CORRELATION AND PATH COEFFICIENT ANALYSIS IN GUINEA GRASS

(*Panicum maximum* Jacq.)

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Correlation and path coefficient analysis in guinea grass (Panicum maximum Jacq.)" is a bonafide record of research 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.

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CERTIFICATE

Certified that this thesis entitled "Correlation and path coefficient analysis in guinea grass (Panicum maximum Jacq.)" is a record of research work done independently by Sreenivasan, E. under my guidance and supervision and that it had not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Introduction

INTRODUCTION

Ever since agriculture started, the grain crops and other food crops received more attention from man, compared to other crops and considerable success has been made in their genetic improvement. But in the case of fodder crops, the progress made so far is not so impressive. The present trend in advanced agriculture is a sort of 'refined human nutrition' wherein the plant biomass is converted into various forms of high quality animal proteins as in milk, meat and egg. Consumption of such animal proteins will enhance the nutritional standards of human beings. Fodder grasses being the cheapest source of all livestock feeds, functions as the basic factor in the conversion of plant biomass into animal proteins.

In Kerala, the present fodder production shows a 23 per cent deficit in meeting the requirements of the 34 lakhs adult heads of cattle population in the state. But the land available for pure culture of fodder grasses is very limited due to high density of population. At present there are a few fodder species grown on a limited scale in dairy farmer's holdings and in Government farms and research stations. All these areas together account for nearly

7000 hectares of the state. The importent fodder grass species at present grown in the state are guinea, hybrid napier, setaria, congosignal, deenanath, para and gautemala. The most importent and popular among these is guinea grass (Panicum maximum Jacq.)

Guinea grass, a native of Tropical Africa, was introduced to India in 1790 by the Europeans. Now it has attained the status of an indigenous grass due to its long history of cultivation here. It is a nutritious, drought resistant and densely tufted perennial grass. Shoots usually arise in large bunches from short, stout rhizomes and grows upto a height of 1 to 3 metres. The crop produces flowers in abundance. But seed set is very limited. Therefore propagation is mainly by vegetative means, which reduces variability available in the species. Also, apomixis is very common in this crop. Hence even in a population raised from seeds, the heterogenity and variability available is very limited. However, it is a naturally cross pollinated species and individual plants in a population are heterozygous in nature.

Guinea grass is valuable for pasture, green soiling, hay and silage. The fresh fodder contains about 4.4 per cent crude protein. It is very palatable in the younger stages, tending to become coarse and less readily eaten by cattle as it matures. The most ideal stage suited for feeding cattle is the 50 per cent flowering stage, when the crude protein content is maximum (Bodgen, 1977). The average yield per hectare is 50 to 60 tons from rainfed crop, and about 150 tons from irrigated crops. In the partial shades of coconut gardens, where it can be raised as an intercrop, the yield is 35 to 38 tons per hectare. It remains productive upto five years, with peak yields during second and third year.

Varietal diversity is very prominent in this crop. Nearly 1500 strains are available and maximum collection is maintained at National Fodder Research Institute, Kitale, Kenya. Wide range of variability is present in respect of growth habits, plant height, leaf size, colour of spikelets, quality aspects, yield of green and dry fodders, drought tolerance etc. 'Common guinea' is a robust type, whereas 'Green Panic Grass' or 'Slender guinea' (Panicum maximum var. trichoglume) is more slender and smaller with finer leaves. 'Gatton', a South Rhodesian variety grows about 1.2 metre high, whereas 'Colonio' grows to 3 metres height and the West African variety 'Hamil' grows about 4.4 metres tall. 'Purple top guinea' (Panicum maximum var. coloratum) is a low, coarse variety suitable for grazing. 'Silk guinea', a Jamaican variety, is a very leafy type suited to drier areas, whereas 'St. Mary's Cow Grass' popular in U.S.A. is more robust and stemmy and is grown in more humid areas. Likewise, considerable amount of variability exists in the species. However, only limited attempts had been made so far with a view of exploiting this available variability.

The variability available can be partitioned into three types:

(1) Variability due to phenotype
(2) Variability due to genotype and
(3) Variability due to interaction between genotype and environment.

Fodder yield in guinea grass is a complex trait involving a number of component characters contributing to it directly or indirectly. All these are governed by polygenic systems. Hence the improvement of yield involves the assessment of quantitative variation for characters contributing to it, so that appropriate parents are chosen for utilization in hybridisation.

Not much research works have been conducted in our country so far, on the varietal characteristics and yield potential of the different clones of this crop. During the All India Annual Workshop on Forage crops held at the College of Agriculture, Vellayani, in September, 1981, forage scientists suggested to initiate genetic studies on fodder crops. Such studies are valuable to set up selection parametres for high yielding fodder grass strains suited to the humid tropical conditions of Kerala. Determining the associations among the fodder yielding attributes and fodder yield serves as a basis for selection of desirable parents, which is done by correlation analysis. It also permits the evaluation of relative selection efficiency of various characters on green fodder yield.

The correlated variables exert their influence both directly and indirectly through other variables and since the residual factor also gets involved, for the proper understanding of the role of causation on the ultimate effects, path coefficient analysis is resorted to. It is applied to partition the genetic associations between yield and its component characters into direct and indirect effects on yield. Path coefficient analysis has been identified as a potent method for resolving accurate and dependable criterion in selection procedures (Dewey and Lu, 1959).

The present study in guinea grass was thus undertaken with the following objectives.

(1) To evaluate the extent of variability in the selected germ plasm material.

(2) To determine the characters associated with yield and quality of green foddor and their degree of association and relative influence on yield.

(3) To partition the genetic associations into direct and indirect effects on yield, to find out the real contribution of each component character to the end product, i.e. fodder yield.

Review of Literature

REVIEW OF LITERATURE

Genetic improvement of fodder grasses is a field of investigation which has not received adequate attention. Guinea grass (<u>Panicum maximum</u>. J.) is the most important and popular fodder grass of Kerala. Even though this crop exhibits vast degree of varietal diversity, only limited attempts had been made to exploit this variability, for the genetic improvement of its fodder yield and quality. Informations on the yield component analysis of this crop is very meagre. The available literature in this area of research in the case of guinea grass, other tropical grasses and cereal fodders, all belonging to the family Gramineae is being reviewed here, under the following three categories.

I. Studies on variability
II. Correlation studies
III. Path coefficient analysis

I. Studies on variability

Plant breeding in its true sense relates to the efficient management and utilisation of variability. It is the prerequisite before embarking on any plant breeding programme to survey and assess the genetic variability present in a population in respect of various yield attributes. Johnson *et al.* (1955) introduced a methodology for partitioning the total variance into that due to genotype, phenotype and error which is the genotype X environment interaction. Lush (1949) gave the formulae for computing these variances. Burton (1952) suggested formulae for computing phenotypic and genotypic coefficients of variability.

Many workers have studied the extent of variability available in different fodder crops, by working out the genotypic coefficient of variability (g.c.v.) and phenotypic coefficient of variability (p.c.v.). The g.c.v. obtained by different workers in various grass fodders is reviewed below, character wise:

1. Plant height

Patnaik (1968), Chaudhari and Acharya (1969), Kempanna *et al.* (1971), Patnaik and Jana (1973), Mahudeswaran and Murugesan (1973), Appadurai *et al.* (1977), Mishra *et al.* (1978) and Agalodia *et al.* (1979) reported g.c.v. values of less than 15 per cent for this character in fodder ragi. Rana *et al.* (1976) in forage sorghum, Abinash Yadav and Srivatsava (1976) in little millet (*Panicum miliare*) and Sethi and Singh (1978) in barley reported similar findings. But Gupta and Athwal (1966) in forage pearl millet, Gill and Randhawa (1975) in foxtail millet, and Nair and Gupta (1977) in fodder oats observed g.c.v. values exceeding 50 per cent. But in fodder oats itself, Thyagi et al. (1977) observed a g.c.v. value of 10.5 per cent for this trait.

2. Leaf characteristics

In forage sorghum g.c.v. values between 15 to 30 per cent was reported by Rana et al. (1976) for leaf number. However, Gupta and Athwal (1966) in pearl millet and Nair and Gupta (1977) in fodder oats obtained g.c.v. values exceeding 30 per cent for this character, whereas in fodder oats itself, Thyagi et al. (1977) observed g.c.v. value below 15 per cent for leaf number. Rana et al. (1976) obtained the g.c.v. values for leaf length as below 15 per cent and between 15 to 30 per cent for leaf width, in forage sorghum. Thyagi et al. (1977) reported g.c.v. values of 10.29 per cent and 5.2 per cent respectively for leaf length and leaf width in fodder oats. Information on works regarding leaf area index is not available.

3. Days to flowering

In ragi, Patnaik (1968), Choudhari and Acharya (1969) Patnaik and Jena (1973), Appadurai et al. (1977) and Mishra et al. (1978) reported g.c.v. values below 12 per cent for this character; while Gupta and Athwal (1966) obtained g.c.v. values exceeding 30 per cent in forage pearl millet. Abinash Yadav and Srivatsava (1976) in little millet and Sethi and Singh (1978) in barley reported g.c.v. values below 15 per cent. But Gill and Randhawa (1975) obtained g.c.v. values exceeding 30 per cent in foxtail millet for this trait.

4. Tiller number

In finger millet, Mishra *et al.* (1978) observed a g.c.v. value of 9.7 per cent for the number of effective tillers. Kempanna and Thirumalachar (1968), Choudhari and Acharya (1969), Kempanna *et al.* (1971), Mahudeswaran and Murugesan (1973) and Appadurai *et al.* (1977) observed g.c.v. values exceeding 30 per cent for number of productive tillers in the same crop. However, Goud and Lakshmi (1977) and Agalodia *et al.* (1979) reported g.c.v. values between 15 to 30 per cent for total number of tillers in ragi. But g.c.v. values below 15 per cent were reported by Patnaik (1968) and Patnaik and Jena (1973) in the same crop. Gupta and Athwal (1966) in pearl millet and Sethi and Singh (1978) in barley reported g.c.v. values between 15 to 30 per cent. Nair and Gupta (1977) in fodder oats and Manoharan (1978) in prosomillet obtained g.c.v. values exceeding 30 per cent. However, Thyagi *et al.* (1977)

reported g.c.v. value of 23.8 per cent for this character in fodder oats.

5. Leaf/Stem ratio

Thyagi *et al.* (1977) reported a g.c.v. value of 15.75 per cent for this character in fodder oats.

6. Dry matter yield

Thyagi *et al.* (1977) reported a g.c.v. value of 29.56 per cent for this character in fodder oats.

7. Green fodder yield

Rana *et al.* (1976) and Gupta and Athwal (1966) observed g.c.v. values more than 30 per cent in forage sorghum and pearl millet respectively. But Sethi and Singh (1978) obtained g.c.v. values between 15 to 30 per cent in barley. Thyagi *et al.* (1977) reported a g.c.v. value of 23.43 per cent for this trait in fodder oats.

