GENETIC ANALYSIS OF OPEN POLLINATED SEED PROGENY OF GUINEA GRASS (*Panicum maximum* Jacq.) CLONES

By

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THESIS

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1988

DECLARATION

I hereby declare that this thesis entitled "Genetic analysis of open pollinated seed progeny of guinea grass (*Panicum maximum* Jacq.) clones" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis "Genetic analysis of open pollinated seed progeny of guinea grass (*Panicum maximum* Jacq.) clones" is a record of research work done independently by Smt. Sally V. Joseph under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

The livestock population of India is the largest in the world but the animal productivity is the lowest. This could be ascribed to the malnutrition and under nutrition of the over populous animals resulting from the deficit in the production of green forage. It has been estimated that the production of the green fodder is less that one-third of the total requirements in India. This is not surprising as only about three per cent of the total cultivated area is under fodder crops in our country. While research and developmental efforts in the past years have resulted in increasing the yield and production of important cereal crops, endeavour for increasing the production of fodder crops has not been intensive. Further, the area available for the cultivation of fodder crops is also very much limited. Considering the importance of livestock population in Indian economy, the only possible alternative is to increase the per hectare production and quality of fodder. Since the non-availability of nutritive and high yielding grass varieties is mainly responsible for the low productivity of our cattle population, genetic improvement of those crops for both increased production and superior quality is imperative and of immediate priority.

Among the different fodder grasses grown in India, guinea grass assumes the most important position with respect to its palatability and nutritive value. Guinea grass is a perennial fodder crop growing to a height of 1.5 to 2 m with heavy tillering forming big clumps. It is fairly tolerant to drought conditions. The centre of origin of guinea grass is tropical Africa. This crop was introduced to India as early as 1793. It is relished by all kinds of livestock and is more nutritious than Napier grass and compares favourably with jowar and fodder maize.

Eventhough guinea grass is capable of producing viable seeds, the crop is propagated mainly through vegetative means as it is very easily established if slips are transplanted during the onset of South-west monsoon. The continuous vegetative propagation for a long period has resulted in very limited variability in this crop. Further, the crop is reported to be facultative apomictic with only five per cent cross pollination which still reduce the extent of genetic variability. Hence an attempt on creating variability by inducing mutation was undertaken in the Department of Plant Breeding, College of Agriculture, Vellayani. Preliminary observations on some of the mutant clones of M_1 V_1 progeny of guinea grass have shown that they vary very much in green fodder yield and other morphological characters. Considering the convenience of handling the planting material, seed propagation is gaining popularity in guinea grass also. Eventhough this method is widely followed in co-ordinated trials under National level, no such trial has been conducted so far in Kerala using open pollinated seeds collected from guinea grass clones. Hence the present study was initiated with the following objectives.

(1) To evaluate the newly evolved mutant clones in comparison with their parental variety FR-600 and check variety Mackeunii in relation to fodder yield and quality.

(2) To estimate genetic parameters like variability, heritability and genetic advance.

(3) To study the association of characters with special reference to fodder yield and its components.

(4) Divergence analysis to identify the diverse types for further hybridization works to produce more vigorous hybrid clones.

(5) To study the population structure of seedling progeny of the superior types evolved in relation to hairiness of leaves and other quality aspects.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Guinea grass (*Panicum maximum* Jacq.) is an important fodder grass native to tropical Africa. It was introduced to India in 1793 and its cultivation spread in South India as early as 1870 (Bor, 1960). It has now become well aclimatised in Kerala so as to become the most popular fodder grass grown here. As a drought resistant and hardy crop, it is most suitable for cultivation under rainfed condition in Kerala. Burton *et al.* (1973) has reported 0.6 per cent seed setting through sexual reproduction in this facultative apomictic species. But Dutt and Pugh (1940), Whyte (1958) and Purseglove (1975) have reported cross pollination upto an extent of five per cent under natural conditions in guinea grass. Only very limited studies have been undertaken for genetic analysis of the sparsely available genetic variability existing in this crop.

Variability, heritability, genetic advance, association of characters and divergence analysis are some of the main parameters which help the selection of superior genotypes from genetically diverse population. A brief review of the work done on these aspects in relation to green fodder yield and its components and quality aspects in guinea grass and the other gramineae fodder crops relevant to the present study are given below.

1. Variability

Burton (1952) introduced a convenient procedure for the estimation of phenotypic and genotypic coefficient of variation.

Johnson *et al.* (1955) reported a methodology for partitioning the total variance due to genotype, phenotype and error in the analysis of variance.

a) Guinea grass

From the variance analysis of 24 guinea grass varieties Sreenivasan (1983) reported that maximum genotypic coefficient of variation (GCV) was observed for dry weight (74.58 per cent) followed by green fodder yield (71.29 per cent) and leaf area index (63.61 per cent). Medium GCV estimate was recorded for plant height (31.93 per cent), panicle length (28.88 per cent), leaf-stem ratio (27.75 per cent) and number of tillers (21.83 per cent). Studies on quality aspects revealed that the crude fibre content exhibited the least GCV estimate (7.52 per cent) while crude protein content showed a GCV value of 8.93 per cent. The highest phenotypic coefficient of variation (PCV) was recorded for dry weight (78.28 per cent) followed by green fodder yield (72.15 per cent). PCV values recorded by other characters were: Plant height (34.19 per cent), number of tillers (30.49 per cent), length of panicle (30.03 per cent) and leaf-stem ratio (27.79 per cent). Among the quality aspects, the least PCV was recorded for crude fibre content (8.73 per cent) while crude protein content recorded 11.10 per cent.

b) Other fodder crops

Based on the study of the genetic variability in a collection of 70 widely divergent varieties of fodder sorghum (*Sorghum vulgare*) Swarup and Chaugale (1962,a) reported GCV estimates of 95.88 per cent for green fodder yield, 65.88 per cent for peduncle length, 56.27 per cent for leaf number and 53.11 per cent for plant height. Sindagi *et al*. (1970) carried out investigations on the variability in the F_2 progenies of inter-varietal crosses of sorghum viz. TBR x IC 3437 and TBK x IC 2397. They observed a maximum GCV value of 44.63 per cent and 65.40 per cent for green fodder yield in the two crosses respectively. The GCV estimates for leaf number were 16.84 per cent and 14.87 per cent and for the plant height were 19.7 per cent and 16.4 per cent respectively for the same crosses.

Sanghai and Singh (1973) studied genetic variability in Pennisetum typhoides and observed that maximum PCV and GCV were recorded for green fodder yield (19.41 and 18.72 per cent respectively) followed by number of tillers (12.77 and 12.22 per cent respectively). The least estimates of PCV (4.08 per cent) and GCV (3.85 per cent) were recorded for ear length.

Nair and Gupta (1977) based on the study of 32 diverse fodder oat types revealed maximum GCV estimate of 33.68 per cent for green weight of leaves. This was closely followed by the green weight of stem (27.28 per cent) and tiller count (25.36 per cent). The green fodder yield recorded GCV value of 27.77 per cent while dry matter yield recorded a value of 8.74 per cent. For plant height a very low estimate of GCV(8.65 per cent) was reported. Among the other characters studied leaf-stem ratio recorded GCV value of 18.95 per cent and percentage dry weight 10.41 per cent. Among the quality characters, the maximum GCV was recorded for percentage ash content (13.88 per cent) followed by crude protein which recorded a GCV estimate of 10.16 per cent. Tyagi et al. (1977) conducted variability study in fodder oats and reported GCV estimates of 29.56 per cent for dry matter yield, 28.94 per cent for plant height and 25.81 per cent for tiller number per plant. The green fodder yield recorded GCV of 23.43 per cent and leaf-stem ratio 15.75 per cent while leaf breadth recorded the least value (5.2 per cent).

Tyagi et al. (1980) investigated the component analysis for green fodder yield in *Pennisetum typhoides* and observed maximum GCV estimate of 14.71 per cent for green fodder yield. The number of leaves and leaf breadth showed almost equal GCV values of 11.77 and 11.78 per cent respectively. The plant height showed a GCV estimate of 5.57 per cent followed by tiller number (7.8 per cent) and dry matter yield (9.94 per cent). The least GCV value was recorded for leaf length (4.67 per cent).

Kunjir and Patil (1986) have observed high genotypic and phenotypic variability for tiller number in pearl millet.

2. Heritability and Genetic advance

Fisher (1918) first introduced the term heritability and defined it as the ratio of fixable (additive genetic) variance to the total genetic variance.

Lush (1949) and Johnson *et al.* (1955) devised an accurate procedure for the calculation of genetic advance under specified intensity of selection.

According to Johnson *et al.* (1955) estimation of heritability along with genetic gain is usually more helpful in predicting the resultant effect through selection.

Hanson *et al.* (1956) reported the mathematical relationship of various estimates for computation of heritability. In broad sense this attribute refers to the proportion of genotypic variance over phenotypic variance.

a) Grasses

Yadav *et al.* (1976) studied the heritability and correlations between the fodder yield components in the pasteur grass, *Dichanthium annulatum* and reported that the heritability and the expected genetic advance of the characters studied ranged from 27.9 to 90.5 per cent for leaf number and 13.2 to 87 per cent for tiller number.

Salach-Warecha and Goral (1979) studied the heritability of yield components in *Phleum pratense* and reported that the highest heritability values were recorded for height (75.5 per cent) and number of vegetative tillers (61.85 per cent). Kazuba *et al.* (1981) also carried out heritability studies in *Phleum pratense* and reported that the broad sense heritability values were high exceeding 60 per cent for plant height, number and length of flowering shoots and length and breadth of the third leaf.

