X_3 - Leaf number per plant

X_4 - Leaf weight per plant (g)

X_5 - Tiller number per plant

X_6 - Internodal length (cm)

X_7 - Leaf area index

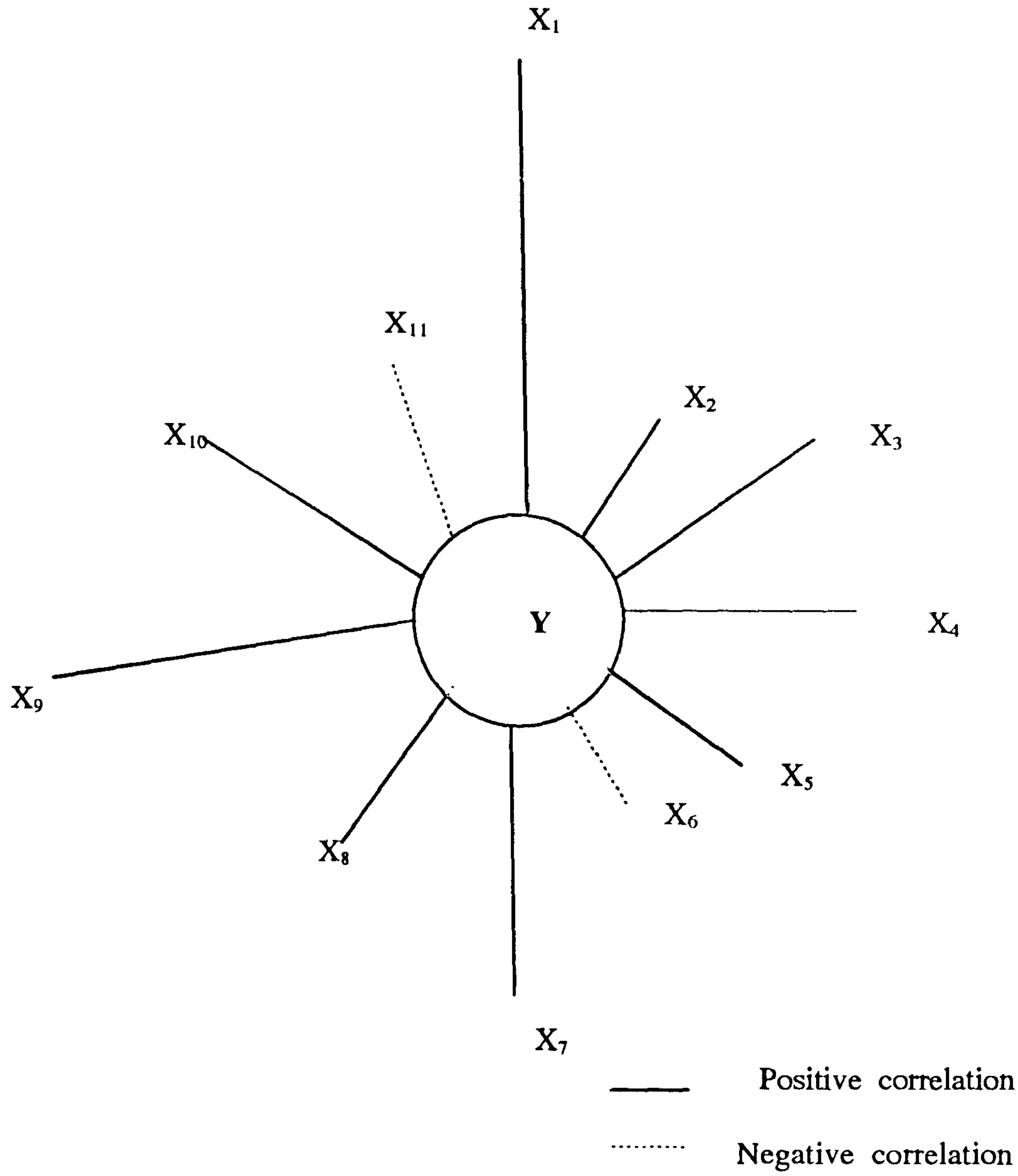
X_8 - Leaf-stem ratio

X_9 - Dry matter yield (t/ha)

X_{10} - Crude fibre (%)

X_{11} - Crude protein (%)

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



At the genotypic level plant stand after germination had high positive correlation with dry matter yield (0.9516) followed by leaf number per plant, tiller number per plant, leaf weight per plant, plant height and leaf area index. Crude protein content had high negative correlation with plant stand after germination (- 0.3063) followed by internodal length (- 0.2503).

Plant stand after germination had high positive and significant phenotypic correlation with dry matter yield (0.7199) and leaf number per plant (0.4207) and non significant negative correlation with internodal length (- 0.1221) and leaf-stem ratio (- 0.0427).

Plant height had high positive genotypic correlation with leaf area index (0.6659) followed by leaf number per plant and dry matter yield. Maximum negative genotypic correlation between plant height and internodal length (- 0.6461) was also noticed.

Plant height had positive non significant phenotypic correlations with leaf-stem ratio (0.7732), leaf area index (0.6115) and internodal length (0.5703). Plant stand after germination, plant height, leaf number per plant, tiller number per plant, dry matter yield and crude protein content recorded positive but non significant phenotypic correlation with leaf weight per plant. Crude fibre content had negative but non significant phenotypic correlation with leaf weight per plant.

Tiller number per plant had high positive genotypic correlation with plant stand after germination (0.5204), crude fibre (0.4797) and leaf area index

(0.4586) and negative genotypic correlation with crude protein (- 0.2546) and internodal length (- 0.2069).

Tiller number per plant had high positive phenotypic correlations with leaf area index (0.2877), plant stand after germination (0.2691), plant height (0.2045) and crude fibre (0.2038) and negative phenotypic correlation with crude protein (-0.1911) and internodal length (-0.0806).

Internodal length had high positive genotypic correlation with leaf-stem ratio (0.7952), follwed by leaf weight per plant and crude protein content. Internodal length had high negative genotypic correlation with plant height (-0.6461), followed by leaf number per plant (-0.3030), crude fibre (-0.3091), plant stand after germination (-0.2503) and tiller number per plant (-0.2061).