II. Correlation Studies

The expression of inherited character is often influenced by the genotype, the environment and the genotype X environment interaction. Yield is a complex character, since it is the expression of sum total effects of all other associated characters. Therefore, it is necessary to have a knowledge about the relationship existing between yield and its components and their magnitude, before initiating a crop improvement programme. Galton (1889) conceived the correlation of variables for the first instance. Fisher (1954) developed the method of applying the theory of correlation of variables in the understanding of their influence in bilogical systems. Burton (1952) introduced a convenient procedure for the calculation of the phenotypic and genotypic coefficients of correlation. Snedecor and Cochran (1967) improved the mathematical computation of coefficients of correlation.

Various workers have studied the association between yield and its components and the interrelationships among the components in various fodder grasses, which are briefly reviewed below.

(a) Green fodder yield and its association with component characters

In guinea grass (*Panicum maximum* J.) Sotomayour-Rios *et al.* (1972) observed that tillering ability and forage volume showed the highest correlation with yield. However, yield also showed significant positive correlation with greenness and negative correlation with rooting at nodes.

Pillai *et al.* (1974) reported that there is no correlation between yield and leaf:stem ratio in this grass.

In Kolukkattai grass (*Cenchrus ciliaris*) Bohra *et al.* (1969) have reported positive correlation of plant height and number of tillers with fodder yield. Yadav *et al.* (1974) reported significant and positive association of tiller number, plant height, leaf breadth and spike length with green fodder yield in the same crop. Also Ramaswamy (1974) and Gopalan (1976) have reported that number of tillers, length and breadth of leaves, length and thickness of internode and height of the clones are positively correlated with green fodder yield.

In tall fescue Jones *et al.* (1979) reported that low rate of tiller production and high rate of leaf elongation were found to be the predominant morphological character associated with forage yield.

Sotomayour-Rios *et al.* (1971) found that plant vigour and dry matter yield were positively correlated with green forage yield in thirty *Digitaria* selections.

Fujimoth and Susuki (1976) observed high genetic correlation of dry matter yield, plant height and number of tillers with green fodder yield in Italian rye grass (*Lolium multiflorum*).

In forage sorghum (*Sorghum bicolor.*), Vishnuswarup and Chaugule (1962) reported that the characters plant height, leaf number and days to flowering were positively associated between plant height and fodder yield. The positive association of plant height and leaf number with fodder yield was reported by Naphude (1972) Pokle *et al.* (1973) and Chauhan and Singh (1975). According to Paroda *et al.* (1975) plant height, leaf length, leaf width and days to flowering were positively associated with fodder yield. But Rana *et al.* (1976) noticed positive association of plant height and leaf width with fodder yield. The studies by Jhorar and Paroda (1976) revealed positive association of plant height, leaf number, leaf length, leaf width and days to flowering with green fodder yield. Blum (1966) reported the positive correlation existing between internodal length and fodder yield. Vasudeva Rao and Ahluwalia (1977) observed that green fodder yield is positively associated with plant height, days to flowering, leaf number, leaf width, leaf:stem ratio and stem circumference in this crop. In forage sorghum itself, Rous *et al.* (1979) found that fodder yield was positively correlated with plant height and days to flowering. Vaithialingam (1979) reported that plant height, culm diameter, fourth leaf area and dry fodder yield were positively associated with green fodder yield of this crop.

In fodder bajra (*Pennesetum americanum*) Gupta and Athwal (1966), Gupta and Nanda (1971) and Gupta and Sindhu (1973) observed positive correlation of plant height, leaf number and tiller number with fodder yield. Also Saxena *et al*. (1978) found that high tillering and seedling vigour are positively associated with fodder yield in this crop. Thyagi *et al*. (1980) reported positive correlation of leaf area, days to flowering and number of tillers with green fodder yield of bajra fodder.

In fodder oats, Nair and Gupta (1977) reported that leaf area and number of tillers were positively correlated with fodder yield. Rao *et al*. (1978) observed positive association between plant height and fodder yield. Dhumale and Mishra (1978) reported positive association of the characters plant height, leaf width and tiller number with fodder yield. In fodder oats itself, Singh *et al*. (1980) have reported that plant height at flowering and tiller number per plant are positively correlated with green forage yield, both per day and per hectare basis.

From their studies in barley, Sethi and Singh (1978) concluded that plant height, days to flowering and tiller number were positively correlated with fodder yield.

Investigations by Dhanakodi (1980) has revealed that significant and positive association exists between green fodder yield and its components, namely plant height, leaf number, leaf length, leaf width, days to flowering and internodal length, in fodder ragi (*Eleusine coracana*).

In *Echinochloa frumentacea*, Naina Mohammed (1979) has reported that plant height, culm diameter, fourth leaf area, and dry fodder yield were significantly and positively associated with green fodder yield.

(b) Association among the yield components

Yadav *et al.* (1974) have found that number of leaves was positively correlated with plant height, spike length and leaf breadth in *Cenchrus ciliaris*. In the same crop, Ramaswamy (1974) reported that there was no association between plant height and number of tillers.

In Italian rye grass (*Lolium multiflorum*), Vivero (1979) has reported high correlation ($r = 0.95$) between flowering date and dry matter yield.

In ragi, Appadurai *et al.* (1977) reported that plant height was positively correlated with number of productive tillers and days to flowering. Goud and Lakshmi (1977) reported that plant height was negatively correlated with number of tillers. Days to heading was positively correlated with productive tillers (Chaudhari and Acharya, 1969).

In forage sorghum, Nephude (1972) observed positive correlations between leaf number and leaf area, and leaf number and plant height. Plant height and leaf area were not significantly correlated. According to Jhorar and Paroda (1976) plant height showed positive association with leaf length, leaf breadth, leaf weight and stem weight. The number of tillers showed negative association with plant height and leaf breadth, but showed positive association with leaf number, leaf weight and stem weight. In general, number of leaves, leaf length, leaf breadth and leaf weight showed significant and positive correlation with other characters.

Gupta and Athwal (1966) reported positive significant correlation between leaf number and plant height in pearl millet.

Dhumale and Mishra (1978) obtained high positive correlation between leaf length and flag leaf length, leaf width and flag leaf width and number of leaves per plant and straw stiffness in forage oats.

(c) Association of green forage yield with quality aspects

Study on association of quality aspects with yield attracted very little attention of research workers. While going for yield increase in fodder crops, the quality aspects also should be given an equal importance. As regards to fodder grass, the most important quality aspects of the crop include crude protein content, crude fibre content, oxalic acid content and balance among the mineral constituents, especially the K:(Ca+Mg) ratio.

Crude protein content is the most important quality aspect of a fodder crop. In general, the grasses are poor in crude protein content. In forage sorghum Ross et al. (1979) observed that green fodder yield was negatively correlated with protein content. Bray and Hacker (1981) also reported negative correlation (r = -0.64) of nitrogen content with fodder yield in Setaria sphacelata. From a study involving thirty Digitaria selections, Sotomayour-Rios et al. (1971) found that yield of protein per acre was positively correlated with green forage yield. Another study by Silva (1981) with five open pedigree hybrids of forage maize revealed that relatively later maturing hybrids had acceptable amounts of crude protein content.

Maggiore et al. (1980) has reported that dry matter yield is positively associated with fibre content in maize. Reports on correlation analysis of fibre content with yield are not available in most of the fodder grasses.

Mineral concentration in forage grasses is an important consideration when examining forage quality (Corkil, 1965; Burton, 1974). The relative amounts of potassium with calcium and magnesium have been implicated in the occurrence of grass tetany in cattle grazing on cool season herbage, especially when K:(Ca+Mg) ratio exceeds 2.2 (Butler, 1963; Kemp and t'Hart, 1957). Hill and Guss (1976) and Sleper (1979) reported that concentration of minerals in many forages appeared to be under genetic control and it could be altered through plant breeding. Correlations of mineral concentrations with yield was found to be very low in orchard grass herbage (Stratton and Sleper, 1978). They also found the intercorrelations among these mineral aspects. Concentrations of calcium and magnesium were found to be positively correlated with each other. Potassium concentration was also positively correlated with both calcium and magnesium. This indicated that it will be difficult to narrow down the K: (Ca+Mg) ratio, since the Ca+Mg concentration cannot be kept at a higher level, without an increase in the potassium concentration. But Sleper (1979) have found a negative and non-significant correlation of potassium with calcium and magnesium in the first harvest in tall fescue. Bray and Hacker (1981) also reported negative correlations of potassium ($r = -0.16$), calcium ($r = -0.77$) and magnesium ($r = -0.30$) with dry matter content in *Setaria sphacelata*.

High amounts of oxalic acid in forage impair calcium assimilation and might induce severe alkalosis (Gupta and Talapatra, 1970), Gupta *et al.* 1970). Kripal Sigh *et al.* (1979) have reported that a total oxalate content of 3.08% or less was not likely to affect calcium utilisation, when fed to animals. He analysed the genetic variability of oxalates in pearl millet forage and reported that it varied from 1.01 per cent to 2.81 per cent. Sen (1953) has given an account of the oxalic acid contents of various Indian feeding stuffs. According to him the oxalate content of guinea grass varies from 2.00 per cent in early cut fodders to 0.80 per cent in dead ripe fodders. Early cut napier has 3.06 per cent, whereas in dead ripe napier, it was only 0.65 per cent. Reports on the correlation studies of total oxalate content with fodder yield are not available.

III. Path Coefficient Analysis

Path coefficient analysis is applied to partition the genetic associations between yield and its component characters into direct and indirect effects on yield.

The correlated variables exert their influence both directly and indirectly through other variables. Besides, the residual factor also gets involved in it. Therefore, inorder to get a clear picture, it would be desirable to separate out the direct contribution of each yield component and the indirect contribution that it makes through its relationship with other attributes. Path coefficient analysis provides informations on the nature of association of several related characters contributing to yield by means of untangling the direct and indirect contribution of various factors in building up a complex correlation (Wright, 1921 and 1923, Niles, 1923). Li (1956) discussed the concept of path coefficient and its implications on population genetics. According to him, when the causal factors are uncorrelated the path coefficient is simply the ordinary correlation between two variables concerned, and the separation of the correlation coefficient into various components is one of the main objects of path coefficient analysis. Dewey and Lu (1959) recommended the application of path coefficient analysis as a potent method for resolving the accurate and dependable criteria in selection procedure in the breeding of plants and animals.

Durate and Adams (1972) emphasised the identification and classification of the components (causes) to different orders (first, second, third *et cetera*) and the vital importance of the formulation of the causal scheme in path analysis studies. The recommendations have been followed by various workers in different crop species with success. Reports on path coefficient analysis carried out in various grass fodders are briefly reviewed here.

In *Cenchrus ciliaris*, Bohra *et al*. (1969) have concluded that plant height and number of tillers directly contributed to green fodder yield. Ramaswamy (1974) worked on *Cenchrus ciliaris* and *C. setegerus*, and reported that the number of tillers exerted the maximum direct effect on yield followed by length of leaf, thickness of internode, length of internode and height of the clone. Gopalan (1976) reported that in *Cenchrus ciliaris*, the direct effect of stem girth on green fodder yield was low and positive and that it had indirect influence on yield through plant height, leaf length and leaf breadth.