Riley and Vogel (1983) based on the studies on heritability of plant characters in *Andropogon halli* cv Goldstrike reported heritability estimates of 28 per cent for yield and 33 per cent for dry matter content.

Wafford (1983) reported heritability estimates of 49 per cent for leaf length and 46 per cent for leaf breadth in Bermuda grass.

Bugge (1984) estimated the heritability for forage yield in 20 ecotypes and their F_1s in Lolium multiflorum and observed heritability value of 48 per cent for dry matter yield per plant.

b) Fodder sorghum

Swarup and Chaugale (1962,a) carried out studies on genetic variability and heritable components in a collection of 70 widely divergent varieties of fodder sorghum and reported high heritability values for plant height (98.36 per cent), leaf number (98.18 per cent) and panicle length (98.04 per cent). These characters also exhibited high genetic advance ranging from 108.53 to 120.08 per cent. A heritability value of 84.33 per cent and a genetic advance of 181.31 per cent were recorded for green fodder yield.

Sindagi et al. (1970) had studied the variability and heritability of some quantitative characters in fodder sorghum. The investigations were carried out using parents, F_1s and F_2s of two intervarietal crosses, TBK x IC 3437 and TBK x IC 2397. The results revealed that maximum heritability was recorded for the plant height (82.14 and 75.66 per cent respectively for the two crosses).

The genetic advance recorded for this character was 36.81 per cent and 37.62 per cent respectively. Heritability values of 62.18 per cent and 86.05 per cent were recorded for green fodder yield for the two crosses respectively. The highest value of genetic advance was also recorded for this character (72.47 per cent and 125.5 per cent respectively). The heritability estimate recorded for number of leaves for these two crosses were 59.03 per cent and 40.08 per cent respectively and the estimates of genetic advance were 26.81 per cent and 17.86 per cent respectively.

Singhania *et al.* (1977) based on the genetic analysis of 74 genotypes of sorghum reported heritability value of 20.52 per cent for the green fodder yield per plant.

Sainy and Paroda (1975) studied the genetic architecture of 11 forage characters using a 6 x 6 diallel set involving six species of Eu-sorghum and reported low estimates of heritability (below 30 per cent) for the characters leaf weight, stem weight, green fodder yield and medium heritability (30-45 per cent) for number of tillers.

Sood *et al.* (1980) studied the genetic variabilities in forage sorghum and reported heritability estimates exceeding 30 per cent for all the characters viz. plant height, number of leaves per plant, leaf length, green fodder yield per plant and dry matter yield per plant.

c) Fodder bajra

Gupta and Nanda (1971) based on their study on fodder bajra germ plasm consisting of 30 Indian varieties and inbreds, 25 African varieties and 51 American inbreds reported that heritable differences were high for leaf number (67.60 per cent) and stem thickness (55.55 per cent) in Indian varieties; for leaf size (53.11 per cent) and plant height (61.72 per cent) in Indian inbreds; for leaf number (72.68 per cent), green fodder yield (61.28 per cent) and leaf size (54.18 per cent) in African varieties; and for plant height (93.24 per cent) and green fodder yield (63.12 per cent) in American inbreds.

Sanghai and Singh (1973) reported high heritability values for number of tillers (92 per cent), fodder yield (93 per cent) and ear length (89 per cent). The genetic advance recorded for these characters were 24.08, 37.18 and 7.47 per cent respectively.

Based on the study on 30 strains of fodder bajra for component analysis Tyagi *et al.* (1980) reported heritability estimates of 66.48 per cent for green fodder yield and 65.05 per cent for plant height. The heritability estimates for leaf breadth and number of tillers were 25.56 and 37.27 per cent respectively. The maximum genetic advance was recorded for green fodder yield (24.64 per cent) followed by number of leaves (15.79 per cent) and leaf breadth (11.58 per cent). Tiller number recorded a genetic advance of 9.81 per cent only.

Kunjir and Patil (1986) have observed high heritability estimates for tiller number (64.8 per cent) and plant height (56 per cent) in pearl millet. The genetic advance for these characters were also found to be very high indicating additive gene action.

d) Fodder oats

Nair and Gupta (1977) in fodder oats reported high estimates of heritability exceeding 90 per cent for green fodder yield, green weight of leaves, green weight of stem, tiller counts, height of plants and leaf-stem ratio. The maximum genetic advance was recorded for green fodder yield (88.56 per cent). A very low estimate of genetic advance was recorded for leaf-stem ratio (1.00 per cent) and tiller counts (5.92 per cent).

Tyagi *et al*. (1977) in fodder oats observed heritability values exceeding 90 per cent for green fodder yield, leaf-stem ratio, leaf breadth and plant height, while dry matter yield recorded heritability value of 79.89 per cent only. All the characters except height and leaf breadth recorded a genetic advance exceeding 30 per cent.

3. Correlation studies

a) Guinea grass

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

Pillai *et al*. (1974) in a study to isolate superior clones in guinea grass observed no correlation between green fodder yield and leaf-stem ratio.

Based on the study on 24 diverse varieties of guinea grass Sreenivasan (1983) reported significant positive association of characters such as dry weight, leaf area index, plant height, length of panicle, days to fifty per cent flowering, girth of internode and crude fibre content with green fodder yield. The association was found negative in the case of crude protein and number of tillers with green fodder yield. In the same study correlation analysis among yield components revealed that days to fifty per cent flowering, plant height, dry weight, leaf area index, girth of internode and leaf-stem ratio had significant positive association among themselves. The crude fibre content showed positive correlation with all characters except crude protein content and number of tillers. Crude protein content showed negative correlation with all characters except tiller counts.

b) Other grass species

Sotomayour-Rios *et al*. (1972) in a trial on 30 accessions of *Digitaria* spp. observed positive correlation between yield of green forage and dry matter yield per hectare.

In a study involving 28 varieties of the pasteur grass, *Cenchrus ciliaris* Yadav *et al*. (1974) reported that plant height, leaf breadth, spike length and fodder yield were positively and significantly correlated with each other at both the phenotypic and genotypic level. Tiller number was positively correlated with yield and number of leaves.

Fujimato and Susuki (1975) conducted a study on variation and selection in Italian rye grass and reported high genetic correlation between dry weight and plant height and also between tiller number and fresh weight.

Yadav et al. (1976) analysed the correlation among six characters in 18 populations of the pasteur grass *Dichanthium annulatum* and reported that the tiller number was positively and significantly correlated with fodder yield while leaf number was significantly and positively correlated with culmn girth and number of nodes at phenotypic level.

Based on a diallel analysis in tall fescue (*Festuca arundinacea*) Sleper et al. (1977) reported high correlation between number of tillers and total forage yield per plant.

Based on a study in Rhodes grass (*Chloris gayana*) Boonman (1978) reported that herbage yield was negatively correlated with digestibility and leaf-stem ratio.

Studying the association between economically useful and morphological characters in *Festuca pratense*, Titov *et al*. (1978) have reported that the forage yield has a moderate correlation with height of the plant and length of leaf blade.

Nelson and Sleper (1977) have studied the morphological characters associated with productivity of tall fescue (*Festuca arundinacea*) and reported an inverse relationship between yield per tiller and tiller number. A correlation of r = 0.58 was found between yield per tiller and area of the sixth leaf. The yield per tiller showed a very high correlation of r = 0.81 with rate of leaf growth.

Salach-Warecha and Goral (1979) studying the heritability of yield components in Timothy grass (*Phleum pratense*) observed that both green and dry matter yield showed stronger positive correlations with the number of fertile tillers, than with purely vegetative tillers while plant height was negatively correlated with number of vegetative tillers.

In a comparison of interspecific hybrids of Timothy grass, Sokolova and Turkina (1979) have reported direct correlation of plant yield with height and number of tillers.

Tan _et al_. (1979) have evaluated parents and progenies of a 7 x 7 diallel cross to study the association of morphological characters with forage yield in smooth brome grass and reported that both tiller density and height were significantly correlated with forage yield.

Based on the genetic analysis of the pasteur grass _Setaria sphacelata_ Hacker and Bray (1981) reported that dry matter yield was genetically correlated with the number of inflorescence and consequently also with number of days to flowering.

In a study on the variability of 148 ecotypes of tall fescue Martusewicz (1983) observed positive association between plant height and area of leaf blade, but no significant correlation was found between height and either length or breadth of leaf blades.

In _Andropogon hallii_ cv Goldstrike Riley and Vogel (1983) reported negative correlation of yield and crude protein content. Similar finding was reported by Berg and Hill (1983) in Timothy grass also.

Schitea (1983) carried out correlation studies in 44 varieties of Italian rye grass and reported significant positive correlation between both green matter and dry matter yield with plant height. In the same study significant positive correlation was also observed between green matter yield and crude protein content.

In brome grass Vogel (1983) reported that forage yield was negatively correlated with crude protein content.

Jatasra and Thakral (1986) observed that in *Cenchrus ciliaris* plant height and number of tillers per plant were positively correlated and leaf-stem ratio was negatively correlated with green fodder yield.

Gaborick (1986) has reported non-significant correlation between leaf chlorophyll content and relative growth rate in tall fescue.

Sen and Hamid (1986) in proso millet reported that straw weight was positively correlated with plant height and negatively correlated with tiller per plant.

c) Fodder sorghum

Based on a study of 70 divergent varieties of fodder sorghum, Swarup and Chaugale(1962;b) have observed a positive correlation of height and number of leaves with fodder yield. They have also observed positive correlation between leaf number and height of plants.