Internodal length had high significant positive phenotypic correlation with leaf weight per plant (0.5703) and non significant positive phenotypic correlation with leaf-stem ratio (0.4146). Plant stand after germination , plant height, leaf number per plant, tiller number per plant and crude fibre content showed negative phenotypic correlation with internodal length.

Leaf area index had high positive genotypic correlation with leaf weight per plant (0.8401) followed by plant height, leaf-stem ratio and dry matter yield. Leaf area . index had negative genotypic correlation with crude fibre content (- 0.1206).

Fig. 4. Correlation diagram showing genotypic correlation in all possible combinations between twelve characters.

X_1 - Plant stand after germination

X_2 - Plant height (cm)

X_3 - Leaf number per plant

X_4 - Leaf weight per plant (g)

X_5 - Tiller number per plant

X_6 - Internodal length (cm)

X_7 - Leaf area index

X_8 - Leaf-stem ratio

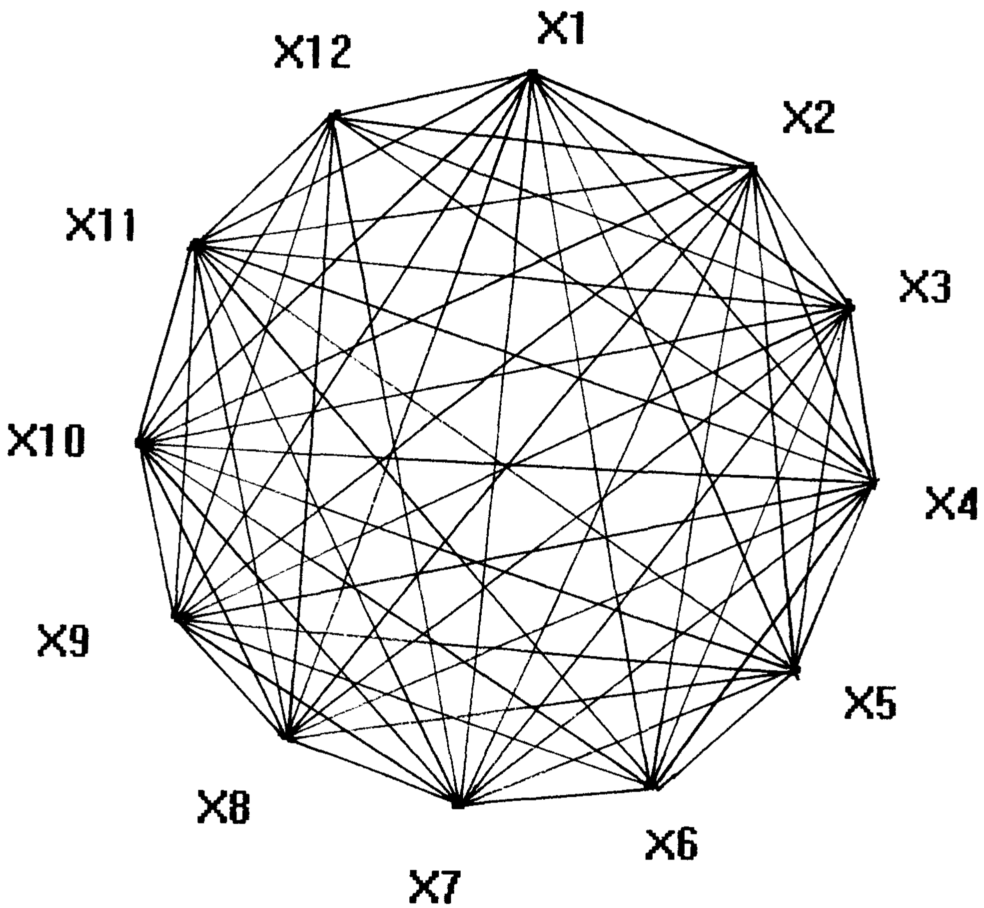
X_9 - Green fodder yield (t/ha)

X_{10} - Dry matter yield (t/ha)

X_{11} - Crude fibre (%)

X_{12} - Crude protein (%)

Fig. 4 . Correlation diagram (showing genotypic correlations in all possible combination)



Negative correlation

Positive correlation

Leaf area index had high positive significant phenotypic correlation with leaf weight per plant (0.6115). Plant stand after germination, plant height, leaf number per plant, tiller number per plant, leaf-stem ratio and dry matter yield showed positive but nonsignificant correlation with leaf area index. Crudefibre content had negative phenotypic correlation with leaf area index (- 0.1264).

Leaf-stem ratio exhibited positive genotypic correlation with leaf weight per plant (0.9324), internodal length (0.7952), leaf area index (0.5900), dry matter yield (0.3033) and plant stand after germination (0.9516). Leaf-stem ratio exhibited high negative correlation with plant height (- 0.3756).

Leaf-stem ratio had high positive significant phenotypic correlation with leaf weight per plant (0.7732). Leaf number per plant, tiller number per plant, internodal length, leaf area index, dry matter yield and crude protein content recorded positive but non significant phenotypic correlation with leaf-stem ratio. Plant stand after germination (- 0.0427), plant height (- 0.1151) and crude fibre (- 0.0030) exhibited negative phenotypic correlation with leaf-stem ratio.

Dry matter yield had positive genotypic correlation with all the characters studied except with crude protein. Crude protein content had negative genotypic correlation with dry matter yield (- 0.1128).

Dry matter yield had high significant positive phenotypic correlation with plant stand after germination (0.7199) and leaf number per plant (0.5041) and negative non significant phenotypic correlation with crude protein content (- 0.1124).

Crude fibre content had positive genotypic correlation with leaf number per plant (0.4870), tiller number per plant (0.4797), plant stand after germination (0.3682), dry matter yield (0.3496) and plant height (0.1990). It showed negative genotypic correlation with crude protein (- 0.8494), internodal length (- 0.3091), leaf-stem ratio (- 0.1288), leaf area index (- 0.1206) and leaf weight per plant (- 0.0998).

Crude fibre content had high significant negative phenotypic correlation with crude protein content and non significant negative correlation with internodal length, leaf area index, leaf weight per plant and leaf-stem ratio. Leaf number per plant (0.3421), plant stand after germination (0.2267), tiller number per plant (0.2038), dry matter yield (0.1644) and plant height (0.0746) had positive phenotypic correlation with crude fibre content.