Dhanakodi (1980) reported the positive direct effects of days to flowering, number of tillers and leaf number; and the high and positive indirect effects of plant height, leaf breadth and length of internode through days to flowering in the fodder yield of ragi (*Eleusine coracana*).

Naphade (1972) observed that in forage sorghum number of leaves per plant had a high, direct and positive effect on green fodder yield, followed by plant height. Leaf area influenced the fodder yield, mainly through the number of leaves per plant. In the same crop, studies by Patel *et al.* (1973) revealed that stalk diameter showed large, positive and direct influence on fodder yield, followed by plant height. Leaf area indirectly influenced fodder yield through plant height and stalk diameter. The length of internode was the major component in plant height. Paroda *et al.* (1975) reported that days to flower and plant height had a negative direct effect on both dry and green matter yield of fodder sorghum. They also estimated that the direct effect of leaf length and leaf breadth were high and positive while the stem girth had low, positive and direct effect on fodder yield. Jhorar and Paroda (1976) reported that leaf weight had the highest direct and positive effect on yield of fodder sorghum, followed by leaf breadth and leaf length, while leaf number showed negative direct effect. Leaf number influenced the fodder yield mainly through leaf weight.

Nair and Gupta (1976) in their studies on fodder oats observed that the various second order components like number of tillers, leaf area and number of leaves had a major role in the accumulation of dry matter yield through the first order components namely green weight of stem and green weight of leaves. Dhumale and Mishra (1978) observed in the same crop that the plant height had a high positive and direct effect, while all other characters studied except number of tillers per plant had indirect effect through plant height.

Sethi and Singh (1978) reported that stem girth had negative direct effect and positive indirect effect on dry matter production through green forage yield and number of tillers per plant in barley. Plant height exerted a positive direct effect and indirect effect through green forage yield. Tillers per plant, days to flowering and leaf area had low, negative and direct effects and indirect effects through other characters.

Reports on path analysis involving the various quality aspects are not available.

Materials and Methods

MATERIALS AND METHODS

The investigation was carried out at the Department of Agricultural Botany, College of Agriculture, Vellayani, during 1981-82 to determine the characters associated with yield and quality of green fodder and their degree of association and relative influence on the yield of guinea grass.

Materials

Twenty four diverse varieties of guinea grass were chosen for the study from the germplasm maintained in the All India Co-ordinated Project for Research on Forage crops, I.C.A.R. Vellayani Centre, based on the variability in the fodder characteristics and yield. Details of these types are listed in Table 1.

Methods

A. Field layout

The experiment was laid out in the Instructional Farm attached to College of Agriculture, Vellayani during the south west monsoon of 1981-82, following uniform management practices as recommended in the package of

Table 1. Details of the varieties used

Sl. No.	Variety No.	Name/Accession No. of the variety	Description
1	2	3	4
1.	V_1	M.S.4600	Short duration, slender variety with light green leaves. Average height one metre.
2.	V_2	M.S.4681	Short duration slender variety. Average height 0.9 metre.
3.	V_3	M.S.4675	Short duration type with vegetative phase lasting for about 25 days. Leaves light green. Leaf sheath hairy. Thin light red lines are seen along internodes.
4.	V_4	M.S.4687	Light green short duration plants growing to about 0.9 metre height.
5.	V_5	M.S.4732	A slender, short duration type. Average height one metre.
6.	V_6	M.S.4690	Leaves dark green. A reddish brown patch of about 2 mm. width are seen at the upper end of each internode. Average height 1.2 metres.
7.	V_7	M.S.4688	Average height 1.2 metres. Slender plants with dark green leaves.

(Table 1 contd...)

1	2	3	4
8.	V_8	F.R.426	The vegetative phase is longer and lasts for about 45 days. Grows to an average height of 1.5 metres.
9.	V_9	M.S.4691	Characterised by poor tillering and thin stands. Nodes are hairy and internodes non-hairy. Stout plants, growing for about 2 metres height. Vegetative phase lasts for about 45 days.
10.	V_{10}	F.R.428	A medium duration type with the vegetative phase lasting for about 40 days. Average height 1.5 metres.
11.	V_{11}	P.M.4728	A slender short duration type. Average height 0.9 metre. The whole plant is covered with short grey hairs.
12.	V_{12}	P.M.F.R.553	A quick growing, photosensitive variety. Yields very heavily according to the length of vegetative phase. Leaves are large, erect and bluish green in colour. Average height 3 to 4 metres. Culm is woody, covered with ashy powder.
13.	V_{13}	Mackuenil	A popular cultivar in Kerala. Average height 1.6 metre. The vegetative phase lasts for about 45 - 50 days. All the plant parts are covered with short grey hairs, which is more prominent at the nodes.
14.	V_{14}	P.M.4729	Slender, light green plants. Spikelets light brown. Hairs present on leafsheath, but absent on culms. Thin dark brown lines seen along internodes. A reddish brown patch of 2 mm. length seen just below each node.

(Table 1, concl...)

1	2	3	4
15.	V_{15}	F.R.42	Medium duration type. Average height 1.5 metres.
16.	V_{16}	F.R.550	Average height 1.5 metres. Leaf sheaths, nodes and internodes are covered with short hairs.
17.	V_{17}	A.C.3834	Slender, light green plants growing to a height of one metre. Hairs seen on leaf-sheaths, but absent on culms.
18.	V_{18}	F.R.443	Average height 1.5 metre. Hairiness profuse at nodes. Leaves bright green.
19.	V_{19}	A.C.3836	Slender, light green plants growing to about 0.9 metre height. Just below each node, a reddish brown patch is seen.
20.	V_{20}	M.S.4733	A short duration slender type growing to a height of 1 metre. Spikelets brown in colour.
21.	V_{21}	F.W.429	Hairy outgrowths seen on leaf-sheaths. Average height 1.6 metre. The panicle remains closed as if webbed together.
22.	V_{22}	F.R.552	Average height 1.6 metre. Medium duration type with vegetative phase lasting for 40 to 45 days.
23.	V_{23}	F.R.559	Average height 1.5 metre. Leaves as well as spikelets are light green in colour.
24.	V_{24}	F.R.600	Vegetative phase lasts for about 40 days. Average height 1.6 metre.

practices of Kerala Agricultural University. The field was prepared after thorough digging and removal of weeds. Slips of uniform vigour and length, possessing approximately equal number of nodes were selected for all the twenty four varieties tried. Ridges were taken 60 cm apart and the slips were planted on the ridges at a spacing of 30 cm. The experiment was laid out in randomised block design with three replications. Fifty slips were planted in each plot in five rows of ten plants each. Five clumps from each plot in each replication were selected at random from the middle rows, leaving the outer rows for border effect, for recording the observations.

B. Observations

Nine morphological characters and four chemical attributes relating to the fodder quality were chosen for observation. These observations were made from the five sample hills selected for the purpose. As and when each of the plots attained 50 per cent flowering, the selected sample hills were harvested for recording the following thirteen observations, of which 1 to 8 were recorded at the time of harvest and 9 to 13 from dried samples.

1. Plant height at maturity: The height was measured in centimetres from ground level to the tip of the head of main tiller and recorded.

2. Number of tillers per hill: The total number of tillers produced per hill, excluding very small tillers having less than three fully opened leaves was counted and recorded.

3. Girth of internode: Most of the culms were ovate in shape. Hence the maximum and minimum diameters of the culm were noted at 5 cm height from the base, with the help of a Vernier calipers and the girth was computed by the formula used by Naina Mohammed (1979) in *Echinochloa frumentacea*, viz., girth = $2\pi\sqrt{\frac{a^2 + b^2}{2}}$ where 'a' and 'b' stands for the maximum and minimum diameters of the culm respectively.

4. Leaf area index: It refers to the ratio of leaf area (one side) to ground area (Leopold and Kriedemann, 1975). The length and breadth of all the leaves of the main tiller were measured in centimetres. Area of each of these leaves were computed using the formula suggested by Gomez (1972) in Rice; Choudhar *et al.* (1978) in sorghum and Ferraris and Wood (1980) in *Pennesetum purpureum* viz., $A = k \times l \times w$, where, A = area, l = lamina length, w = maximum lamina width and k = leaf area constant which is computed from the actually measured leaf area. In this case, the actual length and breadth of 10 sample leaves were measured and their area was found out

using graph paper method. The leaf area constant for the experimental crop was computed by substituting these in the formula. The average value for the leaf area constant for a single leaf was obtained as 0.74 approximately. The average leaf area of a tiller was multiplied by the total number of tillers in the five sample hills to get the total leaf area of five hills. Leaf area index was computed by dividing this value, by the land area occupied by five hills, namely 9000 cm^2.

5. Leaf:stem ratio: The leaves and stems of the five harvested hills were weighed separately and the leaf:stem ratio was calculated on a fresh weight basis.

6. Days to fifty per cent flowering: The number of days taken from the date of planting to the date of emergence of anthers in 50 per cent of the plants in each plot was recorded.

7. Length of panicle: The length of panicle from the point where branching starts at the base, to the tip of the main axis was measured in centimetres and recorded.

8. Yield of green fodder: Total yield of green fodder from the five harvested sample hills was noted in grams. This value was multiplied by ten to get an estimate of the per plot yield, since each plot contained fifty hills.

9. Dry matter yield: Thousand grams of green fodder was collected from the harvested lot of each plot and dried first in sun and then in oven at 60°C for 8 hrs. to get a constant weight. The per plot yield of dry matter corresponding to the green fodder yield was estimated from the weight of this oven-dried material, corresponding to thousand grams of green fodder.

10. Crude protein content: Total nitrogen content of the samples were determined by the modified microkjeldhal method (Jackson, 1967) and crude protein percentage was worked out by multiplying the nitrogen content by the factor 6.25 (Simpson et al., 1965).

11. Crude fibre content: This was estimated by the method suggested by Cullison (1978) and recorded in percentage.

12. Oxalate content: The total oxalic acid content was estimated by the analytical procedure as outlined by Sen (1953).

13. K:(Ca+Mg) ratio: Potassium content was determined by using EEL Flame photometer. The total content of (Ca+Mg) was estimated by the versenate titration method as described by Jackson (1967). The K: (Ca+Mg) ratio was worked out from these and recorded.

C. Statistical analysis of the data

(i) Unit analysis

Estimates of mean, variance and standard error were worked out by adopting the standard methods proposed by Panse and Sukhatme (1961).

(ii) Analysis of variance

The mean values of the five clumps in each replication were used for the Analysis of variance, by the method suggested by Panse and Sukhatme (1961). The analysis of variance table was constructed as follows:

Source	d.f.	M.S.	Expectation
Replication	$(r - 1)$	..	..
Genotypes	$(t - 1)$	M_1	$\sigma^2 e + r\sigma^2 g$
Replication x Genotypes (error)	$(r - 1)(t - 1)$	M_2	$\sigma^2 e$
Total	$(rt - 1)$		

Where,

r = number of replications

t = number of genotypes used

M_1 = Variance due to genotypes and

M_2 = Variance due to error.