In a study on the correlation of some characters contributing to fodder yield in sorghum, Rohewal *et al*. (1964) observed that the fodder yield was positively and significantly correlated with plant height.

Naphude (1972) reported significant correlation between height and fodder yield in sorghum. But the leaf area and yield were found to be non-significantly correlated. A positive correlation was observed between leaf number and leaf area; and leaf number and plant height. However, no significant correlation was observed between plant height and leaf area.

Based on the correlation studies in a 10 x 10 diallel cross in forage sorghum Paroda *et al*. (1975)

reported positive correlation between plant height and number of tillers per plant, leaf length and green fodder yield, leaf breadth and green fodder yield, leaf length and dry matter yield and leaf breadth and dry matter yield. However, Jhorar and Paroda (1976) have reported negative correlation between the number of tillers and both green and dry matter yield.

Based on the study of 52 fodder sorghum varieties Rana et al. (1976) have reported positive and significant correlation at the phenotypic level between width of leaves and green fodder yield. Girth of stem was also found positively correlated with green fodder yield.

Rao and Ahluwalia (1977) studied the correlation of fodder yield in sorghum and they have observed highly significant positive correlation between total fodder yield and daily production at fresh and dry weight basis.

Based on the study of sorghum hybrids for silage production, Green (1977) has reported that plant height and silage yield were positively and significantly correlated. The tallest varieties were found giving the highest yields.

In fodder sorghum Singhania _et al_. (1977) reported that plant height, fifth leaf area and stem diameter were positively correlated with forage yield and also among themselves. But the number of leaves and leaf-stem ratio showed either negative or non significant positive correlation with forage yield.

Based on character association studies in 23 lines of fodder sorghum Gopalan and Balasubramanian (1978) have reported that number of leaves, length and breadth of leaves and thickness of stem were positively correlated with green fodder yield. Sidhu and Mehindiratta (1980) carried out investigations on the genetic analysis of forage yield components in 36 varieties of sorghum and concluded that green fodder yield was highly and positively correlated with leaf number, stem thickness, leaf length and leaf breadth.

d) Fodder bajra

In *Pennisetum typhoides* Gupta and Athwal (1966) observed positive correlation of leaf size, leaf number, leaf height and tillering with green fodder yield. Gupta and Nanda (1971) carried out component analysis in fodder bajra germplasm consisting of 30 Indian varieties and inbreds, 25 African varieties and 51 American inbreds. They have observed that green fodder yield depended only on leaf size in Indian inbreds, leaf number, tiller number and plant height in African varieties and only plant height in American inbreds.

Based on the study of 38 stocks of *Pennisetum pedicellatum* Singh and Prasad (1976) have reported that number of days to flowering, leaf length, plant height, tiller number and stem girth were positively correlated with green fodder yield at the genotypic level.

Tyagi *et al.* (1980) evaluated 30 strains of pearl millet for nine characters and concluded that the green fodder yield was positively correlated with dry matter yield and negatively with days to flower.

(e) Fodder oats

Nair and Gupta (1977) based on their study in fodder oats reported that dry matter yield was highly correlated with green weight of stem and leaves. The number of tillers, leaf area and number of leaves were to be considered as major components for the increase in green weight of stem and green weight of leaves which could contribute to dry matter yield in fodder oat. They have observed positive correlation between green weight of stem and leaves while no correlation was observed between height and number of leaves.

In a study conducted on 26 varieties of oats Singh *et al.* (1980) have observed that plant height at flowering was positively and significantly correlated with green fodder yield. A highly significant and positive association was also recorded for the number of tillers per plant and green fodder yield per hectare.

According to Solanki (1977) leaf area per plant contribute maximum to dry matter accumulation in fodder oat.

f) Other fodder crops of gramineae family

Based on the study of 28 diverse types of barley Sethi and Singh (1978) have found that the forage yield, both green and dry were highly correlated with days to fifty per cent flowering, tiller number per plant and plant height.

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

Investigation by Dhanakody (1980) has revealed that significant and positive association existed 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 a study on association of protein and fibre content with green fodder yield in fodder maize Maggiore *et al*. (1980) have reported that there was no correlation between dry matter yield and crude fibre content with green fodder yield when taken separately but both were positively correlated when taken together.

4. D^2 analysis

Divergence analysis is performed to identify the diverse genotypes for hybridisation purpose. Clustering by D^2 statistics is useful in this matter. Among the various methods the multivariate analysis suggested by Mahalanobis (1936) was found to be more useful for the classification as well as choice of parents for breeding works in crops with diverse breeding systems. (Murty and Pavate, 1962). Many workers have utilized this method for measuring the genetic divergence in many crops and other biological populations. However, the works done on this line in fodder crops are very limited and hence the studies undertaken in other crops under gramineae family are reviewed here.

An analysis of geographical and genetic diversity in a population consisting of 80 genetic stocks of cultivated sorghum revealed that various characters like days to 50 per cent flowering, number of leaves per plant, height, number of whorls in rachis were found to be important for divergence (Arunachalam and Ram, 1967).

Mehindiratta and Sidhu (1972) have studied the genetic divergence in fodder sorghum and they have reported forage yield and leaf length as major factors contributing to genetic divergence.

While conducting studies on the genetic divergence in wheat Yadav et al. (1974) have reported that the flowering time followed by 1000 grain weight and grain weight of main ear were important forces of differentiation at the intra cluster level.

Hussaini et al. (1977) have studied the genetic divergence in 640 genetic stocks of finger millet (*Eleusine coracana*) and identified 12 broad groups.

Syambulingam and Jebrani (1977) employed the D^2 technique to classify 34 short duration varieties of *Eleusine coracana* into six clusters.

Nair and Gupta (1977) employed this technique in fodder oats to classify 32 varieties into 14 clusters.

Mukerji et al. (1981) grouped 51 *Pennisetum americanum* inbreads of four Indian sources into 14 clusters using D^2 statistics.

Varma and Gulati (1982) have applied this technique for genetic divergence studies in barley and reported that the varieties derived from the same cross would appear in different clusters while varieties from diverse origin could appear in the same cluster.

Shukla and Dua (1983) studied the genetic divergence in 94 lines of Pennisetum typhoides and grouped the varities into seven distinct groups. The clustering pattern revealed that the dry matter, days to flowering, stem weight and number of leaves were the major factors contributing to divergence.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was carried out in the Department of Plant Breeding, College of Agriculture, Vellayani from October 1985 to June 1987. A general view of the experimental field is shown in Plate 1.

A. MATERIALS:

The material consisted of six guinea grass clones maintained in the Department of Plant Breeding, College of Agriculture, Vellayani. They are FR-600, Mackeunii, MC-2, MC-14, MC-16 and MC-23 (Plates 2-7). The salient features of these varieties and their origin are summarised in Table 1.

B. METHODS:

I. Seed Collection

Open pollinated seeds were collected from the six guinea grass types at the time of maturity as decided by the complete emergence of panicle (Favorette and Toledo, 1975). After drying them in open sun for two hours they were stored in paper bags for a period of

Plate 1. A general view of the experimental field.

Plate 1.

Plate 2. A close up view of the clone FR-600

Plate 3. A close up view of the clone Mackeunii.

Plate 2.

Plate 3.

Plate 4. A close up view of the clone MC-2

Plate 5. A close up view of the clone MC-14

Plate 4.

Plate 5.

Plate 6. A close up view of the clone MC-16

Plate 7. A close up view of the clone MC-23

Plate 6.

Plate 7.

Table 1. Origin and description of the six guinea grass clones used for the study

Sl. No.	Characters	FR-600	Mackeunii	MC-2	MC-14	MC-16	MC-23
1.	Origin	Local selection	Introduction	Mutant of FR-600	Mutant of FR-600	Mutant of FR-600	Mutant of FR-600
2.	Habit	Erect	Erect	Erect	Erect	Erect	Erect
3.	Stem						
a)	Colour	Purple	Purple	Purple	Purple	Purple	Purple
b)	Hairiness	Glabrous	Pubescent	Glabrous	Pubescent	Glabrous	Pubescent
4.	Leaves						
a)	Colour of lamina	Dark green	Green	Dark green with dorsal side of older leaves purple coloured.	Dark green	Dark green	Dark green
b)	Hairiness of lamina	Glabrous	Pubescent	Glabrous	Pubescent	Glabrous	Pubescent
c)	Auricles	Absent	Absent	Absent	Absent	Absent	Absent
d)	Other characters	Serrations on both the margins of the leaf blade. Medium hairy at the junction of sheath and blade.	Serrations on both the margins of the leaf blade. Profusely hairy at the junction of sheath and blade.	Serrations on both the margins of the leaf blade. Medium hairy at the junction of sheath and blade.	Serrations on both the margins of the leaf blade. Profusely hairy at the junction of sheath and blade.	Serrations on both the margins of the leaf blade. Medium hairy at the junction of sheath and blade.	Serrations on both the margins of the leaf blade. Profusely hairy at the junction of leaf blade and sheath.
5.	Inflorescence						
a)	Nature of flowering	Medium	Profuse	Medium	Profuse	Medium	Profuse
b)	Nature of panicle	Open	Open	Open	Open	Open	Open
c)	Colour of glumes	Light green with purple tint pigmentation	Light green	Light green	Light green	Light green	Light green
d)	Colour of stigma	Purple	Purple	Purple	Purple	Purple	Purple

100 days before sowing to enhance germination (Prasad, 1982).