Crude protein content had positive genotypic correlation with leaf weight per plant, internodal length, leaf area index and leaf-stem ratio and negative genotypic correlation with plant stand after germination, plant height, leaf number per plant, tiller number per plant, dry matter yeild and crude fibre content.

Crude protein content had nonsignificant positive phenotypic correlation with internodal length (0.1725), leaf weight per plant (0.0683), leaf-stem ratio (0.0433) and leaf area index (0.0094). Crude protein content had negative phenotypic correlation with plant stand after germination, plant height, leaf number per plant, tiller number per plant, crude fibre content and dry matter yield.

4.6.a. Path analysis (using green fodder yield as effect)

Path coefficient analysis was done using green fodder yield as effect and characters such as plant height, leaf number per plant, leaf weight per plant, tiller number per plant and leaf area index as causal factors.

Direct and indirect effect of five component characters on green fodder yield are presented in Table 9. The path diagram showing the direct effects and genotypic correlations of five component characters on green fodder yield are presented in Figure 5.

Direct effect

Leaf number per plant (0.8458) showed maximum positive direct effect followed by leaf area index (0.4225) while plant height (- 0.3233) recorded the maximum negative direct effect. The direct effect of leaf weight and tiller number per plant were negligible. The high correlation of leaf number per plant is nearly equal to its direct effect, revealing that this character has maximum influence on yield.

Indirect effect

Plant height exerted maximum positive indirect effect through leaf number per plant (0.4046) followed by leaf area index (0.2813), leaf weight per plant (0.0023) and tiller number per plant (0.0014). The positive correlation of plant weight with yield may be accounted for the positive indirect effect via leaf number per plant and leaf area index..

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

Sl. no.	Character	Direct and indirect effects					Total correlation
		Plant height	Leaf number per plant	Leaf weight per plant	Tiller number per plant	Leaf area index	
1.	Plant height	<u>-0.3233</u>	0.4046	0.0023	0.0014	0.2813	0.3664
2.	Leaf number per plant	-0.1547	<u>0.8458</u>	-0.0072	0.0011	0.1719	0.8568
3.	Leaf weight per plant	0.0331	0.2695	<u>-0.0227</u>	0.0016	0.3549	0.6364
4.	Tiller number per plant	-0.0741	0.1420	-0.0056	<u>0.0063</u>	0.1938	0.2624
5.	Leaf area index	-0.2153	0.3441	-0.0191	0.0029	<u>0.4225</u>	0.5351

Residual effect (R) = 0.4249

Underlined figures are the direct effects.

Fig. 5. Path diagram showing direct effect and genotypic correlation in fodder bajra

Y - Green fodder yield

X_1 - Plant height

X_2 - Leaf number per plant

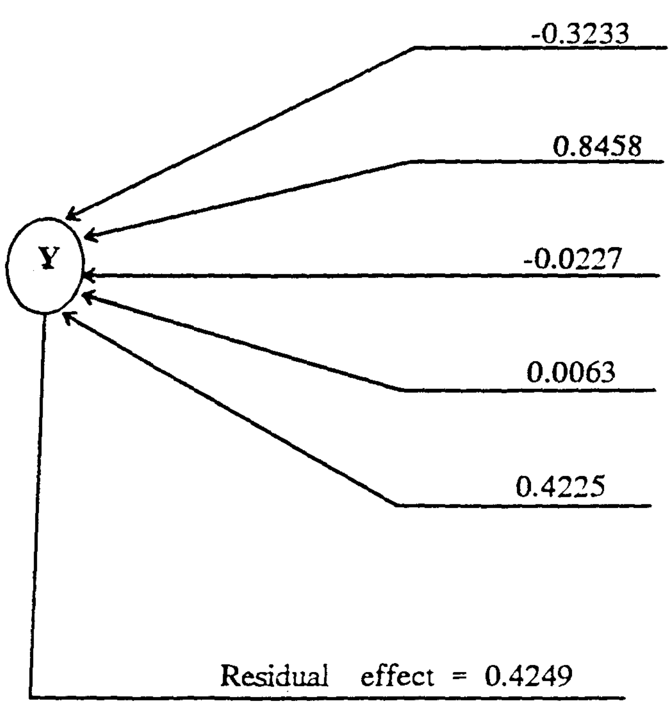
X_3 - Leaf weight per plant

X_4 - Tiller number per plant

X_5 - Leaf area index

Fig. 5. Path diagram showing direct effect and genotypic correlation in fodder bajra

PATH COEFFICIENTS



CORRELATION

X_1				
X_2	0.4784			
X_3	-0.1024	0.3186		
X_4	0.2291	0.1679	0.2471	
X_5	0.6659	0.4068	0.8401	0.4586

Leaf number per plant exerted positive indirect effect through leaf area index (0.1719) and tiller number per plant (0.0011) and negative indirect effects through plant height (- 0.1547) and leaf weight per plant (- 0.0072).

Leaf weight per plant exerted maximum positive indirect effect through leaf area index (0.3549) followed by leaf number per plant (0.2695). Though the direct effect of leaf weight was negative and negligible the correlation cooefficient was high, according to the fact that the indirect effects of leaf weight per plant via leaf member and leaf area index were responsible for this association. Tiller number per plant had positive indirect effects throught leaf area index (0.1938) and leaf number per plant (0.1420) and negative indirect effects through plant height (- 0.0741) and leaf weight per plant (- 0.0056) were negligible. So tiller number has no direct influence on yield but through leaf number and leaf area index.

Leaf area index had maximum indirect effect through leaf number per plant (0.3441) and negative indirect effects through plant height (- 0.2153). The indirect effects via other factors were negligible.

Residual effect was 0.4249 indicating that 57.5% of variation may be attributed to direct and indirect effect of five component characters taken for path analysis.