The 'Test of Significance' was carried out with reference to the 'F' table given by Snedecor (1961).

(iii) Parameters of variability

a. Range:

The interval between the lowest and highest values of a character represents the range for that character.

b. Phenotypic and Genotypic Variances:

These were estimated according to the formula given by Lush (1949).

Environmental variance $(\sigma^2 e) = M_2$

Genotypic variance $(\sigma^2 g) = \dfrac{M_1 - M_2}{r}$

Phenotypic variance $(\sigma^2 ph) = \sigma^2 g + \sigma^2 e$

c. Phenotypic and genotypic coefficients of variability (p.c.v. and g.c.v.):

These coefficients were computed according to Burton (1952).

$$\text{p.c.v.} = \frac{(\text{Phenotypic variance})^{\frac{1}{2}}}{\text{Mean}} \times 100$$

$$\text{g.c.v.} = \frac{(\text{Genotypic variance})^{\frac{1}{2}}}{\text{Mean}} \times 100$$

(iv) Correlation analysis

Analysis of covariance was done in similar manner as that of Analysis of variance. The Error Sum of Products (Mean S.P. for replication x genotypes) was used as Environmental covariance. The genotypic and phenotypic covariances were derived as detailed for genotypic and phenotypic variances. The approximate variance and covariance components were used to calculate phenotypic, genotypic and environmental correlation coefficients. (Johnson *et al.*, 1955).

a. Phenotypic correlation coefficients:

They were computed using the formulae,

$$\text{Phenotypic 'r'} = \frac{\text{Cov. ph } 1.2.}{\sqrt{(\sigma^2 ph_1)(\sigma^2 ph_2)}}, \text{ where}$$

Phenotypic 'r' = Phenotypic correlation coefficient,

Cov. ph 1.2. = Phenotypic covariance between 2 traits (1 and 2)

$\sigma^2 ph_1$ = Phenotypic variance of first trait and

$\sigma^2 ph_2$ = Phenotypic variance of second trait.

b. Genotypic correlation coefficients:

$$\text{Genotypic 'r'} = \frac{\text{Cov. } g_{1.2.}}{\sqrt{(\sigma^2 g_1)(\sigma^2 g_2)}} \quad \text{where,}$$

Genotypic 'r' = Genotypic correlation coefficient

$Cov.\ g_{1.2}$ = Genotypic covariance between 2 traits (1 and 2)

$\sigma^2 g_1$ = Genotypic variance of first trait

and

$\sigma^2 g_2$ = Genotypic variance of second trait.

c. Environmental correlation coefficients:

$$\text{Environmental 'r'} = \frac{Cov.\ e_{1.2}}{\sqrt{(\sigma^2 e_1)\ (\sigma^2 e_2)}} \quad \text{where,}$$

Environmental 'r' = Environmental correlation coefficient

$Cov.\ e_{1.2}$ = Environmental covariance between 2 traits (1 and 2)

$\sigma^2 e_1$ = Environmental variance of first trait and

$\sigma^2 e_2$ = Environmental variance of second trait.

The significance of phenotypic and environmental correlation coefficients were tested by referring to the table given by Snedecor (1961). The genotypic correlation coefficients were tested by the formula given by Prem Narain *et al.*, (1979).

v. Path coefficient analysis

Path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1956) was utilized to partition the cause and effect relationship among the characters. Five morphological characters showing highly significant genotypic correlation with green fodder yield were subjected to path coefficient analysis in order to separate the cause and effect relationship among the characters into measures of direct and indirect effects on yield, by assuming a linear model $Y = a_1 X_1 + a_2 X_2 + \cdots\cdots + a_5 X_5$, where Y and X's are standardised variates corresponding to yield and the five yield attributes respectively. The following set of simultaneous equations were formed and solved for estimating the various direct and indirect effects.

$$r_{iy} = \sum_{j=1}^{5} P_{iy} \; r_{ij}; \quad i = 1, \ldots\ldots 5,$$

where, r_{iy} denotes coefficient of correlation between independent character X_i and dependent character Y, r_{ij} denotes the coefficient of correlation between i^{th} and j^{th} characters, P_{iy} denotes the direct effects of the i^{th} character on Y.

The above equation can be written in a matrix form as shown below:

$$
\overset{A}{\begin{bmatrix} r_{1Y} \\ r_{2Y} \\ r_{3Y} \\ r_{4Y} \\ r_{5Y} \end{bmatrix}}
\quad
\overset{B}{\begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} \end{bmatrix}}
\overset{C}{\begin{bmatrix} P_{1Y} \\ P_{2Y} \\ P_{3Y} \\ P_{4Y} \\ P_{5Y} \end{bmatrix}}
$$

where,

$$r_{ij} = r_{ji}; \quad r_{ii} = 1.$$

$A = BC$; hence $C = B^{-1}A$, where, B^{-1} is the inverse of B.

The residual effect which measures the contribution of rest of the characters not included in the causal scheme was obtained by the formula $(1 - R^2)^{\frac{1}{2}}$ where,

$$R^2 = \sum_{i=1}^{5} P^2_{iy} + 2 \sum_{i} \sum_{j} P_{iy} \; P_{jy} \; r_{ij}$$

$$i < j$$

Results

RESULTS

The data collected on the various morphological and chemical attributes were statistically analysed and the results obtained are presented below as under.

A. Mean performance of individual traits

B. Variability analysis

C. Correlation analysis and

D. Path coefficient analysis

A. Mean Performance of Individual Traits

The mean performance of each of the twenty four genotypes for the thirteen characters under study are furnished in Table 2 and the values of general mean and range in Table 3.

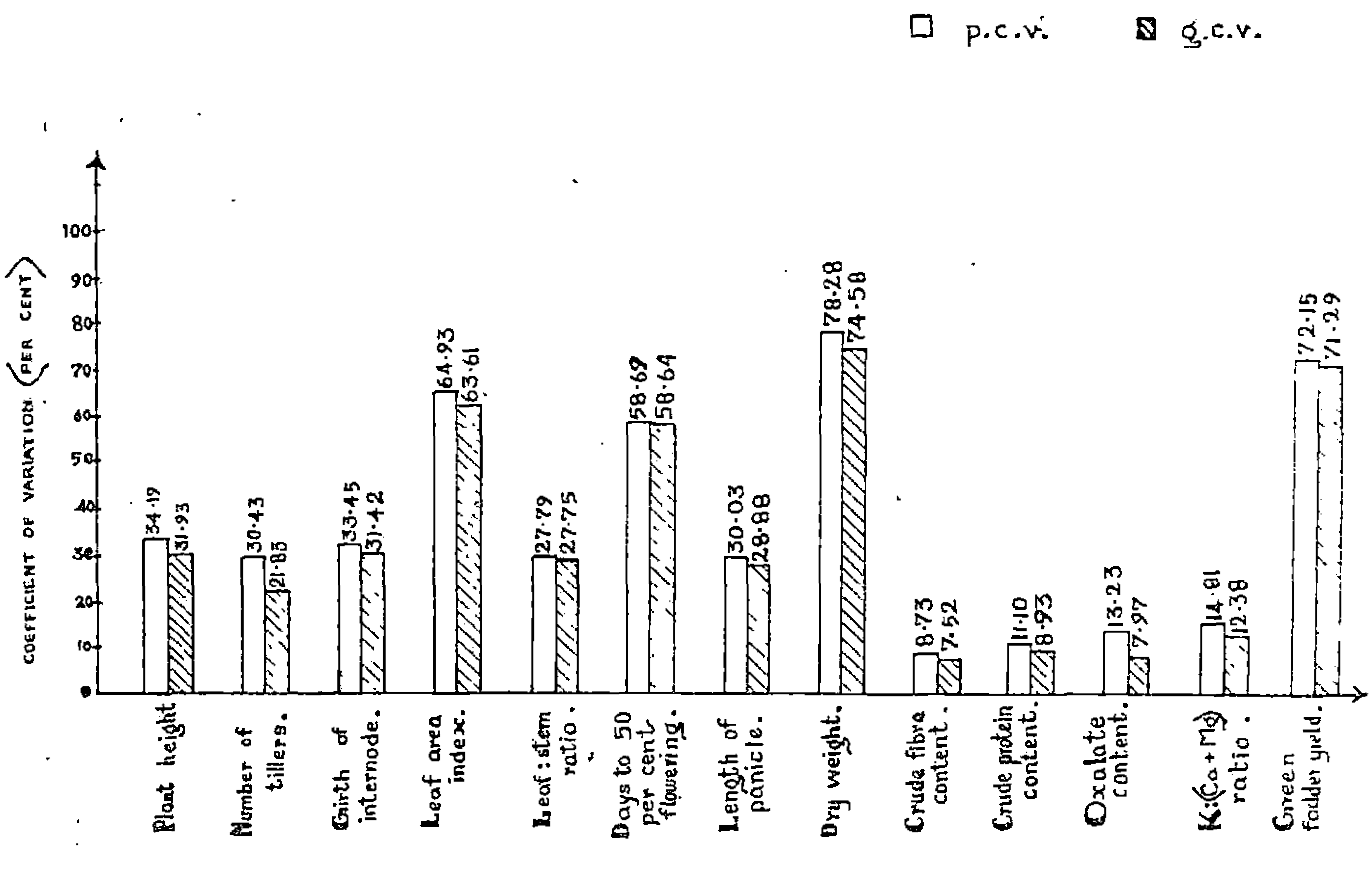
The genotypes exhibited wide and significant differences among themselves for each of the character studied. The mean values for plant height ranged from 97.73 cm in V_{17} to 318.47 cm in V_{12}. The mean values of twelve types were above the general mean value (135.51 cm). The number of tillers ranged between 8.20 in V_9 and 40.93 in V_{13} and fourteen types exceeded the general mean

Table 3. The General mean, range, phenotypic coefficient of variation and genotypic coefficient of variation for thirteen characters in twenty four varieties of guinea grass fodder