II. Nursery plot technique

The nursery was raised in plots of 2 x 2 m in randomised block design with four replications. The soil of fine tilth was thoroughly mixed with dry cowdung powder at the rate of 1 kg /m^2. Seeds were sown at the rate of 20 g/plot in shallow furrows. After sowing, the seeds were covered with loose soil and pressed tightly with a wooden plank and profusely watered using a flower can. The following observations were taken in the nursery.

i) Germination count

The emergence of plumule was taken as the criterion for the germination. The germination counts were taken at weekly intervals for one month and expressed as percentage of seeds germinated over total number of seeds sown.

2) Height of seedlings

The seedling height was taken at the time of transplanting (60th day of sowing) on a random sample of 10 seedlings per plot. The height was measured from the base of the seedling to the tip of the tallest leaf and was expressed in centimetres.

3) Number of early tillered seedlings

The total number of tillered seedlings per plot at the time of transplanting were counted and recorded.

4) Count of glabrous and pubescent types

The total number of glabrous and pubescent types in each plot were counted and recorded at the time of transplanting.

5) Width of leaves

The width of leaves was taken at the broadest point of topmost fully opened leaf on a random sample of 10 seedlings per plot and expressed in centimetres. The observation was taken at the time of transplanting.

III. Main field experiment

The main field was laid out in RBD with six treatments replicated four times with a plot size of 2.8 x 1.4 m. Two hundred seedlings were selected randomly from the nursery and transplanted in the main field. Single seedling was transplanted in each hill at a spacing of 40 x 20 cm so that each plot had a population of 49 hills.

The crop was given timely management care as per the recommendations given in the Package of Practices of Kerala Agricultural University (Anon., 1986).

The following observations were taken.

1) Green fodder yield

The green fodder yield from the whole plot was taken at an interval of 45 days from the time of transplanting. This was continued for one full year taking a total of eight harvests. The green fodder harvested from each plot was weighed and expressed in Kilograms.

2) Tiller counts

The total number of tillers on a random sample of 10 hills/plot were counted and recorded during the 2nd, 4th, 6th and 8th harvests.

3) Inflorescence count

The total number of inflorescences from each plot were counted and recorded during the 2nd, 4th, 6th and 8th harvests.

4) Leaf-stem ratio

A random sample of 1000 g green fodder from each plot was separated into leaf and stem and the ratio was worked out during the 2nd, 4th, 6th and 8th harvests.

5) Height of plants

The height was recorded on a random sample of 10 hills per plot during the 2nd, 4th, 6th and 8th harvests. The height was measured in centimetres from the base of the plant to the tip of the tallest leaf.

6) Width of leaves

The width of the leaf in centimetres was taken at the broadest point of the top most fully opened leaf of the innermost five tillers on a random sample of 10 hills per plot, during 2nd, 4th, 6th and 8th harvests.

7) Dry matter yield

The random sample of 1000 g green fodder taken from each plot during 2nd, 4th, 6th and 8th harvests for estimating the leaf-stem ratio was dried in sun to a constant weight and the dry matter percentage was computed for each treatment. Based on this estimate the total dry matter yield was worked out on per plot green fodder yield.

8) Quality characters

For assessing the quality characters samples were drawn from the dry matter yield obtained in item (7) above and the samples were ground to fine powder for analysis.

a) Protein content

The total nitrogen content of the sample was estimated by the modified microkjeldahl method (Jackson, 1967) and crude protein was calculated by multiplying the nitrogen content by the factor 6.25 (Simpson *et al.*, 1965) and expressed as percentage.

b) Crude fibre content

The crude fibre content was estimated as per the A.O.A.C. method (1975) and expressed as percentage.

IV. Statistical analysis

The data collected for all the characters were tabulated and mean values were subjected to statistical analysis.

1) Analysis of variance and covariance

Analysis of variance and covariance were done

(i) to test whether there was any significant differences among the varieties, with respect to various traits,

(ii) to estimate the variance components and

(iii) to estimate the correlation coefficients (Singh and Choudhary, 1979).

The extent of phenotypic variation for any character is the sum of the genetic and environmental effects and can be determined by the methods given by Kempthorne (1957).

$$V(P) = V(G) + V(E) + 2\,Cov(G,E)$$

Where $V(P) = \sigma_p^2(x)$ = Variance due to phenotype

$V(G) = \sigma_g^2(x)$ = Variance due to genotype

$V(E) = \sigma_e^2(x)$ = Variance due to environment

$Cov(G,E)$ = Covariance between genotype and environment

If the genotype and environment are independent Cov(G,E) is equal to zero, so that

$$V(P) = V(G) + V(E) \quad \text{or}$$

$$\sigma_p^2(x) = \sigma_g^2(x) + \sigma_e^2(x)$$

If there are observations on two characters x and y on each individual, the extent of covariance between x and y due to genotype and environment can be estimated as suggested by Kempthorne (1957) as follows:-

$$Cov\,P(x,y) = Cov(G(x,y)) + Cov(E(x,y)) \quad \text{or}$$

$$\sigma_p(x,y) = \sigma_g(x,y) + \sigma_e(x,y)$$

Where $\sigma_p(x,y)$ = Phenotypic covariance between x and y

$\sigma_g(x,y)$ = Genotypic covariance between x and y

$\sigma_e(x,y)$ = Environmental covariance between x and y.

If the experiment is designed in a randomised block design with 'v' treatments and 'r' replications, the estimate of $\sigma^2_p(x)$, $\sigma^2_p(y)$, $\sigma^2_g(x)$, $\sigma^2_g(y)$, $\sigma^2_e(x)$, $\sigma^2_e(y)$, $\sigma_p(x,y)$, $\sigma_g(x,y)$ and $\sigma_e(x,y)$ are obtained from the analysis of variance/covariance (Table 2).

Different genetic parameters were estimated from the various components in the analysis of variance as suggested by Burton (1952) is as follows:

2) Coefficient of variation

Both phenotypic and genotypic coefficient of variation were calculated as suggested by Burton (1952).

a) Phenotypic coefficient of variation $= \frac{V_p}{\text{Mean}} \times 100$

b) Genotypic coefficient of variation $= \frac{Vg}{\text{Mean}} \times 100$

3) Heritability in broad sense (Hanson *et al.*, 1956)

$$h^2 = \frac{Vg}{Vp} \times 100$$

Where h^2 = heritability expressed as percentage.

Table 2. Analysis of variance - covariance table

Source	df	MS_{xx}	Expectation of MS_{xx}	$MSP_{(x,y)}$	Expectation of $MSP_{(x,y)}$	$MS_{(yy)}$	Expectation of MS_{yy}
Block	(r-1)	B_{xx}		$B_{x,y}$		B_{yy}	
Treatment	(v-1)	V_{xx}	$\sigma_e^2(x) + r\sigma_g^2(x)$	$V_{x,y}$	$\sigma_e(x,y) + r\sigma_g(x,y)$	V_{yy}	$\sigma_e^2(y) + r\sigma_g^2(y)$
Error	(r-1)(v-1)	E_{xx}	$\sigma_e^2(x)$	$E_{x,y}$	$\sigma_e(x,y)$	E_{yy}	$\sigma_e^2(y)$
Total	rv-1	T_{xx}		$T_{x,y}$		T_{yy}	

Hence we have the following estimates

$$\sigma_g^2(x) = \frac{1}{r}(V_{xx} - E_{xx}) \qquad \sigma_e^2(x) = E_{xx}$$

$$\sigma_g^2(y) = \frac{1}{r}(V_{yy} - E_{yy}) \qquad \sigma_e^2(y) = E_{yy}$$

$$\sigma_g(x,y) = \frac{1}{r}(V_{x,y} - E_{x,y}) \qquad \sigma_e(x,y) = E_{x,y}$$

4) Expected genetic advance under selection (Allard, 1960).

$$GA = k\, h^2 \sqrt{V_p}$$

Where GA = Genetic advance

h^2 = heritability in broad sense

k = Selection differential

= 2.06 in the case of five per cent of selection in large samples.

5) Simple Correlation

$$r_{x_1 x_2} = \frac{Cov(x_1, x_2)}{\sqrt{V_{(x_1)} \times V_{(x_2)}}}$$

Where $Cov(x_1, x_2)$ = Covariance between the 2 traits x_1 and x_2

$V_{(x_1)}$ = Variance of the trait x_1

$V_{(x_2)}$ = Variance of the trait x_2

Values of 'r' corresponding to 22 degrees of freedom at 5 per cent level of significance was used for the test of significance of the phenotypic correlation coefficients (Fisher and Yates, 1957).

6) D^2 Analysis

The D^2 analysis was carried out as suggested by Singh and Choudhary (1979). Mahalanobis D^2 statistics was used for assessing the group distance between population. From the data collected, variance and covariance were calculated using appropriate model and a test of significance was carried out using Wilke's Lamba criterion to find out the difference between means in respect of pooled effect of 'P' characters between different populations.

For the computation of D^2 statistics, for each combination the mean deviation ie. $y_i^1 - y_i^2$ with $i = 1, 2 \ldots\ldots\ldots P$ was computed and the D^2 calculated as sum of squares of these deviations ie. $(y_i^1 - y_i^2)^2$. For testing the significance of D^2 values, the value obtained for a pair of population was taken as the calculated value of x^2 and tested against the tabulated value of x^2 for 'p' degrees of freedom, where 'p' was the number of characters considered.

The grouping of varieties into different clusters was done according to Tocher method (Rao, 1952).

The average intracluster distance was measured using the formula D_i^2/n where D_i^2 is the sum of distance between all combinations possible, (n) of the populations included in a cluster. To find out the average intercluster distance, the clusters were taken one by one and their distances from each other was calculated.