4.6.b. Path analysis (using dry matter yield as effect)

Fig. 6. Path diagram showing direct effect and genotypic correlation in fodder bajra

Y - Dry matter yield

X_1 - Plant height

X_2 - Leaf number per plant

X_3 - Leaf weight per plant

X_4 - Tiller number per plant

X_5 - Leaf area index

Fig . 6. Path diagram showing direct effect and genotypic correlation in fodder bajra

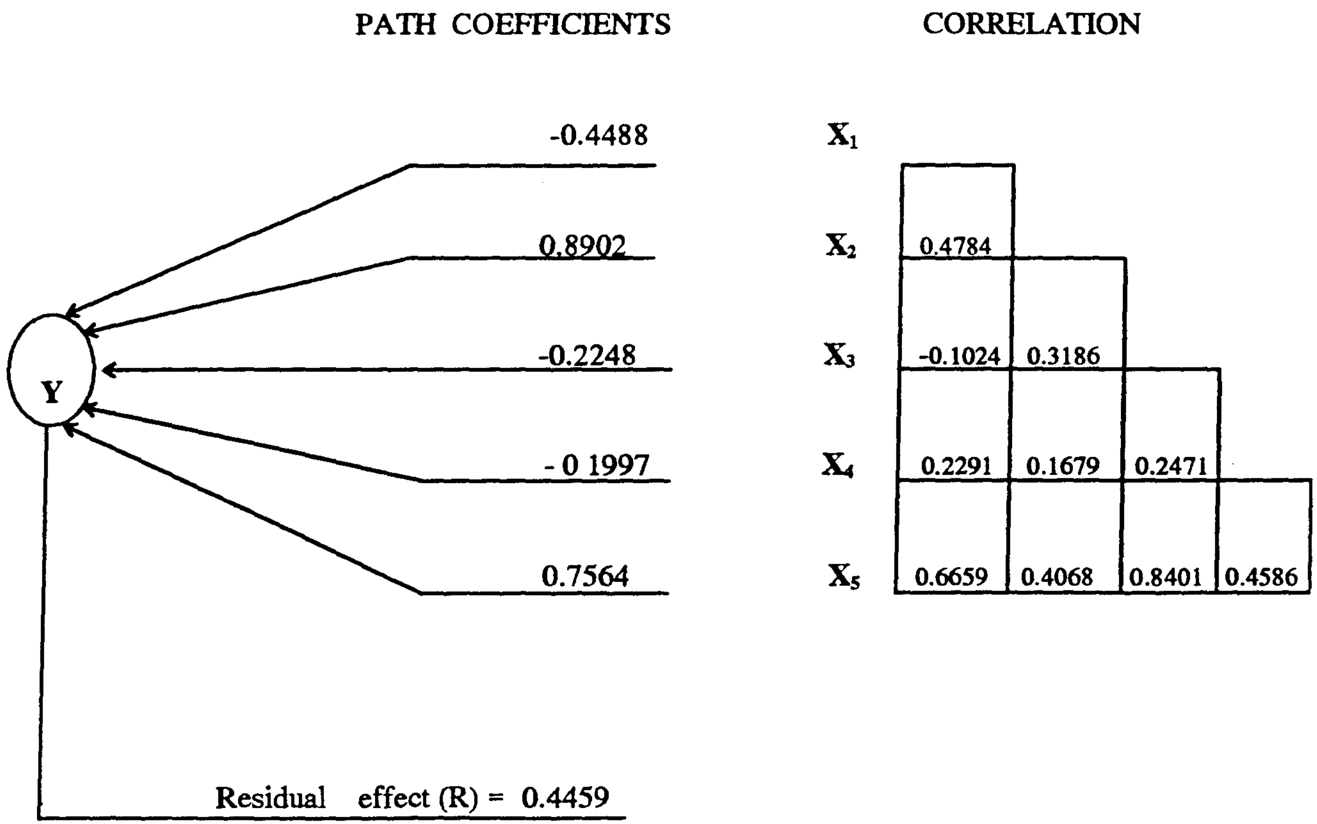


Table 10. Direct and indirect effects of five component characters on dry matter yield.

Sl. no.	Character	Direct and Indirect effects					Total correlation
		Plant height	Leaf number per plant	Leaf weight per plant	Tiller number per plant	Leaf area index	
1.	Plant height	-0.4488	0.4259	0.0230	-0.0458	0.5037	0.4581
2.	Leaf number per plant	-0.2147	0.8902	-0.0716	-0.0335	0.3077	0.8781
3.	Leaf weight per plant	0.0460	0.2836	-0.2248	-0.0493	0.6355	0.6909
4.	Tiller number per plant	-0.1028	0.1495	-0.0555	-0.1997	0.3469	0.1383
5.	Leaf area index	-0.2988	0.3621	-0.1889	-0.0916	0.7564	0.5393

Residual effect (R) = 0.4459

Underlined figures are the direct effects.

Path coefficient analysis was done using dry matter yield as effect and characters such as plant height, leaf number per plant, leaf weight per plant, tiller number per plant and leaf area index as causal factors.

Direct and indirect effects of five component characters on dry matter yield are presented in Table 10. The path diagram showing the direct effects and genotypic correlations of five component characters on dry matter yield are presented in Figure 6.

Direct effect

Leaf number per plant (0.8902) had the maximum positive direct effect followed by leaf area index (0.7564). Plant height (- 0.4488) recorded maximum negative direct effect followed by leaf weight per plant (- 0.2248) and tiller number per plant (- 0.1997).

Indirect effect

Plant height exerted positive indirect effects through leaf area index (0.5037), leaf number per plant (0.4259) and leaf weight per plant (0.0230) and negative indirect effect through tiller number per plant (- 0.0458). Though the direct effect was negative its positive indirect effect via plant height and leaf number per plant contributed for its positive correlation with yield.

Leaf number per plant exerted positive indirect effect through leaf area index (0.3077) and negative indirect effect through plant height (- 0.2147), leaf weight per plant (- 0.0716) and tiller number per plant (- 0.0335). The high direct effect of leaf number per plant was nullified through its negative indirect effect via plant height.

Leaf weight per plant exerted positive indirect effects through leaf area index (0.6355), leaf number per plant (0.2836) and plant height (0.0460) and negative indirect effect through tiller number per plant (- 0.0493). The positive correlation of leaf weight per plant with yield may be attributed to the positive indirect effects via leaf number per plant and leaf area index..

Tiller number per plant exerted positive indirect effects through leaf area index (0.3469) and leaf number per plant (0.1495) and negative indirect effects through plant height (- 0.1028) and leaf weight per plant (- 0.0555).