Sl. No.	Characters	General Mean	Range	Genotypic coefficient of variation (g.c.v.)	Phenotypic coefficient of variation (p.c.v.)
1.	Plant height (cm.)	135.51	97.73-318.47	31.93	34.19
2.	Number of tillers	26.86	8.20- 40.93	21.83	30.43
3.	Girth of internode (cm.)	0.434	0.273- 0.849	31.42	33.45
4.	Leaf area index	3.79	1.76-12.13	63.61	64.93
5.	Leaf:stem ratio	0.594	0.386- 1.060	27.75	27.79
6.	Days to 50 per cent flowering	22.43	11.67-76.67	58.64	58.69
7.	Length of panicle (cm.)	26.43	19.17-49.60	28.88	30.03
8.	Dry weight (gm)	4,623.34	1,820.00-17,636.67	74.58	78.29
9.	Crude fibre content (per cent)	28.91	25.37-34.10	7.52	8.73
10.	Crude protein content (per cent)	8.28	6.98- 9.86	0.93	11.10
11.	Oxalate content (per cent)	1.29	1.14- 1.65	7.97	13.23
12.	K: (Ca+Mg) ratio	0.403	0.327-0.540	12.30	14.81
13.	Green fodder yield (gm.)	21,584.03	9,000.00-74333.33	71.29	72.15

of 26.86. The girth of internode was maximum for V_{12} (0.849 cm) and minimum for V_{17} (0.273 cm). Twelve types had mean values above the general mean of 0.434 cm. Leaf area index had a range between 1.76 in V_7 to 12.13 in V_{12} and eleven types had mean values above the general mean (3.79). The leaf:stem ratio had a range between 0.386 in V_2 and 1.060 in V_{12}. Eleven types exceeded the general mean (0.594). The days taken for 50 per cent flowering was minimum in V_7 (11.67) and V_{12} took the maximum period (76.67 days) to attain 50 per cent flowering. In this case, twelve types exceeded the general mean of 22.43 days. The length of panicle ranged between 19.17 cm in V_{21} and 49.60 cm in V_{12}. Eleven types exceeded the general mean value (26.43 cm). The dry matter yield was the least for V_{14} (1,820.00 gms) and the maximum in V_{12} (17,636.67 gms.) and eleven types exceeded the general mean of 4,623.34 gms. The crude fibre content varied between 25.37 per cent in V_{11} and 34.10 per cent in V_{12} and twelve types exceeded the general mean of 28.91 per cent. Crude protein content was maximum in V_5 (9.86 per cent) and minimum in V_{12} (6.98 per cent). Mean values of 10 types exceeded the general mean of 8.28 per cent. The oxalate content ranged between 1.14 per cent in V_1 and 1.65 per cent in V_{14} and ten types had mean values above the general mean value (1.29 per cent). The

FIG. 1. PHENOTYPIC AND GENOTYPIC COEFFICIENTS OF VARIATION FOR THIRTEEN CHARACTERS IN GUINEA GRASS.



K: (Ca+Mg) ratio ranged between 0.327 and 0.540. Here, twelve types had mean values above the general mean of 0.403. The maximum quantity of green fodder was obtained from V_{12} (74,333.33 gms) and it was the least in V_4 (9,000.00 gms) and eleven varieties yielded above the general mean yield of 21,584.03 gms.

D. Variability Studies

The variability estimates for penotypic coefficient of variation (p.c.v.) and genotypic coefficient of variation (g.c.v.) among the twenty four varieties for the thirteen characters are presented in Table 3 and in Fig. I. The maximum value for genotypic coefficient of variation (g.c.v.) was observed for dry weight (74.58 per cent) followed by green fodder yield (71.29), leaf area index (63.61), days to 50 per cent flowering (58.64), plant height (31.93), girth of internode (31.42), length of panicle (28.88), leaf:stem ratio (27.75), number of tillers (21.83), K: (Ca+Mg) ratio (12.38), crude protein content (8.93), oxalate content (7.97) and crude fibre content which had the least value of 7.52 per cent of genotypic coefficient of variation.

The highest phenotypic coefficient of variation was observed for dry weight (78.23 per cent), followed by green fodder yield (72.15), leaf area index (64.93), days to 50 per cent flowering (58.69), plant height (34.19), girth of internode (33.45), number of tillers (30.43), length of panicle (30.03), leaf:stem ratio (27.79), K: (Ca+Mg) ratio (14.81), oxalate content (13.23) and crude protein content (11.10). The least p.c.v. was observed for crude fibre content (8.73).

The least difference between the two coefficients (g.c.v. and p.c.v.) was observed for leaf:stem ratio (0.04 per cent).

The difference was maximum for number of tillers (8.60 per cent) followed by oxalate content (5.26), dry weight (3.70), K: (Ca+Mg) ratio (2.43), plant height (2.26), crude protein content (2.17), leaf area index (1.32), crude fibre content (1.21), length of panicle (1.15), green fodder yield (0.86) and days to 50 per cent flowering (0.05).

C. Correlation Studies

The analysis of covariance was done for all the possible seventy eight (13 C_2) pairs of characters. The genotypic, phenotypic and environmental covariance components were computed in a similar manner as for the corresponding variance components. From these values, the genotypic, phenotypic and environmental correlation coefficients were estimated. The data on correlations are presented under the following heads.

a. Correlations between green fodder yield and its components

b. Correlations among the yield components

a. Correlation between green fodder yield and its components.

The genotypic and phenotypic covariances between green fodder yield and its components are presented in Table 4. and the corresponding correlation coefficients in Table 5. The genotypic correlation coefficients were higher than the phenotypic correlation coefficients, for all the characters under study.

The genotypic correlation of yield with all other characters except K: (Ca+Mg) ratio and oxalate content were found to be significant. The correlation was the highest with dry weight (r = 0.9900), followed by that with leaf area index (r = 0.9740), plant height (r = 0.9373), days to 50 per cent flowering (r = 0.9282), length of panicle (r = 0.9127), girth of internode (r = 0.8846), crude fibre content (r = 0.8795) and leaf:stem ratio (r = 0.8531). However, its correlation

Table 4. The genotypic (G) and phenotypic (P) covariances between green fodder yield and yield components

Sl. No.	Characters	Covariance	
		Genotypic (G)	Phenotypic (P)
1.	Plant height (cm)	624546.99	635924.04
2.	Number of tillers	-32331.06	-33974.09
3.	Girth of internode (cm.)	1856.04	1870.92
4.	Leaf area index	36121.47	36720.56
5.	Leaf:stem ratio	2311.28	2310.00
6.	Days to 50 per cent flowering	107837.59	107705.56
7.	Length of panicle (cm.)	107195.16	108082.37
8.	Dry weight (gm)	53054159.20	54926014.70
9.	Crude fibre content (per cent)	29424.80	29045.38
10.	Crude protein content (per cent)	-4419.49	-4419.76
11.	Oxalate content (per cent)	239.02	190.94
12.	K: (Ca + Mg) ratio	81.77	64.22

Table 5. The phenotypic (r_p) and genotypic (r_G) correlation coefficients and standard error of genotypic correlation coefficients (S.E. r_G) between green fodder yield and yield components.

Sl. No.	Character	r_p	r_G	S.E. r_G
1.	Plant height (cm.)	0.8906**	0.9373**	0.0201
2.	Number of tillers	-0.2670*	-0.3535**	0.2370
3.	Girth of internode (cm)	0.8276**	0.8846**	0.0585
4.	Leaf area index	0.9587**	0.9740**	0.0046
5.	Leaf:stem ratio	0.8413**	0.8531**	0.0300
6.	Days to 50 per cent flowering	0.9155**	0.9282**	0.0113
7.	Length of panicle (cm.)	0.8748**	0.9127**	0.0189
8.	Dry weight (gm.)	0.9746**	0.9900**	0.00006
9.	Crude fibre content (per cent)	0.7392**	0.8795**	0.0584
10.	Crude protein content (per cent)	-0.6173**	-0.7764**	0.0966
11.	Oxalate content (per cent)	0.0717	0.1510	0.3240
12.	K: (Ca + Mg) ratio	0.0693	0.1066	0.2391

* Significant at 5 per cent level.

** Significant at 1 per cent level.

with number of tillers (r = -0.3585) and crude protein content (r= -0.7764) were found to be significant and negative.

The phenotypic correlation coefficients of these characters with yield also were found to have the same order of magnitude as that of genotypic correlation coefficients. Its value was the highest with dry weight (r = 0.9746) followed by leaf area index (r = 0.9587), days to 50 per cent flowering (r = 0.9155), plant height (r = 0.8806), length of panicle (r = 0.8748), leaf:stem ratio (r = 0.8413), girth of internode (0.8276) and crude fibre content (r = 0.7392). The phenotypic correlation of green fodder yield was not significant for oxalate content (r = 0.0717) and K: (Ca+Mg) ratio (r = 0.0693). It was significantly negative with crude protein content (r =-0.6173) and number of tillers (r = -0.2670) per clump.

b. Correlations among the yield component characters.

The genotypic and phenotypic covariance values among the yield components were computed and are presented in Table 6 and the corresponding correlation coefficients in Table 7.

(i) Plant height

The plant height showed significant positive genotypic association with days to 50 per cent flowering (r = 0.9900), dry weight (r = 0.9567), girth of internode (r = 0.9255), length of panicle (r = 0.9255), leaf area index (r = 0.9232), crude fibre content (r = 0.8746), leaf: stem ratio (r= 0.8007) and oxalate content (r = 0.2842). It had no genotypic association with K: (Ca+Mg) ratio (r= 0.1415). The genotypic association of plant height with crude protein content (r = -0.7611) and number of tillers (r = -0.5674) were negative and significant. The phenotypic correlations of this character also was significant and positive with days to 50 per cent flowering (r = 0.9424), dry weight (r = 0.8887), leaf area index (r = 0.8591), girth of internode (r = 0.8421), length of panicle (r= 0.8271), leaf: stem ratio (r = 0.7461) and crude fibre content (r = 0.6782). Significant and negative phenotypic association was observed with crude protein content (r = -0.5841) and number of tillers (r = -0.3656) per clump. No phenotypic association with oxalate content and K: (Ca+Mg) ratio was observed for this particular character.

(ii) Number of tillers.

Number of tillers per clump showed significant negative genotypic association with almost all the characters under study except crude protein content, where the association was significantly positive ($r = 0.6303$). It exhibited significant negative genotypic correlation with girth of internode ($r = -0.7911$), crude fibre content ($r = -0.6697$), oxalate content ($r = -0.6042$), length of panicle ($r = -0.5682$), plant height ($r = -0.5674$), days to 50 per cent flowering ($r = -0.5251$), leaf:stem ratio ($r = -0.3903$) dry weight ($r = -0.3227$) and leaf area index ($r = -0.2689$). There was no genotypic association between this trait and K: (Ca+Mg) ratio. The phenotypic correlations also showed trends similar to that of the genotypic correlations. Significantly negative phenotypic correlation was observed between this character and girth of internode ($r = -0.4786$), crude fibre content ($r = -0.4618$), length of panicle ($r = -0.3874$), days to 50 per cent flowering ($r = -0.3740$), plant height ($r = -0.3656$), leaf:stem ratio ($r = -0.2764$) and oxalate content ($r = -0.2721$). A non-significant negative phenotypic correlation was observed with leaf area index ($r = -0.1694$) and K: (Ca+Mg) ratio ($r = -0.0602$). And also the phenotypic correlation with crude protein content was significant and positive.

(iii) Girth of internode.

Girth of internode recorded a positive genotypic correlation with crude fibre content(r = 0.9865), plant height (r = 0.9555), length of panicle (r = 0.9297), days to 50 per cent flowering (r = 0.9140), dry weight (r = 0.8627), leaf area index (r = 0.8352), leaf:stem ratio (r = 0.8122) and oxalate content (r = 0.3812). It had no genotypic association with K: (Ca+Mg) ratio (r = 0.0464). Highly significant negative genotypic correlation was observed for this character with crude protein content (r = -0.8959) and number of tillers (r = -0.7911). The general trend of phenotypic correlations also was similar. In this case, days to 50 per cent flowering had the highest value (r = 0.8588) followed by length of panicle (r = 0.8565), plant height (r = 0.8421), crude fibre content (r = 0.7928), dry weight (r = 0.7908), leaf area index (r = 0.7826) and leaf:stem ratio (r = 0.7665). The correlation of this character with oxalate content (r = 0.2024) and K: (Ca+Mg) ratio (r = 0.0425) were not significant. In this case also its correlation with crude protein content (r = -0.6753) and number of tillers (r = -0.4786) were negatively significant.