The percentage contribution of each character towards genetic divergence was calculated as shown below.

$$X = \frac{N_1 \times 100}{NC_2}$$

N = Number of varietal combinations which were ranked first for character x

NC_2 = Number of possible pairs of N varieties.

RESULTS

RESULTS

A. Mean performance of individual traits

I. Observations in the nursery

1. Germination

The results are presented in Tables 3 and 4. The mean value of the germination percentage taken on fourth week after sowing revealed that the percentage of germination was very low for all the varieties. The analysis of variance revealed significant difference among the varieties. The mean values for this character ranged from 32.25 to 45.25 per cent. The highest mean value for germination was recorded by FR-600 followed by MC-16 which were on par. Mackeunii gave the lowest value (32.25 per cent).

2. Percentage of early tillered seedlings

The results are presented in Tables 3 and 4. The analysis of variance revealed significant difference among the varieties. FR-600 was significantly superior to all other varieties and was on par with MC-16. The mean value for this character ranged from 31.5 to 47.25 per cent.

Table 3. Analysis of variance for the characters observed in the nursery

Characters	Mean sum of Squares			F Value
	Replication df = 3	Treatments df = 5	Error df = 15	
Germination %	22.11	73.76	11.77	6.22**
% of early tillered seedlings	32.93	120.06	18.60	6.48**
Width of leaves	0.285	0.126	0.050	2.495
Height of plants	424.255	229.75	112.389	2.044

** Significant at 1% level of probability

Table 4. Mean values of observations in the nursery

Sl. No.	Variety	Percentage of germination at fourth week (Transformed values)	Percentage of early tillered seedlings (Transformed values)	Height of seedlings (cm)	Width of leaves (cm)
1.	FR-600	45.25	47.25	76.90	1.39
2.	Mackeunii	32.25	31.50	88.16	1.59
3.	MC-2	36.00	35.50	92.14	1.70
4.	MC-14	37.25	37.00	100.39	1.63
5.	MC-16	40.75	42.00	81.58	1.24
6.	MC-23	38.00	37.50	85.81	1.37
C.D(0.05)		5.15	7.04	N.S	N.S

N.S - Not significant

The highest mean value was recorded for FR-600 and the lowest for Mackeunii.

3. Plant height

The results are presented in Tables 3 and 4. The mean values ranged from 76.90 to 100.39 cm. But the difference was statistically insignificant. The highest mean value was recorded for MC-14 followed by MC-2 and Mackeunii and the lowest for FR-600.

4. Width of the leaves

The mean values are presented in Table 4. No significant difference was observed among the varieties for this character. The mean values ranged from 1.24 to 1.70 cm. The maximum leaf width was recorded for MC-2 followed by MC-14 while MC-16 recorded the least.

5. Segregation of glabrous and pubescent types

The results are presented in Table 5.

Glabrous types were observed among the seedling progeny of the three pubescent types namely Mackeunii, MC-14 and MC-23. The progeny of the three glabrous types namely FR-600, MC-2 and MC-16 were found to breed true for

Table 5. Count of glabrous and pubescent types

Variety	Pubescent	Glabrous	χ^2 value against 3 : 1 ratio
FR-600	0	242	-
Mackeunii	140	65	4.91*
MC-2	0	230	-
MC-14	158	80	11.63**
MC-16	0	216	-
MC-23	147	70	6.54*

Test at P 0.05 = 3.841
Test at P 0.01 = 6.635

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

that character. The χ^2 test against the suspected 3.:1 ratio of pubescent and glabrous types appeared among the progeny of pubescent varieties was found significant either at 1 or 5 per cent levels of probability.

II. Main field observations

The mean green fodder yield obtained from the six varieties of guinea grass during the eight harvests done at 45 days interval and the pooled and adjusted means are given in Table 8. The analysis of covariance done for adjusting against the number of hills per plot and the ANCOVA and ANOVA are given in Tables 6 and 7. The mean data for the eight characters namely tiller counts, inflorescence count, width of leaves, height of plants, leaf-stem ratio, dry matter yield, crude fibre content and crude protein content are given in Table 10. The analysis of variance for the pooled means of these characters are given in Table 9.

1. Green fodder yield

Significant difference was observed among the varieties for this character (Fig.1). MC-16 was significantly superior to all other varieties except MC-2

Table 6. ANCOVA table (SSPS) for green fodder yield

Source	df	SSX	SSY	SSXY
Replication	3	4.834	47.457	9.250
Treatments	5	526.834	184.875	68.875
Error	15	40.166	482.293	104.125

Table 7. ANOVA table of Y (adjusted for X)

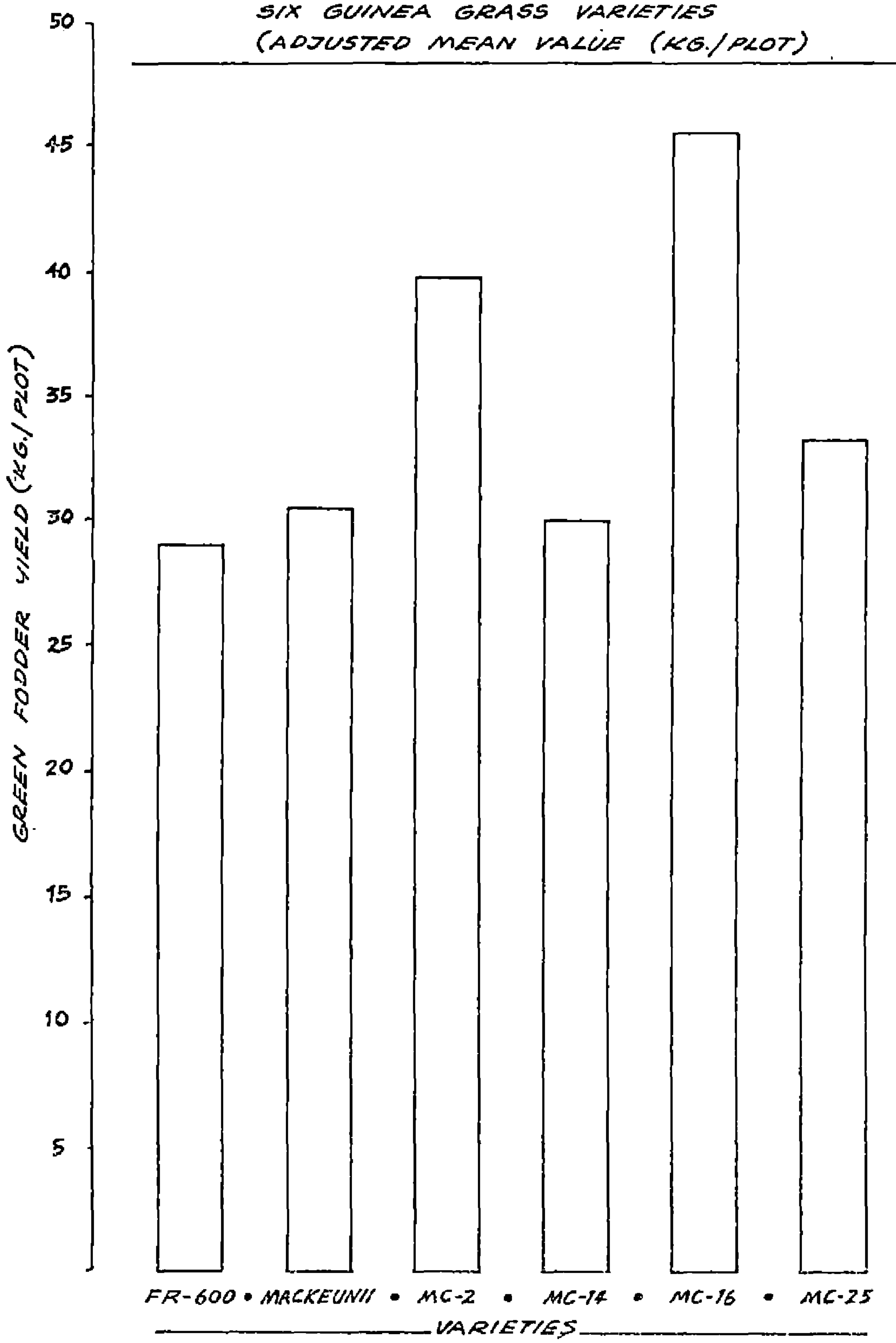
Source	df	MSS	F
Replication	3	10.582	0.698
Treatments	5	80.404	5.300**
Error	14	15.169	

** Significant at 1% level of probability

Table 8. Mean value of the green fodder yield of six guinea grass varieties (kg/plot)

Variety	I Harvest	II Harvest	III Harvest	IV Harvest	V Harvest	VI Harvest	VII Harvest	VIII Harvest	Pooled Mean	Adjusted Mean
FR-600	0.43	8.95	10.13	15.81	5.13	0.74	0.04	0.77	42.00	28.84
Mackeunii	0.88	9.84	10.58	13.81	5.04	0.55	0.02	0.66	41.38	30.48
MC-2	0.54	7.58	8.00	14.19	3.75	0.15	0.02	0.15	34.38	39.66
MC-14	0.53	10.05	10.38	14.34	4.50	0.21	0.03	0.34	40.38	30.12
MC-16	0.82	10.45	9.88	14.87	4.50	0.16	0.45	0.37	41.50	45.18
MC-23	0.51	9.20	9.00	15.35	3.75	0.21	0.03	0.33	38.38	33.30
C.D(0.05)	-	-	-	-	-	-	-	-	-	11.24

FIG.1 MEAN VALUE OF GREEN FODDER YIELD OF SIX GUINEA GRASS VARIETIES (ADJUSTED MEAN VALUE (KG./PLOT)



which was on par with MC-16. The adjusted mean values for this character ranged from 28.84 kg in FR-600 to 45.18 kg in MC-16.