Leaf area index exerted positive indirect effect through leaf number per plant (0.3621) and negative indirect effects through plant height (- 0.2988) and leaf weight per plant (- 0.1889). The reduction in correlation coefficient may be attributed to the negative indirect effect via plant height.

Residual effect recorded a value of 0.4459 indicating that 55.4 per cent variation was attributed to direct and indirect effect of five component characters taken for path analysis.

4.7. Selection index (discriminant function)

Table 11. Selection index (score) for twenty different varieties of fodder bajra

Sl . no.	Varieties	Selection index
1.	HTGPK - 1993	647.10
2.	SSG-59-3	585.86
3.	IP-5714	564.75
4.	LSGP-1995	551.56
5.	FMH-3	531.55
6.	FMH-4	510.44
7.	UUJ-2	503.69
8.	FMH-2	485.31
9.	UUJ-IV-M	484.70
10.	C-1	469.57
11.	UUJ-1	465.27
12.	AFB-9-2-2	461.53
13.	L-74	459.48
14.	IP-3486	456.93
15.	MBFH-7	454.19
16.	AFB-48-1	448.09
17.	C-8	444.29
18.	GK-1005	440.51
19.	AFB-65-14	429.57
20.	EGP-1995	415.89

Selection index is used to discriminate the varieties based on major components of yield, viz. plant height (x_1) leaf weight per plant(x_2) , tiller number per plant(x_3), leaf area index(x_4), crude protein content(x_5) contributing to green fodder yield(x_6) and quality (x_7). The selection index prepared based on green fodder yield and other characters are presented in Table 11. The merit of each character explained in terms of b-coefficients in the discriminant function

$$I = b_1x_1 + b_2x_2 + \ldots\ldots. + b_7x_7$$

Character		**b-coefficient**
Plant height	=	- 0.0125
Leaf weight per plant	=	- 0.4490
Tiller number per plant	=	- 8.1718
Leaf area index	=	21.6640
Crude fibre	=	3.5492
Crude protein	=	3.1009
Green fodder yield	=	0.8583

The highest index was recorded by the variety HTGPK -1993 (647.10) followed by SSG-59-3 (585.86), IP-5714 (564.75), LSGP-1995 (551.56) etc. in that order. If twenty per cent selection was adopted, the varieties HTGPK-1993, SSG-59-3, IP-5714 and LSGP-1995 were identified as superior varieties.

DISCUSSION

DISCUSSION

Crop improvement programme depends on altering the genetic make up of the existing varieties. Selection based on yield alone is not very efficient, but based on its components as well could be more efficient (Evans, 1978) . In the initial stages of a breeding programme breeder looks for genetic variability for attributes which need improvement (Dabholkar, 1992). Only very limited information is available on the variability and correlation among various characters in fodder bajra. So evaluation of genetic variability on hand is indispensable. The present study was hence taken up to estimate some of the basic parameters of quantitative variability and also to prepare a selection index based on major yield contributing characters. The results obtained from this study are discussed below .

5.1. Variability

Analysis of variance on twelve characters revealed significant differences for all the characters. This shows the existence of high variability for all the characters in twenty varieties of fodder bajra studied. Similar trend was reported by Suthamathi and Dorairaj (1995) for all the 18 characters studied in fodder bajra. Thirumeni and Vijendra Das (1993) reported significant differences among varieties of fodder bajra for plant height, number of leaves per clump, internodal length, green fodder yield, dry fodder yield, leaf-stem ratio and crude protein content in agreement with the result obtained in the present study. Similar result was reported by Amirthadevarathinam and Dorairaj (1994) for plant height, leaves per tiller, leaf weight, leaf-stem ratio, dry matter yield, green fodder yield and crude protein in napier grass. Amirthadevarathinam *et al.* (1990) in fodder sorghum reported similar results for plant height, number of leaves, plant stand and dry fodder yield. Dhanakodi (1994) reported significant differences among 50 genotypes of fodder ragi for leaf number, tiller number, internodal length, leaf-stem ratio and fodder yield in conformity with the results obtained in the present study.

Coefficient of variation is another means of expressing the amount of variability. In the present study phenotypic and genotypic coefficients of variation were highest for leaf weight per plant which indicate that the varieties under study showed the highest genetic variability for leaf weight per plant. High values of phenotypic coefficient of variation with correspondingly high values of genotypic coefficient of variation were recorded for dry matter yield, green fodder yield, leaf-stem ratio and internodal length indicating the presence of high amount of genetic variability and scope for their improvement through selection. Similar trends were reported for green fodder yield by Sangha and Singh (1973) in fodder bajra, Tyagi *et al.* (1980) in bajra , Suthamathi and Dorairaj (1995) in fodder bajra , Amirthadevarathinam *et al.* (1990) in fodder sorghum, Dhanakodi (1980) in fodder ragi and Ramasamy *et al.* (1994) in fodder ragi . High genotypic coefficient of variation for dry matter yield obtained in the present study was similar to the results reported by Prakash (1983) in fodder bajra , Thirumeni and Vijendra Das (1993) in pearl millet, Sreenivasan *et al.* (1986) in guinea grass and Joseph (1988) in guinea grass. Joseph (1988) in guinea grass reported the lowest GCV value for weight of leaves which was contrary to the results obtained in this study.

High value of phenotypic coefficient of variation with comparatively low value of genotypic coefficient of variation was recorded for leaf area index. The wide difference between these two parameters revealed the influence of environment in the expression of this character. Contrary to this Thejasee Bhai (1988) in guinea grass reported high values of phenotypic and genotypic coefficients of variation for leaf area index.

The characters such as plant stand after germination, crude fibre content, plant height and tiller number per plant exhibited comparatively lower estimates of phenotypic and genotypic coefficient of variation. Similar result was obtained by Sreenivasan ***et al.*** (1986) for crude fibre content in guinea grass.

5.2. Heritability and genetic advance

Selection acts on genetic difference and gains from selection for a particular character depends largely on the heritability of the character (Allard, 1960). So it is clearly evident that genotypic coefficient of variation alone is not sufficient for successful selection. According to Burton (1952) genotypic coefficient of variation along with heritability will give a clear idea about the amount of genetic advance as expected by selection.