(iv) Leaf area index.

At genotypic level, this character exhibited significant positive correlations with dry weight (r = 0.9898), plant height (r = 0.9232), days to 50 per cent flowering (r = 0.9172), length of panicle (r = 0.8652), leaf:stem ratio (r=0.8602, girth of internode (r = 0.8352) and crude fibre content (r = 0.8198). Negatively significant genotypic association was seen for this character with crude protein content (r = -0.7542) and number of tillers (r = -0.2689). With other characters, the genotypic correlation was not significant. The phenotypic correlation coefficient of leaf area index was the highest with dry weight (r = 0.9437) followed by days to 50 per cent flowering (r = 0.8977), plant height (r = 0.8591), leaf: stem ratio (r = 0.8404), length of panicle (r = 0.8301), girth of internode (r = 0.7826) and crude fibre content (r = 0.6836). The phenotypic correlation was significantly negative with crude protein content (r = -0.5907). Leaf area index had no association with oxalate content and K: (Ca+Mg) ratio at phenotypic as well as genotypic levels

(v) Leaf:stem ratio.

Leaf:stem ratio showed significantly positive genotypic correlations with length of panicle (r = 0.8679), crude fibre content (r = 0.8670), leaf area index (r = 0.8602), dry weight (r = 0.8286), girth of internode (r = 0.8122), days to 50 per cent flowering (r = 0.8034), plant height (r = 0.8007) and oxalate content (r = 0.4343). The genotypic correlations were significantly negative with crude protein content (r = -0.8420) and number of tillers (r = -0.3903). The phenotypic correlations also were significant and positive for this character with other yield components such as leaf area index (r = 0.8404), length of panicle (r = 0.8359), days to 50 per cent flowering (r = 0.8020), dry weight (r = 0.7902), girth of internode (r = 0.7665), crude fibre content (r = 0.7485), plant height (r = 0.7461) and oxalate content (r = 0.2614). Negative phenotypic correlation was observed for crude protein content (r = -0.6772) and number of tillers (r = -0.2764). The character had no association with K: (Ca+Mg) ratio, both at phenotypic and genotypic levels.

(vi) Days to 50 per cent flowering.

Days to 50 per cent flowering showed high positive genotypic correlation with plant height (r = 0.9900), dry weight (r = 0.9567), leaf area index (r = 0.9172), girth of internode (r = 0.9140), length of panicle (r = 0.8872), crude fibre content (r = 0.8582) and leaf:stem ratio (r = 0.8304). Its genotypic association with crude protein content (r = -0.7336) and number of tillers (r = -0.5251) were significantly negative. The phenotypic correlation of this character with other yield components also showed a similar trend. The highest positive phenotypic correlation coefficient was with plant height (0.9424), followed by dry weight (0.9113), leaf area index (0.8977), girth of internode (0.8928), length of panicle (0.8521), leaf:stem ratio (0.8020) and crude fibre content (0.7350). As in the case of genotypic correlations, the phenotypic correlation with crude protein content (r = -0.5890) and number of tillers (r = -0.5740) also were negatively significant. There was no association for this character with oxalate content and K: (Ca+Mg) ratio at genotypic as well as phenotypic levels.

(vii) Length of panicle.

The genotypic correlations of this character was significant and positive with other characters like girth of internode (r = 0.9287), plant height (r = 0.9255), crude fibre content (r = 0.8965), dry weight (r = 0.8952), leaf area index (r = 0.8552) and oxalate content (r = 0.2940). No genotypic association was observed with K: (Ca+Mg) ratio (r = 0.2040). The genotypic association was significant and negative with crude protein content (r = -0.8099) and number of tillers (r = -0.5682). The phenotypic correlations also were significantly positive with girth of internode (r = 0.8369), days to 50 per cent flowering (r = 0.8521), leaf:stem ratio (r = 0.8559), dry weight (r = 0.8314), leaf area index (r = 0.8301), plant height (r = 0.8271) and crude fibre content (r = 0.7506). There was no phenotypic association for the character with K: (Ca+Mg) ratio (r = 0.1539), and oxalate content (r = 0.1459). The correlation coefficients of this character with crude protein content and number of tillers were negative and significant, their values being -0.6458 and -0.3874 respectively.

(viii) Dry weight.

Dry weight exhibited high positive genotypic association with leaf area index (r = 0.9898), plant height (r = 0.9567), length of panicle (r = 0.8952), girth of internode (r = 0.8627), crude fibre content (r = 0.8458) and leaf:stem ratio (r = 0.8286). It had no association with oxalate content (r = 0.0966) and K: (Ca+Mg) ratio (r = -0.1092). It had significantly negative correlations with crude protein content (r = -0.7291) and number of tillers (r = -0.3227). This character had significantly positive phenotypic correlation with leaf area index (r = 0.9437), days to 50 per cent flowering (r = 0.9113), plant height (r = 0.8887), length of panicle (r = 0.8314), girth of internode (r = 0.7908), leaf:stem ratio (r = 0.7902) and crude fibre content (r = 0.6799). The phenotypic association was negatively significant with crude protein content (r = -0.5692) and number of tillers (r = -0.2355) and not significant with K:(Ca+Mg) ratio (r = 0.0646) and oxalate content (r = 0.0401).

(ix) Crude fibre content.

The maximum correlation for this character at genotypic level was observed with girth of internode (r = 0.9865) followed by length of panicle (0.8965), plant height (r = 0.8746), leaf:stem ratio (r = 0.8670), days to 50 per cent flowering (r = 0.8582), dry weight (r = 0.8458), leaf area index (r = 0.8198) and oxalate content (r = 0.3987). With crude protein content and number of tillers, the genotypic correlation coefficients were negative (r = -0.8320) and (r = -0.6697). The phenotypic correlation coefficient of this character was highest with girth of internode (r = 0.7928), followed by length of panicle (r = 0.7506), leaf:stem ratio (r = 0.7485), days to 50 per cent flowering (r = 0.7350), leaf area index (r = 0.6836), dry weight (r = 0.6799), plant height (r = 0.6782) and oxalate content (r = 0.2564). The correlation with K: (Ca+Mg) ratio was not significant both at phenotypic and genotypic levels.

(x) Crude protein content.

Crude protein content showed significant negative correlations with most of the characters under study, except with number of tillers where the correlations were positive both at genotypic and phenotypic levels (r = 0.6303) and r = 0.4593 respectively). At genotypic level, the maximum negative correlation was observed with girth of internode (r = -0.8959), followed by leaf:stem ratio (r = -0.8420), crude fibre content (r = -0.8320), plant height (r = -0.7611), leaf area index (r = -0.7542), days to 50 per cent flowering (r = -0.7336), dry weight (r = -0.7291) and oxalate content (r = -0.5760). At phenotypic levels also negative correlations were observed with leaf:stem ratio (r = -0.6772), girth of internode (r = -0.6753), length of panicle (r = -0.6458), days to 50 per cent flowering (r = -0.5890), plant height (r = -0.5841), dry weight (r = -0.5692) and oxalate content (r = -0.2394). There was no association between this character and K: (Ca+Mg) ratio both at phenotypic and genotypic levels.

(xi) Oxalate content.

In general, this character showed only weak correlations. Significant positive genotypic correlations were observed with leaf:stem ratio (r = 0.4343), crude fibre content (r = 0.3987), girth of internode (r = 0.3812), length of panicle (r = 0.2940) and plant height (r = 0.2342). Also, significant negative correlations were found with number of tillers (r = -0.6042) and crude protein content (r = -0.5760) at genotypic levels. The phenotypic correlations were positively significant with leaf:stem ratio (r = 0.2614) crude fibre content (r = 0.2564) and negatively significant with number of tillers (r = -0.2721). In the remaining cases, the correlations were not significant at phenotypic as well as genotypic levels.

(xii) K: (Ca+Mg) ratio.

This character did not show significant associations with any of the characters under study at phenotypic and genotypic levels.

D. Path Coefficient Analysis

The five morphological characters, which showed highly significant genotypic correlation with green fodder yield viz., days to 50 per cent flowering, plant height, number of tillers, girth of internode and length of panicle were considered for path coefficient analysis in order to partition the total association of the characters with green fodder yield, into direct and indirect effects. Path coefficients were worked out and the results obtained are presented in Table 8 and Fig. II.

(a) Direct effects.

The maximum contribution to green fodder yield was through plant height, since it recorded maximum positive direct effect (3.7924), followed by girth of internode (2.5052) and number of tillers (1.3539). Days to 50 per cent flowering and length of panicle showed negative direct effects, their values being -3.5605 and -1.0068 respectively.

(b) Indirect effects.

(i) Plant height.

Plant height showed positive indirect effect only via. girth of internode (2.3937). All other indirect effects were negative. Maximum negative indirect effect was through days to 50 per cent flowering (-3.5605), followed by length of panicle (-0.9317) and number of tillers (-0.7566).

(ii) Number of tillers.