2. Tiller counts

Significant difference was observed among the varieties for this character (Fig.2). MC-16 was found significantly superior in this character to Mackeunii and MC-23 but was on par with FR-600, MC-2 and MC-14. The original mean values for this character ranged from 25.60 to 31.92 and the transformed values from 5.06 to 5.65. The highest value was recorded for MC-16 and the lowest for Mackeunii.

3. Inflorescence count

Significant variation existed among the varieties with respect to this character (Fig. 3). Mackeunii was found producing significantly higher number of inflorescences when compared to all other varieties except MC-14 and MC-23 which were found on par with Mackeunii. The mean inflorescence count ranged from 41.09 (transformed value 6.41) for MC-16 to 86.49 (transformed value 9.30) for Mackeunii.

Table 9. Analysis of variance for the eight characters studied in the main field

Characters	Mean sum of squares			F Value
	Replication df = 3	Treatments df = 5	Error df = 15	
1. Tiller counts	0.041	0.1582	0.0387	4.09*
2. Inflorescence count	6.48	5.87	0.96	6.11**
3. Height of plants	34.18	57.86	37.82	1.53
4. Width of leaves	0.0753	0.00984	0.00597	1.65
5. Leaf-stem ratio	0.194	0.6334	0.176	3.601
6. Dry matter yield	2.642	24.128	4.017	6.006**
7. Crude fibre percentage	0.223	5.85	1.77	3.31*
8. Crude protein percentage	0.97	1.62	0.2572	6.22**

* Significant at 5 per cent level of probability

** Significant at 1 per cent level of probability

Table 10. Mean values for the eight characters studied in the main field experiment

Variety	Tiller counts *	Inflore-scence count *	Width of leaves (cm)	Height of plants (cm)	Leaf-stem ratio	Dry matter yield (kg/plot)	Crude fibre content (%)	Crude protein content (%)
FR-600	5.41 (29.27)	7.14 (50.98)	1.41	93.22	2.765	7.53	28.98	8.90
Mackeunii	5.06 (25.60)	9.30 (86.49)	1.44	93.46	2.22	8.04	29.85	8.44
MC-2	5.48 (30.03)	7.16 (57.27)	1.43	93.38	2.55	10.78	32.57	9.45
MC-14	5.36 (28.73)	8.57 (73.44)	1.43	100.20	2.60	8.28	30.23	7.67
MC-16	5.65 (31.92)	6.41 (41.09)	1.54	99.63	3.15	12.42	29.86	8.10
MC-23	5.29 (27.98)	9.16 (83.91)	1.40	100.93	1.93	8.34	30.40	8.14
C.D(0.05)	0.297	1.48	N.S	N.S	0.632	3.01	2.005	0.764

* Transformed values

Original values are given in parenthesis

N.S - Not significant

FIG.2 MEAN VALUE FOR THE TILLER COUNTS FOR THE SIX GUINEA GRASS VARIETIES

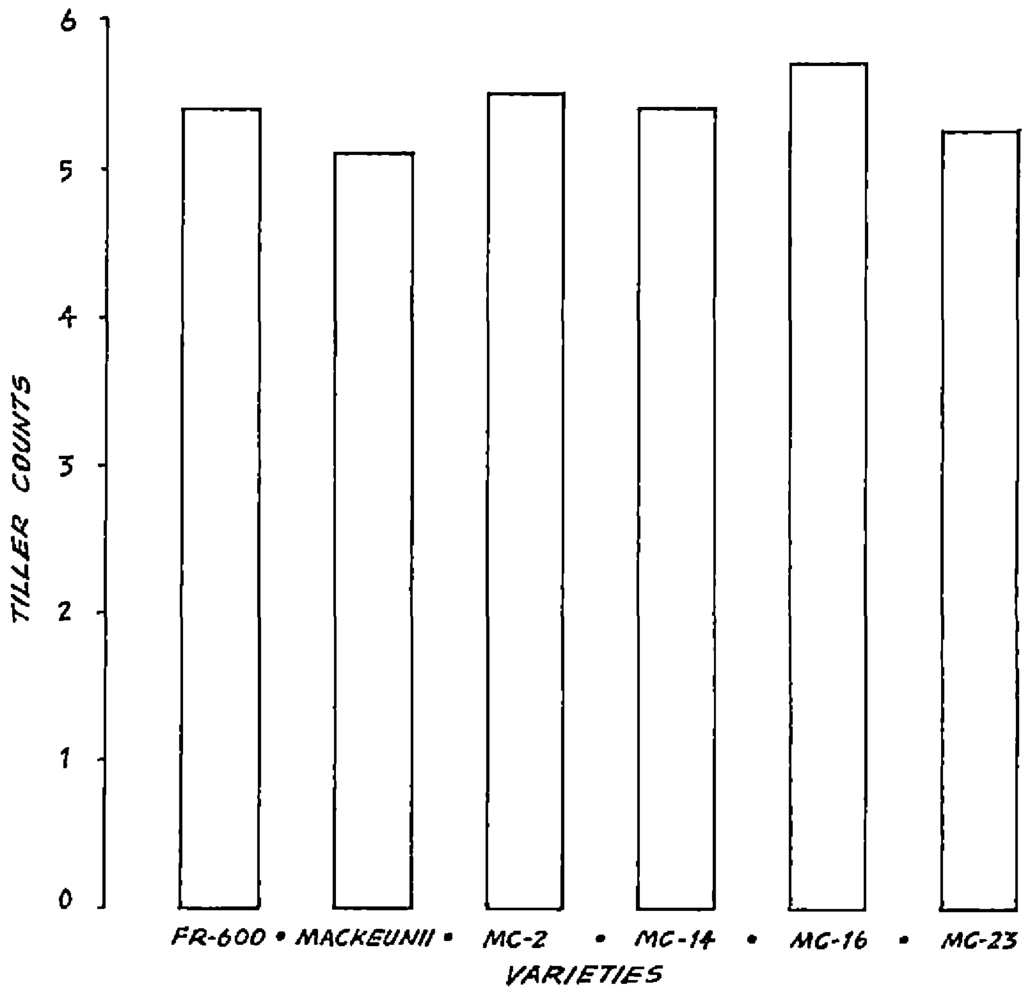
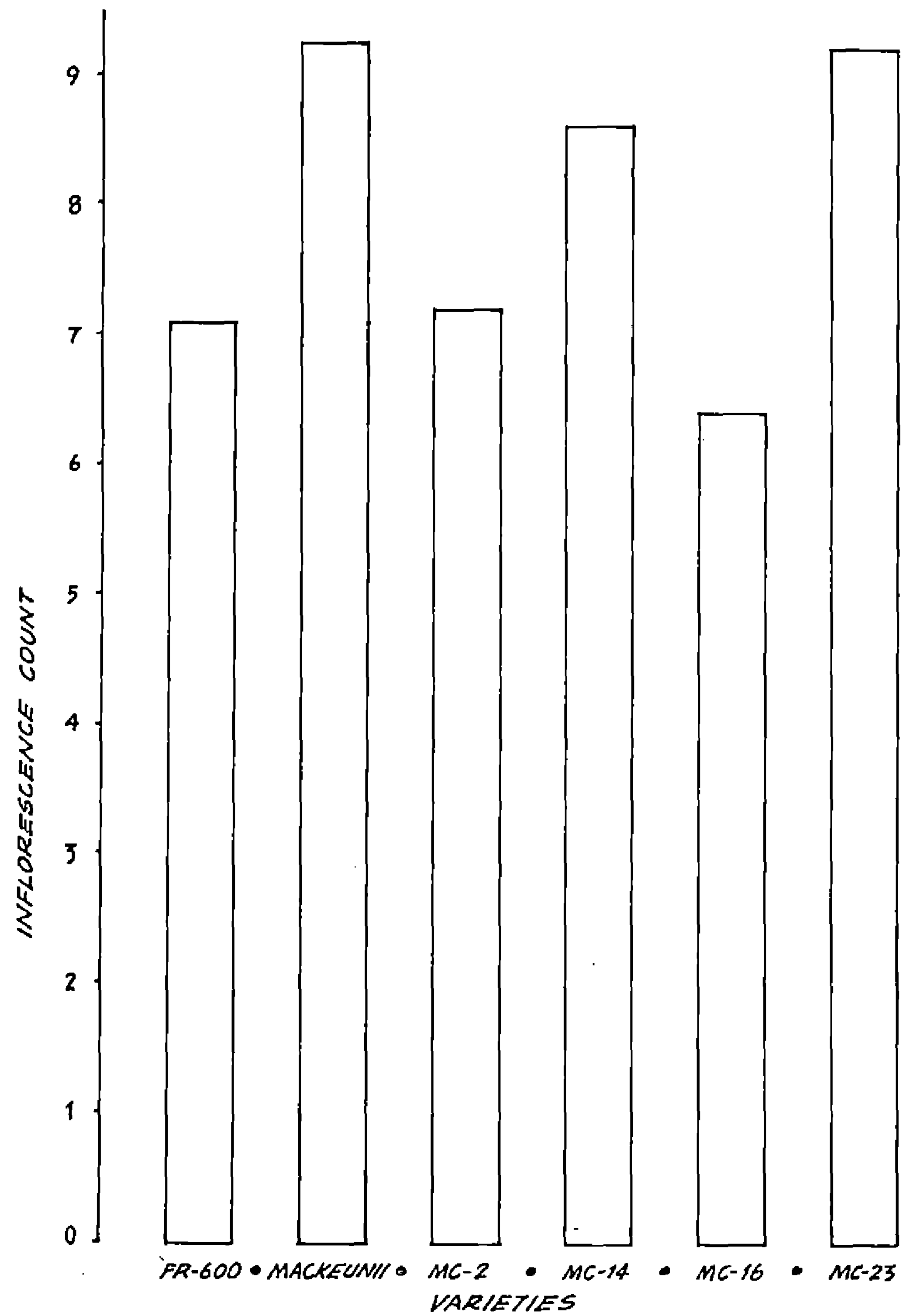


FIG.3 MEAN VALUE FOR THE INFLORESCENCE COUNT FOR THE SIX GUINEA GRASS VARIETIES



4. Width of leaves

No significant difference was observed among the varieties for this character. The mean values ranged from 1.4 to 1.54 cm. The highest mean value was recorded for MC-16 and the lowest for FR-600.