Crude protein content, leaf number per plant, leaf area index, leaf-stem ratio and leaf weight per plant were the characters with high heritability estimates. The high values indicate highly heritable nature and minimum influence of environment in phenotypic expression of these characters. Gupta and Gupta (1971) in fodder bajra, Gupta and Nanda (1971) in Indian bajra, Swarup and Chaugale (1962a) in fodder sorghum, Mathur and Patil (1982) in fodder sorghum and Dhanakodi (1994) in fodder ragi reported similar findings for leaf number. Kumar (1982) in fodder bajra for leaf weight, Thirumeni and Vijendra Das (1993) in fodder bajra for leaf-stem ratio, Suthamathi and Dorairaj (1995) in fodder bajra for crude protein content and Joseph (1988) in guinea grass for crude protein content reported high heritability estimates which were in consonance with the results of this study. Contrary to this Sainy and Paroda (1975) in fodder sorghum for leaf weight and Singhania ***et al.*** (1977) in fodder sorghum for leaf-stem ratio reported low heritability estimates.

Moderate heritability estimates were observed for plant stand after germination, plant height, tiller number per plant, internodal length, green fodder yield, dry matter yield and crude fibre content. Sainy and Paroda (1975) in fodder sorghum for tiller number, Vaithialingam (1979) in fodder sorghum for green fodder yield and dry fodder yield. Mathur and Patil (1982) in fodder sorghum for plant height and tiller number per plant, Kempanna and Thirumalachar (1968) in ragi for number of tillers per plant, Patnaik and Jana (1973) in ragi for plant height and number of tillers, Appadurai ***et al.*** (1977) in ragi for plant height and Joseph (1988) in guinea grass for tiller count reported same trends. None of these character recorded low heritability estimates.

Even though heritability estimates are useful in the selection of superior genotypes on the basis of phenotypic performance of the characters, it does not give a clear picture on the extent of improvement that can be achieved. According to Panse (1957), the characters with high heritability and genetic advance were controlled by additive gene action and therefore amenable to genetic improvement through selection.

In the present study comparatively high heritability estimate along with high genetic advance was recorded for leaf weight per plant, internodal length and green fodder yield. These characters can be considered during selection programme for the improvement of the crop. The high heritability and genetic advance obtained in this study for green fodder yield were in agreement with the findings of Tyagi *et al.* (1980), Kumar (1982), Thirumeni and Vijendra Das (1983) and Suthamathi and Dorairaj (1995) in fodder bajra, Swarup and Chaugale (1962a) in fodder sorghum and Dhanakodi (1994) and Ramasamy *et al.* (1994) in fodder ragi, Kumar (1982) and Suthamathi and Dorairaj (1995) in fodder bajra.

Genetic advance was relatively high for plant height, leaf weight per plant and green fodder yield. This is in agreement with the findings of Tyagi *et al.* (1980), Kumar (1982), Thirumeni and Vijendra Das (1993) and Suthamathi and Dorairaj (1995) in fodder bajra for green fodder yield. Suthamathi and Dorairaj

(1995) in fodder bajra reported high value of genetic advance for leaf weight per plant which is in agreement with the present study.

Crude protein content, leaf-stem ratio, leaf area index and leaf number per plant had high heritability coupled with low genetic gain. This indicates non additive gene action which greatly limits the scope for improvement of these characters through selection (Panse, 1957).

Plant stand after germination, tiller number per plant, dry matter yield and crude fibre content had moderate heritability and low genetic advance which again limits the scope for improvement of the crop based on these traits.

5.3. Correlation

Correlation provides information on the nature and extent of association between characters in a population. The component characters always show inter relationship. When the breeder applies selection on a trait, the population under selection is not only improved for that trait, but also improved in respect of other characters associated with it. This facilitates simultaneous improvement of two or more characters. Therefore analysis of yield in terms of genotypic and phenotypic correlation coefficient of component characters leads to the understanding of characters that can form the basis of selection. The genotypic correlation between the characters provides a reliable measure of genetic association between characters and helps to differentiate the vital association useful in breeding from non vital ones

(Falconer, 1981). Hence correlation between green fodder yield and other eleven characters and their inter correlations were estimated.

5.3.a. Correlation between green fodder yield and other characters

Green fodder yield exhibited high positive genotypic correlation with dry matter yield, plant stand after germination, leaf number per plant and leaf weight per plant and negative genotypic correlation with crude protein and internodal length. Tyagi. *et al.* (1980) in fodder bajra, Girija and Natarajarathinam (1989) in fodder sorghum and Sood and Ahluwalia (1989) in fodder sorghum reported positive genotypic correlation between dry matter yield and green fodder yield in agreement with the present study.

The positive genotypic correlation between green fodder yield and leaf number per plant obtained in this study was in agreement with the results of Dhanakodi and Chandrasekaran (1989) and Ramasamy *et al.* (1994) in ragi, Amirthadevarathinam *et al.* (1990) in fodder sorghum and Chalapathi (1990) in fodder maize. Ramasamy *et al.* (1994) in fodder ragi reported positive genotypic correlation between green fodder yield and leaf weight per plant in agreement with the present study.

The negative genotypic correlation between green fodder yield and crude protein content was in agreement with the results of Joseph (1988) in guinea grass. The negative genotypic correlation between green fodder yield and internodal length was contrary to the results of Dhanakodi and Chandrasekaran (1989) in ragi.

At the phenotypic level dry matter yield, plant stand after germination and leaf number per plant had significant positive correlation with green fodder yield. This was in agreement with the results of Naphade (1972), Hussain and Khan (1973) and Chauhan and Singh (1975) in fodder sorghum for leaf number per plant and Vasudeva Rao and Ahluwalia (1977) and Mathur and Patil (1982) in fodder sorghum for dry matter yield.

By looking at the correlation of other characters with yield it can be concluded that green fodder yield can be improved by exercising selection for the characters plant stand after germination, plant height , leaf weight per plant, leaf number per plant, tiller number per plant, crude fibre content, leaf area index, leaf-stem ratio, and dry matter yield. However priority should be given to characters like dry matter yield, plant stand after germination, leaf number per plant and leaf weight per plant during selection as they have comparatively higher correlation with green fodder yield both at phenotypic and genotypic level.