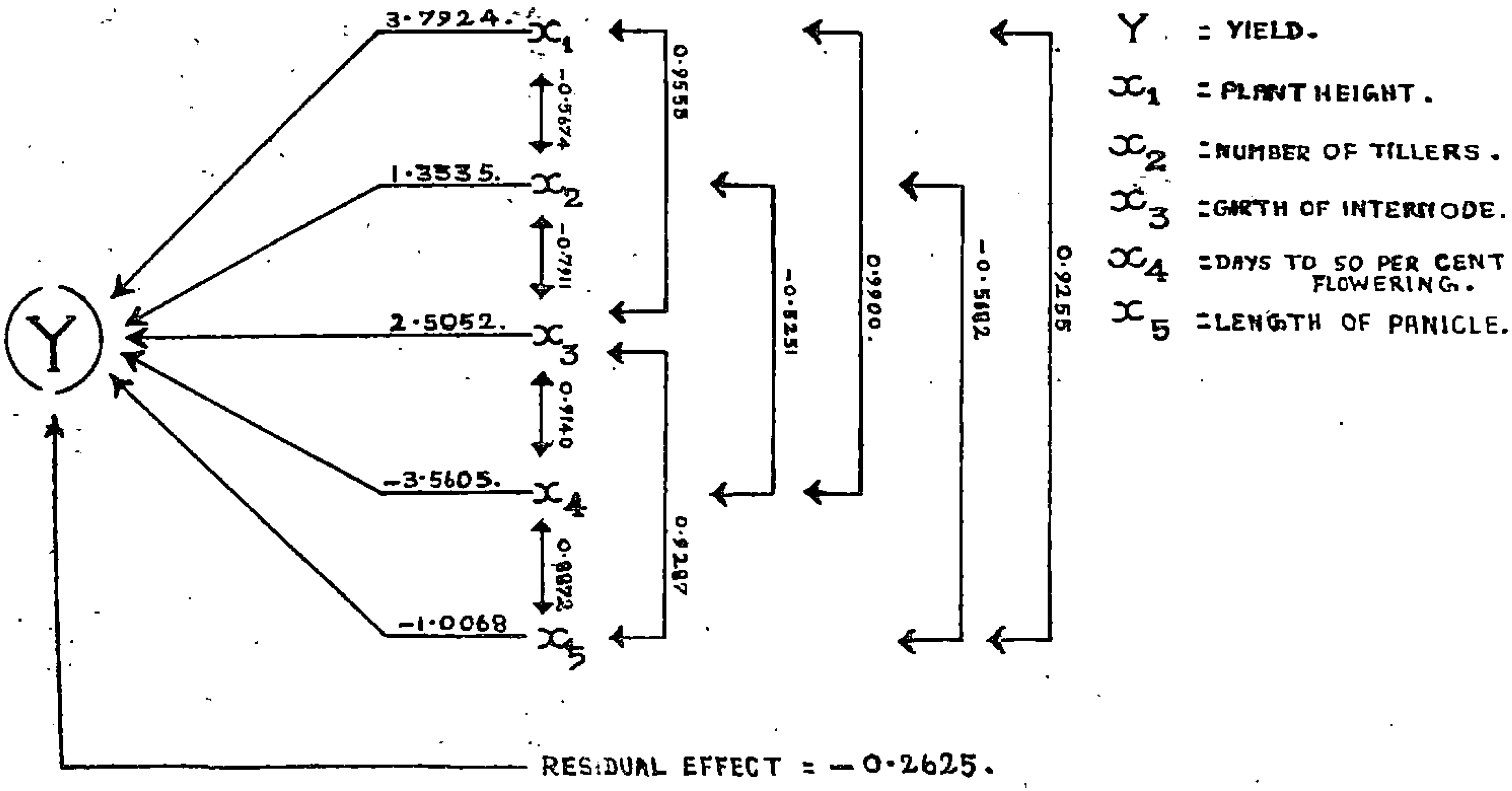
It had positive indirect effects on yield through days to 50 per cent flowering (1.0696) and length of

Table 8. Path coefficient values - Direct and indirect genotypic effects on green fodder yield through various yield components.

Sl. No.	Characters	Direct effect	Indirect effects via					
			Plant height (cm.)	Number of tillers	Girth of inter-node (cm.)	Days to 50 per cent flowering	Length of panicle (cm.)	Total correla-tion
1.	Plant height (cm)	3.7924	..	-0.7566	2.3937	-3.5605	-0.9317	0.9373
2.	Number of tillers	1.3335	-2.1518	..	-1.9019	1.8696	0.5721	-0.3595
3.	Girth of internode (cm)	2.9052	3.6236	-1.0549	..	-3.2543	-0.9350	0.8846
4.	Days to 50 per cent flowering	-3.5605	3.7924	-0.7002	2.2897	..	-0.8932	0.9282
5.	Length of panicle (cm)	-1.0068	3.5095	-0.7577	2.3266	-3.1589	..	0.9127

Residual effect = -0.2625.

FIG. II. PATH DIAGRAM SHOWING THE DIRECT EFFECTS AND INTER-RELATIONSHIPS BETWEEN GREEN FODDER YIELD AND FIVE SELECTED YIELD COMPONENTS.



panicle (0.5721) and negative indirect effects through plant height (-2.1518) and girth of internode (-1.9819).

(iii) Girth of internode.

Girth of internode showed positive indirect effect on yield only through plant height (3.6236). It had maximum negative indirect effect through days to 50 per cent flowering (-3.2543) followed by number of tillers (-1.0549) and length of panicle (-0.9350).

(iv) Days to 50 per cent flowering.

This character exhibited maximum positive indirect effects through plant height (3.7924), followed by girth of internode (2.2897). It also had negative indirect effects through length of panicle (-0.8932) and number of tillers (-0.7002).

(v) Length of panicle.

The positive indirect effect of length of panicle on yield was maximum through plant height (3.5095), followed by girth of internode (2.3266). It also had negative indirect effects via days to 50 per cent flowering (-3.1589) and number of tillers (-0.7577).

Discussion

DISCUSSION

In any crop, prior to a production breeding programme, basic research has to be carried out to obtain informations on the breeding behaviour, extent of genetic variability existing in the available germplasm, genetic associations between various characters, heritability of characters, the type of gene actions operating in the expression of these characters etc. Knowledge on these parameters help the breeder for direct selection and in choosing the appropriate parent material for the most suitable breeding methodology. The present investigation aims at obtaining some of these basic genetic informations in guinea grass, which is one of the most popular fodder grasses in Kerala. The results obtained from the present study are discussed below:

A. Variability Studies

Guinea grass is a naturally cross pollinated crop and hence exhibits vast amount of variability. In the present study also, the analysis of variance revealed that there was significant difference among the twenty four varieties of guinea grass tested, for all the thirteen characters studied. Of the twenty four varieties used for the study, one variety viz., P.M.E.R. 593 had mean values far above the general mean values, for all the morphological characters considered for the study. Variety dependent variations on mean values were noticed in almost all the characters analysed. Pillai et al. (1974) have reported similar findings in guinea grass. The existence of such varietal diversity offers much scope for formulating future breeding programmes.

Variability is the basis of any crop improvement programme. Wide genetic variability in the base population provides the ways for crop improvement through systematic breeding procedures. It is a pre-requisite in the improvement of any cultivable crop, to precisely assess the nature of variability occurring in a base population and the factors influencing it. The observed variability may be due to genetic or environmental factors, or due to an interaction between the two. Partitioning of the total variability into heritable and non-heritable portions helps the breeder to assess the genetic value of the various genotypes, and also the extent of achievements possible in that particular crop.

To make a more valid comparison, an accurate estimate of phenotypic and genotypic variabilities were computed in terms of the corresponding coefficients of variation viz., phenotypic coefficient of variation (p.c.v.) and genotypic coefficient of variation (g.c.v.) which are free from the units of measurements; whereas phenotypic and genotypic variance estimates are associated with units of measurements. In the present study, high g.c.v. values were observed for characters like dry weight, green fodder yield, leaf area index and days to 50 per cent flowering indicating that these characters are potentially variable. High g.c.v.values for fodder yield were reported by Sethi and Singh (1978) in barley fodder and by Dhanakodi (1980) in fodder ragi. Also, Rana et al. (1976) and Gupta and Athwal (1966) obtained similar observations in fodder sorghum and pearl millet respectively. High g.c.v. values for dry matter yield was reported in fodder oats by Thyagi et al. (1977). In the case of days to 50 per cent flowering Gupta and Athwal (1966) have reported high g.c.v. values in forage pearl millet. But the same is reported to be low in barley fodder (Sethi and Singh, 1978). The high g.c.v. values for these characters in the present study suggest that they can be given priority in selection programmes, in the case of guinea grass. The other characters that showed moderately high g.c.v. were plant height, girth of internode, length of panicle and leaf:stem ratio. Similar trends for plant height was also reported by Nair and Gupta (1977) in fodder oats. This character also needs to be given importance in selection programmes.

A perusal of the difference between phenotypic and genotypic coefficients of variation for different traits indicated that it was the least for leaf:stem ratio, days to 50 per cent flowering and green fodder yield. This clearly suggests that these characters are least influenced by environment and genetic factors play a dominant role in determining the expression of these traits. Patnaik (1968) obtained similar results for days to flowering in ragi. The large difference between these two coefficients of variability (p.c.v. and g.c.v.) observed in the case of number of tillers per clump indicated that external factors play an important role in determining its expression.

B. Correlation Analysis

Yield is a complex quantitative character and many other metric traits which are inter-related influence it. A selection applied on one trait may show a correlated responce on other characters also, since these component characters show intercorrelations. Therefore estimation of phenotypic, genotypic and environmental correlations between yield and yield components and also among the yield components themselves form a pre-requisite for making effective selection, especially when two or more characters are simultaneously considered in the selection programme.

In general, the genotypic correlation for the different characters were higher than the phenotypic correlations. Such a trend has been observed in forage sorghum (Vishnuswarup and Chaugule, 1962); in proso millet and <u>Cenchrus ciliaris</u> (Gopalan, 1976) and in ragi (Dhanakodi, 1980). This suggests that expression of the characters are strongly interrelated and genetically controlled.

In the present investigation, fodder yield was found to be significantly correlated with all the characters except oxalate content and K: (Ca+Mg) ratio. It indicated that majority of the yield components chosen for the study may probably be directly associated with fodder yield.

Plant height had high positive correlation with green fodder yield. Significant positive correlation of plant height with green fodder yield had been reported in several other crops like <u>Cenchrus ciliaris</u>

(Bohra *et al.*, 1969; Yadav *et al.*, 1974; Ramaswamy, 1974 and Gopalan, 1976), Italian rye grass (Fujimoth and Susuki, 1976), fodder bajra (Gupta and Athwal, 1966; Gupta and Nanda, 1971 and Gupta and Sindhu, 1973), barley fodder (Sethi and Singh, 1978), fodder oats (Rao *et al.*, 1978; Dhumale and Mishra, 1978 and Singh *et al.*, 1980) and in *Echinochloa frumentaceae* (Naina Mohammed, 1979). Taller varieties along with their added foliage positively aids for higher photosynthetic efficiency which may account for increased fodder yields.

In the present study, the number of tillers per clump was found to be negatively correlated with green fodder yield. This is in confirmity with the findings of Dhanakodi (1980) in ragi. But, many of the previous workers reported a strong positive correlation between these two traits in other cereal fodders like fodder bajra (Gupta and Athwal, 1966; Gupta and Nanda, 1971; Saxena *et al.*, 1978 and Thyagi *et al.*, 1980) and fodder oats (Nair and Gupta, 1976; Dhumale and Mishra, 1978 and Singh *et al.*, 1980); and also in grass fodders like *Cenchrus ciliaris* (Bohra *et al.*, 1969; Yadav *et al.*, 1974; Ramaswamy, 1974 and Gopalan, 1976) and Italian rye grass (Fujimoth and Susuki, 1976). It is noteworthy to mention at this juncture that most of the types chosen for the present investigation did not exhibit a synchronous 50 per cent flowering. While a few tillers were in bloom, few others were still in vegetative phase, leading to a non-realisation of the full contribution by the tillers to the fodder yield.

Girth of internode exhibited high positive association with green fodder yield. In forage sorghum, Vasudeva Rao and Ahluwalia (1977) observed similar correlations. Positive association between culm diameter and fodder yield had been reported in forage sorghum (Vaithialingam, 1979) and in Echinochloa frumentacea (Naina Mohammed, 1979).