5. Height of plants

The analysis of variance revealed no significant difference among the varieties in height. The mean values ranged from 93.22 to 100.93 cm. The highest mean value was recorded for MC-23 and the lowest for FR-600.

6. Leaf-stem ratio

Significant difference was observed among the varieties for this character (Fig.4). The result has revealed that MC-16 was significantly superior to Mackeunii and MC-23 but was on par with FR-600, MC-2 and MC-14. The mean values ranged from 1.93 in MC-23 to 3.15 in MC-16.

7. Dry matter yield

There was significant difference among the varieties for this character (Fig.5). MC-16 was found significantly

FIG.4 MEAN VALUE FOR THE LEAF-STEM RATIO OF SIX GUINEA GRASS VARIETIES

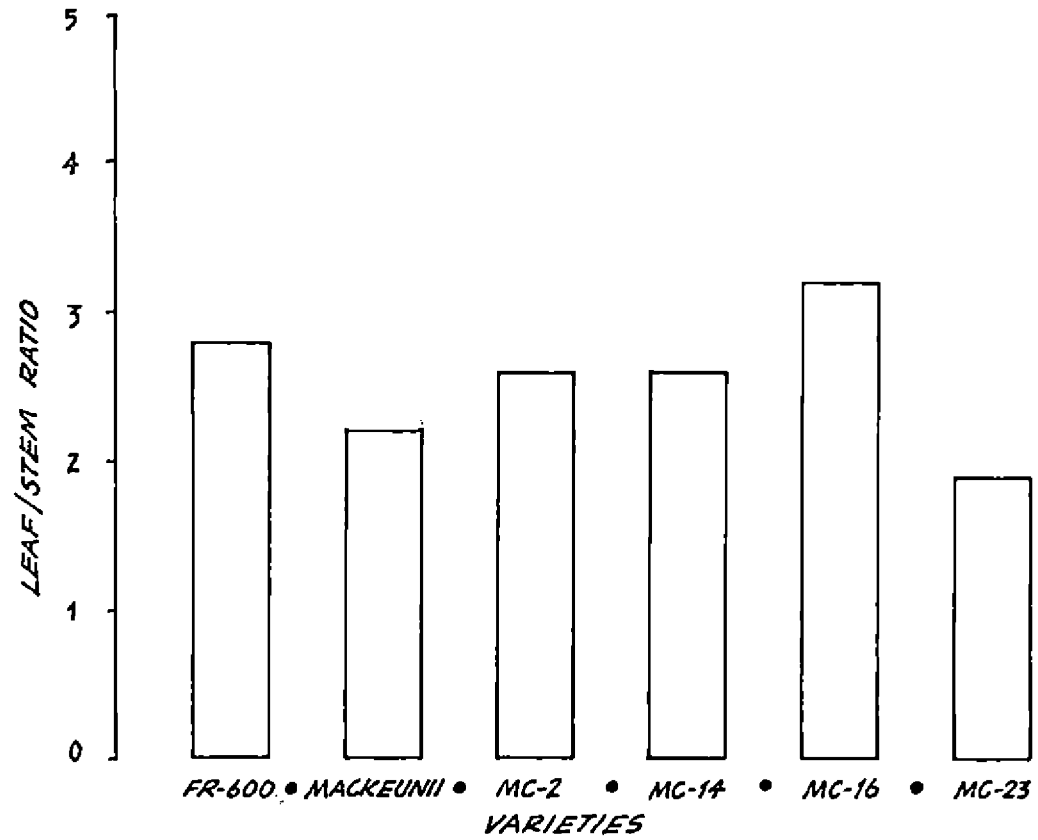
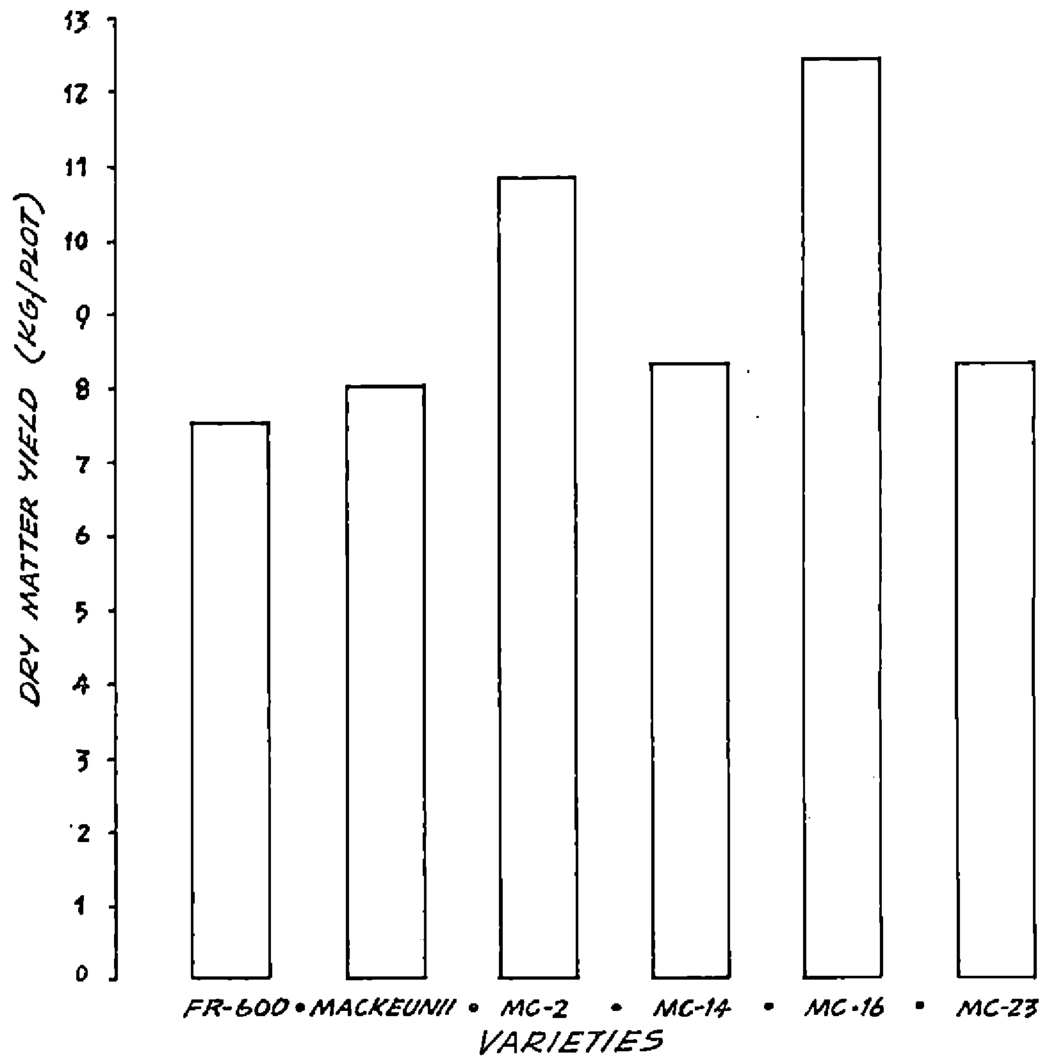


FIG. 5 MEAN VALUE OF DRY MATTER YIELD FOR THE SIX GUINEA GRASS VARIETIES



superior to all over varieties except MC-2. MC-2 and MC-16 were on par in the expression of this character while all others were on par among themselves and also with MC-2.

8. Crude fibre content

Significant difference was observed among the varieties for this character (Fig. 6). MC-2 was significantly superior to all other varieties which were found on par in the expression of this character. The highest mean value (32.57 per cent) was recorded for MC-2 and the lowest (28.98 per cent) was recorded for FR-600.

9. Crude protein content

With respect to this character also significant difference was observed among the varieties (Fig. 7). MC-2 was found significantly superior to all other varieties except FR-600. MC-2 and FR-600 were on par in the expression of this character while all others were on par among themselves and also with FR-600. The highest mean value (9.45 per cent) was recorded for MC-2 and the lowest (7.67 per cent) was recorded for MC-14.