5.3.b. Inter-se correlation between other characters

The positive association of plant stand after germination with dry matter yield, leaf number per plant, tiller number per plant, leaf weight per plant and plant height has helped to conclude that plant stand after germination is an index for dry matter yield and other components of yield. Amirthadevarathinam ***et al.***

(1990) in fodder sorghum reported positive association between plant stand and number of leaves in agreement with present study.

Plant height had high positive genotypic correlation with leaf area index, leaf number per plant and dry matter yield. So selection for plants having high plant height simultaneously will improve the leaf area index, leaf number per plant and dry matter yield. Amirthadevarathinam *et al.* (1990) in fodder sorghum and Dhanakodi and Chandrasekaran (1989) in ragi reported high positive genotypic correlation between plant height and number of leaves per plant in agreement with the present study. But contrary to this Chalapathi (1990) in fodder maize reported negative correlation between plant height and number of leaves per plant. Plant height had negative correlation with internodal length, crude protein content and leaf-stem ratio. So simultaneous improvement of these characters is not possible. This also reveals that plants with increased height are having low crude protein content, leaf-stem ratio and internodal length. Dhanakodi and Chandrasekaran (1989) in ragi reported negative correlation between plant height and leaf-stem ratio in agreement with the present study.

The positive association of leaf number per plant with dry matter yield, crude fibre content and leaf area index indicates that plants with increased leaf number had. high dry matter yield, crude fibre content and leaf area index and simultaneous improvement of those characters could be possible by selection.

Leaf weight per plant exhibited positive correlation with leaf-stem ratio, leaf area index and internodal length both at phenotypic and genotypic level. This indicates that plants with more leaf weight had more leaf-stem ratio, leaf area index and internodal length. So selection for increased leaf weight will automatically improve the characters leaf area index, leaf-stem ratio and internodal length. The negative association of leaf weight per plant with plant height and crude fibre content indicates that plant with more leaf weight had less protein content and height and also the improvement of leaf weight per plant cannot improve other characters like plant height and crude fibre content simultaneously.

The positive phenotypic correlation between tiller number per plant and plant height was in agreement with the results of Phul *et al.* (1974) in fodder bajra and Jhorar and Paroda (1976) in fodder sorghum. Contrary to this Goud and Lakshmi (1977) and Patnaik (1968) observed negative correlation between plant height and tiller number in ragi. Number of tillers per plant had positive association with crude fibre content and negative association with crude protein content. This indicates that plants with more number of tillers had less crude protein content. So the improvement of tiller number per plant will simultaneously improve the crude fibre content and not the crude protein content and is not advantageous.

Internodal length was positively correlated with leaf-stem ratio, leaf weight per plant and crude protein content at the genotypic level. Contrary to this

Dhanakodi and Chandrasekaran (1989) in ragi reported negative genotypic correlation between internodal length and leaf-stem ratio.

The positive association of leaf area index with plant height was in agreement with the results of Thejasee Bhai (1988) in guinea grass. The positive association of leaf area index with dry matter yield indicates that the improvement of leaf area index will simultaneously improve dry matter yield. The negative correlation between leaf area index and crude fibre content reveals that they are under the control of different genes.

Leaf-stem ratio had high positive genotypic and phenotypic correlation with leaf weight per plant. This clearly indicates that as the leaf-stem ratio increases, leaf weight per plant also increases.

Dry matter yield had positive correlation with all the characters studied except crude protein content. This shows that simultaneous improvement is possible. Vasudeva Rao and Ahluwalia (1977) and Sainy and Paroda (1978) in forage sorghum reported similar trends.

The crude fibre content had high negative correlation with crude protein content both at phenotypic and genotypic level. This clearly indicates that as crude fibre content increases the crude protein content decreases.

The positive genotypic correlation of crude protein content with leaf weight per plant , internodal length, leaf area index and leaf-stem ratio clearly indicates that simultaneous improvement by selection is possible.

5.4. Path analysis

Plant breeders have to deal with correlated characters during the improvement programmes (Dabholkar 1992). Rate of improvement is expected to be rapid if differential emphasis is laid on the component characters during selection. The basis of differential emphasis could be the degree of influence of component characters on the economic character of interest. The degree of influence of one variable on the other can be expressed in quantitative terms. Path coefficient analysis, a method developed by Wright (1921) is very efficient in this respect .

5.4.a. Path analysis (using green fodder yield as effect)

Path analysis using plant height, leaf number per plant, leaf weight per plant, tiller number per plant and leaf area index as causal factors and green fodder yield as effect revealed negative direct effect of plant height with green fodder yield. But the correlation coefficient was positive. So it can be concluded that indirect effects seem to be the cause of correlation and the indirect causal factors are to be considered simultaneously. To be more precise the positive indirect effect of plant height through leaf number per plant has to be considered during selection. Thejasee Bhai (1988) and Shajan (1993) in guinea grass and Chalapathi (1990) in forage maize reported positive direct effect of plant height with green fodder yield which was contrary to the present study. Dhanakodi and

Chandrasekaran (1989) in ragi reported negative direct effect of plant height on green fodder yield in agreement with the present study.

The direct effect of leaf number per plant was maximum and positive and almost equivalent to correlation coefficient. So it can be concluded that there exists a true relationship and selection through leaf number per plant will improve the green fodder yield appreciably. Naphade (1972) in sorghum reported similar results.

The direct effect of leaf weight per plant on green fodder yield was negative but correlation coefficient with green fodder yield was positive. So it can be concluded that indirect effects seem to be the cause of correlation. Here leaf weight per plant had high positive indirect effect through leaf area index and leaf number per plant. So these characters have to be considered during selection.

Tiller number per plant had minimum positive direct effect on green fodder yield. Leaf area index showed high positive direct effect and high positive indirect effect through leaf number per plant on green fodder yield. So selection through leaf area index will be advantageous.

The residual effect was relatively low indicating that adequate characters were utilised for studies.

To be more precise leaf number per plant is the most important character influencing green forage yield followed by leaf area index as they have high positive direct and indirect effect through many other characters.