Leaf area index also showed strong positive correlation with yield. Positive correlation between leaf area and fodder yield had been observed in oats (Nair and Gupta, 1976) and bajra (Thyagi et al., 1980). The strong and positive correlation between green fodder yield and leaf area index may be explained on the basis of the 'source-sink' relationships. The leaf area provides the photosynthesising surface which serves as the 'source' for assimilates. This assimilates got accumulated in the vegetative plant parts and also contribute to the production of more 'source' viz., leaf area. As leaf area increases, the biomass accumulation also get increased in a linear order which may lead for higher production.

Days to 50 per cent flowering showed high positive correlation with green fodder yield. This finding is in line with the reports of Vishnu Swarup and Chaugale (1962), Paroda *et al.* (1975), Vasudeva Rao and Ahluwalia (1977) and Ross *et al.* (1979) in forage sorghum. Dhanakodi (1980) also has reported similar finding in fodder ragi. Varieties that take more days to attain 50 per cent flowering stage possess a longer vegetative phase thereby helping to accumulate more assimilates, which finally contributed to increased fodder yields. The length of panicle was another character found to have significant positive association with fodder yield. Such an association had been reported in *Cenchrus ciliaris* by Yadav *et al.* (1974).

Dry matter yield had the highest positive association with green fodder yield. Similar significant associations in biomass accumulation were reported by Sotomayour-Rios *et al.* (1971) in *Digitaria*, Naina Mohammed (1979) in *Echinochloa frumentacea*, Fujimoth and Suzuki (1976) in Italian rye grass and by Vaithialingam (1979) in forage sorghum. This correlation may suggest that succulence and water content are similar in the different varieties tried.

Another character that showed negative correlation with yield was the crude protein percentage. This finding is in confirmity with the observations by Ross *et al.* (1979) in forage sorghum, and by Bray and Hacker (1981) in *Setaria sphacelata*. Convertion of photosynthetic assimilates into crude protein is an energy consuming process. Hence part of the assimilates synthesised may be utilised for protein synthesis, which leads to a reduction in total yield of fodder.

Data on interrelationships among the yield components give a more reliable information, rather than a knowledge of association between yield and its components.

In the present study, the inter-relationships among dry weight, plant height, girth of internode, length of panicle, leaf:stem ratio and leaf area index were high and positive at genotypic level. This suggests the possibility of simultaneous improvement of these characters from a selection programme involving any one of these traits.

Positive correlation was observed between dry matter yield and plant height. Similar results had been reported by Yadav *et al.* (1974) in *Cenchrus ciliaris*. Dry matter yield also had high correlation with days to 50 per cent flowering, which is in conformity with the findings of Vivero (1979) in Italian rye grass. This may be due to the fact that varieties having longer vegetative phase obtained more time for increased dry matter accumulation.

Plant height had negative correlation with number of tillers. Similar findings had been reported in ragi by Goud and Lakshmi (1977) and in forage sorghum by Jhorar and Paroda (1976). But in Cenchrus ciliaris works by Ramaswamy (1974) revealed that there was no association between plant height and number of tillers.

Since plant height, dry matter yield, girth of internode, length of panicle, leaf area index, days to 50 per cent flowering and leaf:stem ratio showed high magnitude of correlation with yield and inter-relations among themselves, selection can perhaps be based on these characters for improving fodder yield in guinea grass.

C. Path Coefficient Analysis

Path analysis suggested by Dewey and Lu (1959) provides amethod for separating the correlation coefficients into direct and indirect effects and it measures the relative importance of the component characters in influencing the yield. Many workers utilized this method to measure the degree of influence of the component characters on fodder yield of several fodder crops. These contributing characters exhibit different degrees of associations among themselves. A change in one character alters its relationship with other associated characters and finally will reflect on yield. To determine the relative contribution of different characters towards fodder yield and to measure the co-ordinated relationship existing among these traits, the fodder yield and five of its component characters in guinea grass were subjected to path analysis. Out of these five component characters, three characters (plant height, girth of internode and number of tillers) exhibited positive direct effect on fodder yield. The other two traits (days to 50 per cent flowering and length of panicle) showed negative direct effects.

Positive direct effect of plant height on fodder yield was in confirmity with the findings of several earlier reports by Bohra et al. (1969) and Ramaswamy (1974) in Cenchrus ciliaris, Naphade (1972) and Patel et al. (1973) in forage sorghum and Dhumale and Mishra (1978) in fodder oats. But Paroda et al. (1975) observed negative direct effects of plant height on green fodder yield of sorghum.

In the present study, the number of tillers also showed positive direct effect on fodder yield. Similar reports are available in fodder ragi as revealed by the studies of Dhanakodi (1980).

Another character that had direct positive effect was girth of internode. Ramaswamy (1974) in Cenchrus ciliaris and Naphade (1972) and Paroda et al. (1975) in forage sorghum also had reported similar results. Patel et al. (1973) reported a positive direct effect of diameter of the culm on fodder yield in fodder sorghum.

The maximum contribution to yield is through plant height, followed by girth of internode and number of tillers. The correlation of plant height with fodder yield is high and positive. This is due to the total effect of its direct contribution and its indirect effect through girth of internode. The significant correlation between girth of internode and yield may be due to the direct effect of that character on yield, along with its indirect effect through plant height.

The correlation of number of tillers on green fodder yield is negative, though its direct effect is positive. This negative correlation may be due to the negative indirect effects through plant height and girth of internode. Plant height and number of tillers are negatively associated, which indicates that taller varieties are having less number of tillers.

Days to 50 per cent flowering also had a strong positive correlation with fodder yield. However, its direct effect on yield was negative. This may be due to its high negative indirect effect through number of tillers and length of panicle. But the direct effect of length of panicle was also negative. Therefore, the influence of number of tillers can be taken to be more reliable than that of length of panicle.

From the above findings, we can conclude that plant height is the factor that affects fodder yield more than any of the other factors. It is also evident that selection for the improvement of fodder yield can be efficient if it is based on plant height and girth of internode, since these characters satisfy both the requirements of correlation analysis and path analysis.

Summary

SUMMARY

An investigation was undertaken at the Department of Agricultural Botany, College of Agriculture, Vellayani, to study the extent of variability, genetic associations between various yield contributing factors and the manner in which these factors contribute to the final green fodder yield, among twenty four selected varieties of guinea grass. Observations were made on nine morphological characters viz., 1. plant height, 2. number of tillers, 3. girth of internode, 4. leaf area index, 5. leaf:stem ratio, 6. days to 50 per cent flowering 7. length of panicle and 8. dry matter yield and four chemical attributes viz., 1. crude fibre content, 2. crude protein content 3. oxalate content and 4. K: (Ca+Mg) ratio from each of the twenty four varieties under study.

The varieties showed significant differences among themselves for all the characters studied, which indicated that considerable amount of variability existed among them. Green fodder yield, dry fodder yield, days to 50 per cent flowering and leaf area index were found to exhibit considerable variability both at phenotypic and genotypic levels indicating that these characters are potentially variable. Variability analysis also revealed that leaf:stem ratio,

days to 50 per cent flowering and green fodder yield are the characters least affected by environment and genetic factors play a greater role in determining the expression of these traits. It was also revealed that in the case of number of tillers, the environmental factors have a greater role in its expression.

The correlation analysis revealed that, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients for all the characters studied. Dry weight, leaf area index, plant height, days to 50 per cent flowering, length of panicle and girth of internode showed high positive association with green fodder yield, both at phenotypic and genotypic levels, whereas these associations were significant and negative for crude protein content and number of tillers. Correlation analysis among the yield components showed that days to 50 per cent flowering, plant height, dry weight, leaf area index, girth of internode and leaf:stem ratio had significant positive associations among themselves. This indicated the possibility of simultaneous improvement of these characters from a selection programme involving any one of these traits.

The association of number of tillers with green fodder yield and of the yield components except crude protein content was negative. This observation was found to differ from that of many previous works in cereal and grass fodders. But this may be explained due to the fact that none of the varieties selected for the study exhibited a synchronous 50 per cent flowering, which was the stage at which the plants were cut and the observations were taken. While a few tillers were in full bloom, few others were still in a vegetative phase, leading to a nonrealisation of the full contribution by the tillers to the fodder yield. The positive association for this character with crude protein content may be due to the fact that both these characters had similar negative association with the other characters.

Five morphological characters viz., plant height, girth of internode, days to 50 per cent flowering, number of tillers and length of panicle which showed highly significant genotypic correlation with green fodder yield were considered for path analysis, so as to separate the total genotypic correlation of these characters with green fodder yield, into direct and indirect effect on yield. Path analysis revealed that the maximum contribution to green fodder yield was through plant height, since it recorded maximum positive direct effect on yield. This was followed by girth of internode and number of tillers. Days to 50 per cent flowering and length of panicle had negative direct effects.

The path analysis showed a considerable positive indirect effect of days to 50 per cent flowering, girth of internode and length of panicle through plant height. The positive indirect effects of days to 50 per cent flowering and length of panicle through girth of internode also were considerably higher in magnitude.

Similarly, high negative indirect effects were observed for plant height, girth of internode and length of panicle, through days to 50 per cent flowering.

Thus the present study revealed that the maximum contribution to yield was through plant height followed by girth of internode and number of tillers. It was also concluded that plant height was the factor that affects yield more than any other factors. Plant height and number of tillers were found to be negatively associated with each other. This indicated that taller varieties were having less number of tillers.

From the above findings it can be concluded that selection for improvement of fodder yield is possible in this crop if it is based on plant height and girth of internode, since these characters satisfied both the requirements of correlation analysis and path analysis.

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* Originals not seen

CORRELATION AND PATH COEFFICIENT ANALYSIS IN GUINEA GRASS

(*Panicum maximum* Jacq.)

By

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ABSTRACT OF A THESIS

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A B S T R A C T

A study was undertaken at the Department of Agricultural Botany, College of Agriculture, Vellayani, to determine the character association for yield and quality of green fodder and their degree of association and relative influence on yield in guinea grass. Twenty four diverse varieties of guinea grass were selected for the study and laid out in randomised block design with three replications. Observations were made on nine morphological characters and four chemical attributes and the data collected were subjected to variability studies and correlation analysis. Five morphological characters which showed highly significant genotypic correlation with green fodder yield were considered for path coefficient analysis in order to separate the total correlation of these characters with green fodder yield into direct effects and indirect effects via. other characters.

Variability studies revealed that considerable amount of variability existed among the varieties used for all the characters studied. In general, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients. The characters viz. dry weight,

leaf area index, plant height, days to 50 per cent flowering, length of panicle and girth of internode showed highly significant positive association with green fodder yield, where as these associations were negative in the case of crude protein content and number of tillers. Correlation analysis among the yield components revealed that days to 50 per cent flowering, plant height, dry weight, leaf area index, girth of internode and leaf:stem ratio had significant positive associations among themselves indicating the possibility of simultaneous improvement of these characters from a selection programme involving any one of these traits. Path analysis revealed that the maximum direct contribution to green fodder yield was through plant height followed by girth of internode. Also, the indirect contributions of days to 50 per cent flowering, girth of internode and length of panicle through plant height were considerably high. In general, it can be concluded that selection for improvement of fodder yield is possible in this crop, if it is based on plant height and girth of internode.