5.4.b. Path analysis (using dry matter yield as effect)

Path analysis using plant height, leaf number per plant, leaf weight per plant, tiller number per plant and leaf area index as causal factors and dry matter yield as effect revealed negative direct effect of plant height on dry matter yield but the correlation coefficient was positive. So it can be concluded that positive indirect effects seem to be the cause for correlation. So the positive indirect effects through leaf area index and leaf number per plant have to be considered. Paroda ***et al.*** (1975) and Mathur and Patil (1982), in pearl millet reported similar trends. But Tyagi ***et al.*** (1980) in pearl millet reported positive direct effect of plant height on dry matter yield which was contrary to present study.

The direct effect of leaf number per plant was maximum, positive and equivalent to correlation coefficient with dry matter yield. So it can be concluded that there exists a true relationship and selection through leaf number per plant will be advantageous.

Leaf weight per plant and tiller number per plant had negative direct effect on dry matter yield but their correlation coefficients with dry matter yield were positive. This reveals that indirect effects may be the cause for the correlation. So the positive indirect effects through leaf area index and leaf number per plant have to be considered during selection.

Leaf area index had high positive direct effect on dry matter yield and selection through this trait will be advantageous.

The residual value was relatively low indicating that adequate characters were utilised for studies.

Leaf number per plant is the most important character influencing dry matter yield followed by leaf area index.

5.5. Selection index

A selection index was formulated to increase the efficiency of selection taking into account the green forage yield and the important characters contributing to yield and quality such as plant height, leaf weight per plant, tiller number per plant, leaf area index, crude fibre content and crude protein content. Santhipriya (1991) in guinea grass formulated a selection index based on plant height, leaf area index and green matter yield in agreement with present study.

Shajan (1993) in guinea grass formulated a selection index by including characters like plant height and leaf area index which was in agreement with the present study. Based on the index constructed twenty per cent selection was exercised and top ranking four superior varieties namely HTGPK-1993, SSG-59-3, IP-5714, and LSGP-

1995 were identified and these varieties can be used for future use in breeding programmes.

SUMMARY

SUMMARY

The present study was conducted at the Departement of Plant Breeding and Genetics, College of Agriculture, Vellayani during May to August 1995 to assess the genetic variability and the scope of selection for forage yield and quality in bajra.

Twenty varieties of fodder bajra were evaluated in a randomised block design with three replications. Data were collected from ten plants selected at random from a population size of two hundred plants per entry on twelve characters namely plant stand after germination, plant height, leaf-stem ratio, internodal length, tiller number per plant, leaf number per plant, leaf weight per plant, leaf area index, green fodder yield, dry matter yield, crude protein content and crude fibre content. The mean was worked out and subjected to statistical analysis.

Salient findings of the study are the following:

Analysis of variance showed significant difference among the varieties with respect to all the characters. This indicates the presence of sufficient variability for all the afore characters in the twenty fodder bajra varieties evaluated.

High genotypic and phenotypic coefficients of variation were observed for the characters · leaf weight per plant, green fodder yield, dry matter yield, leaf-stem ratio and crude protein content. This indicated immense exploitable variability reserve in these lines and the scope for improvement through selection.

High heritability estimates observed for crude protein content, leaf area index, leaf number per plant, leaf-stem ratio and leaf weight per plant promulgated meagre influence of environment in the expression of these characters.

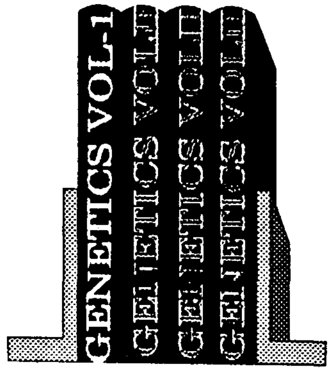
Genetic advance was maximum for plant height followed by leaf weight per plant, green fodder yield and internodal length.

High heritability coupled with relatively high genetic advance recorded for leaf weight per plant and internodal length helped to deduce that the gene action was additive and permanent improvement could be achieved by imparting selection on these traits.

Correlation values of green fodder yield with plant stand after germination, plant height, leaf number per plant, leaf weight per plant, tiller number per plant, leaf area index, leaf-stem ratio, dry matter yield and crude fibre content were positive both at phenotypic and genotypic level. Dry matter yield had the highest positive correlation coefficient followed by plant stand after germination, leaf number per plant, leaf weight per plant and leaf area index indicating that yield can be increased indirectly by improving these components.

Leaf number per plant exerted maximum positive direct effect on both green fodder yield and dry matter yield followed by leaf area index. Plant height exerted maximum positive indirect effect through leaf number per plant, on both green fodder and dry matter yield. This clearly indicated that leaf number per plant and leaf area index were the important characters influencing green fodder yield and dry matter yield.

A selection index was formulated to improve the efficiency of selection based on the characters plant height, leaf weight per plant, tiller number per plant, leaf area index, crude fibre, crude protein and green fodder yield. The varieties were ranked and top ranking four varieties viz. HTGPK-1993, SSG-59-3, IP-5714 and LSGP-1995 were selected by exercising twenty per cent selection.



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GENETIC VARIABILITY IN FODDER BAJRA

By

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ABSTRACT OF THE THESIS

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ABSTRACT

A research programme was carried out at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during May to August 1995, with the objective of assessing the genetic variability and the scope of selection for forage yield and quality in bajra. Twenty varieties were evaluated adopting a randomised block design with three replications. Data on twelve characters were collected and subjected to statistical analysis. Analysis of variance revealed significant difference among the varieties for all the characters studied. Genotypic and phenotypic coefficients of variation were high for leaf weight per plant, green fodder yield, dry matter yield, leaf-stem ratio and crude protein content. High heritability coupled with relatively high genetic advance was recorded for leaf weight per plant and internodal length suggesting the reliability of these characters during selection programme. High positive genotypic correlation of dry matter yield, plant stand after germination, leaf number per plant, leaf weight per plant and leaf area index with green fodder yield had indicated that selection based on the above components results in the improvement of green fodder yield. Path analysis revealed that leaf number per plant and leaf area index were the most important characters influencing green fodder yield and dry matter yield. Selection index based on yield contributing characters had enabled to select four high yielding fodder bajra genotypes namely HTGPK-1993, SSG-59-3, IP-5714 and LSGP-1995.