FIG.6 MEAN VALUE FOR THE CRUDE FIBRE CONTENT FOR THE SIX GUINEA GRASS VARIETIES

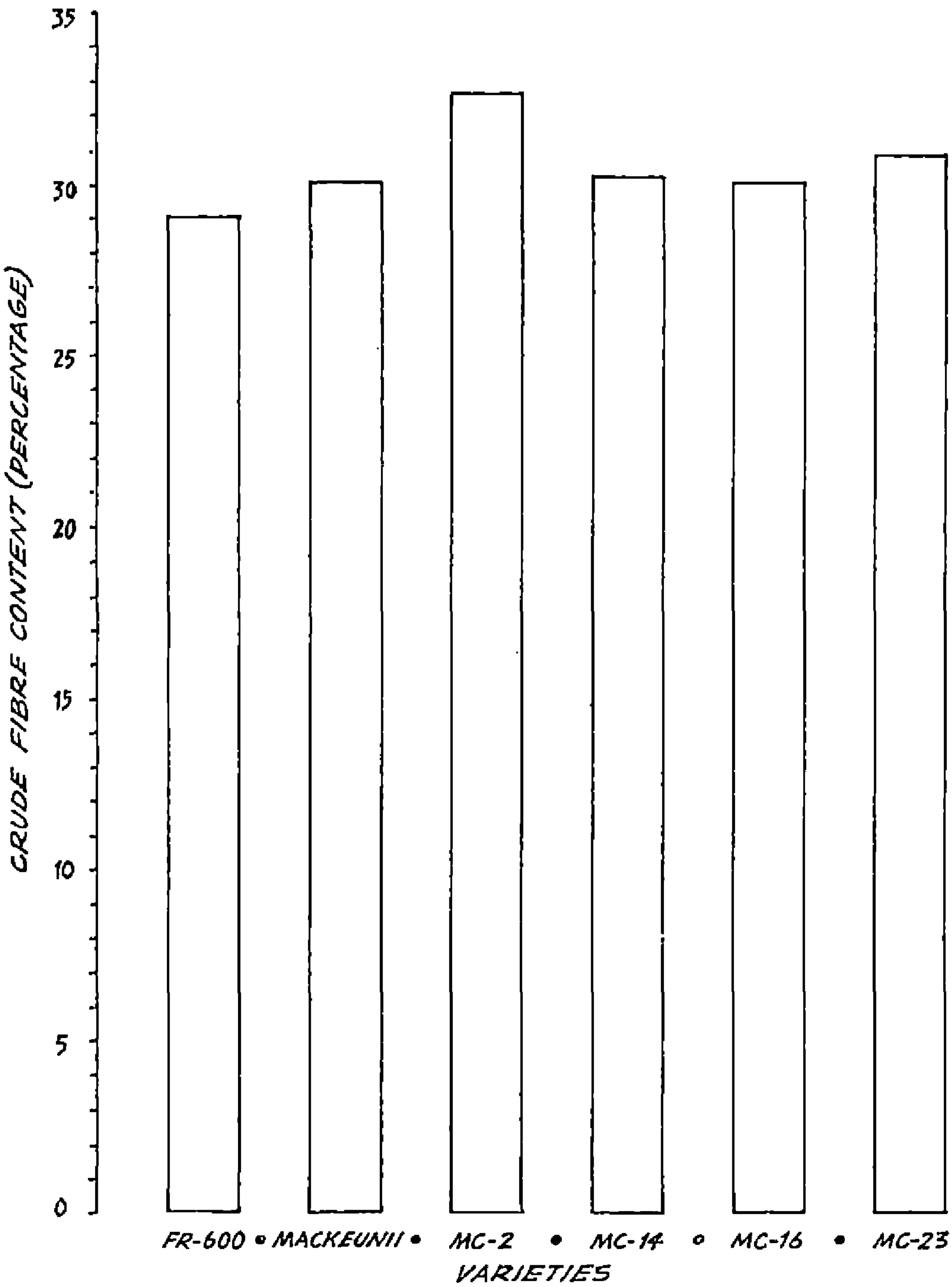
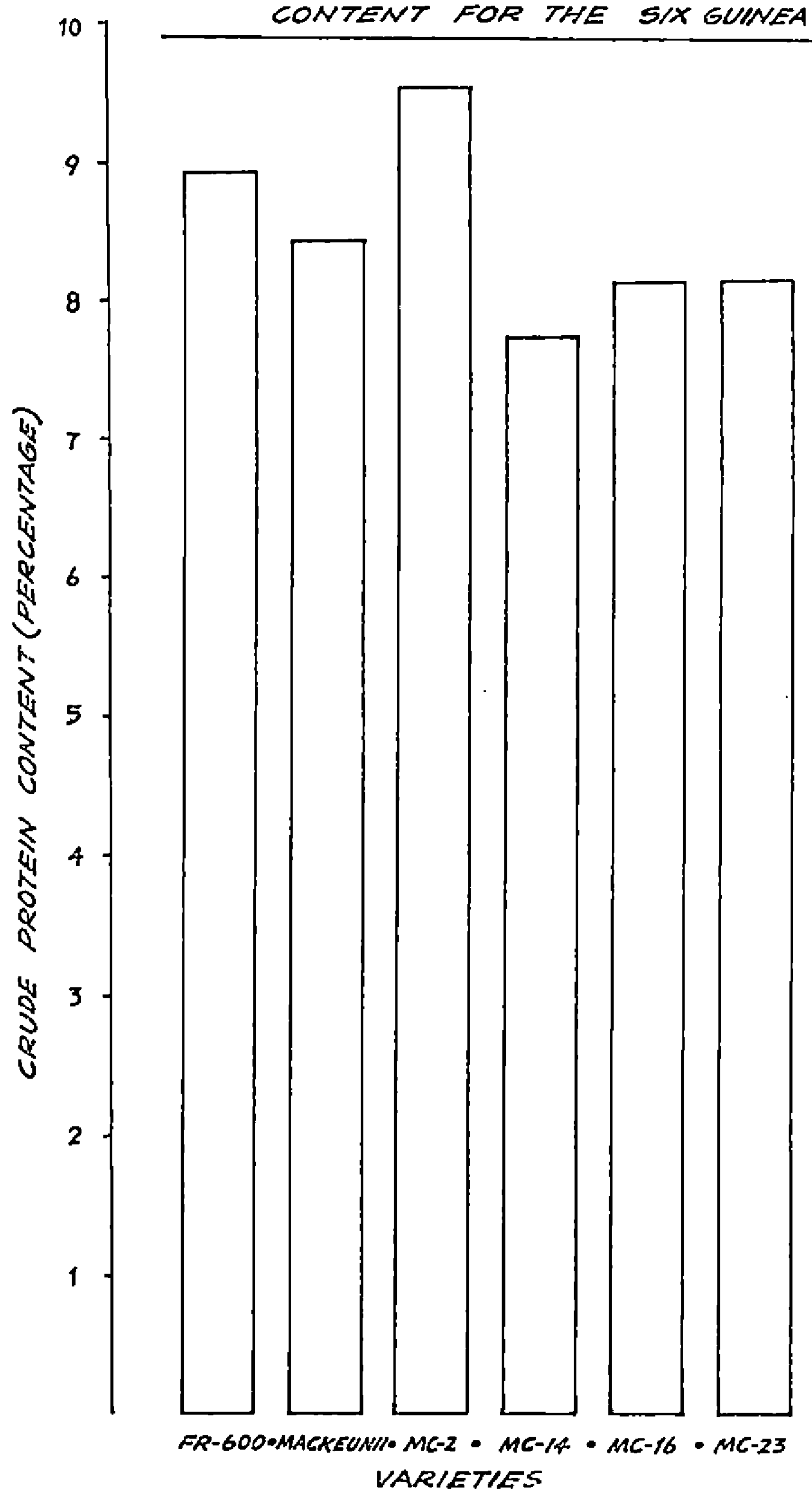


FIG.7 MEAN VALUE FOR THE CRUDE PROTEIN CONTENT FOR THE SIX GUINEA GRASS VARIETIES



B. <u>Phenotypic and Genotypic Co-efficients of variation</u>

The phenotypic and genotypic co-efficients of variation for the nine characters studied are given in Table 11 and graphically presented in Fig.8.

The phenotypic co-efficient of variation (PCV) was in general high for all the characters compared to genotypic co-efficient of variation (GCV). The dry matter yield showed the highest PCV (33.15 per cent) followed by leaf-stem ratio (21.21 per cent) and inflorescence count (18.59 per cent). Green fodder yield recorded a phenotypic co-efficient of variation of 16.99 per cent followed by 9.15 per cent for crude protein content, 6.76 per cent for height of plants and 5.76 per cent for width of leaves. The phenotypic co-efficient of variation recorded for crude fibre content was 5.51 per cent and the tiller counts recorded the least PCV value of 4.88 per cent.

The maximum genotypic co-efficient of variation was recorded for dry matter yield (24.03 per cent) followed by inflorescence count (13.93 per cent), leaf-stem ratio (13.31 per cent) and green fodder yield (11.68 per cent). Crude protein content showed 6.91 per cent GCV. The crude fibre content, tiller count and height of plants recorded

Table 11. Phenotypic and genotypic coefficient of variation for the characters studied in the main field

Sl. No.	Characters	Phenotypic coefficient of variation (percentage)	Genotypic coefficient of variation (Percentage)
1.	Tiller counts	4.88	3.23
2.	Plant height	6.76	2.30
3.	Width of leaves	5.76	2.17
4.	Inflorescence count	18.59	13.93
5.	Leaf-stem ratio	21.21	13.31
6.	Dry matter yield	33.15	24.03
7.	Green fodder yield	16.99	11.68
8.	Crude fibre content	5.51	3.30
9.	Crude protein content	9.51	6.91

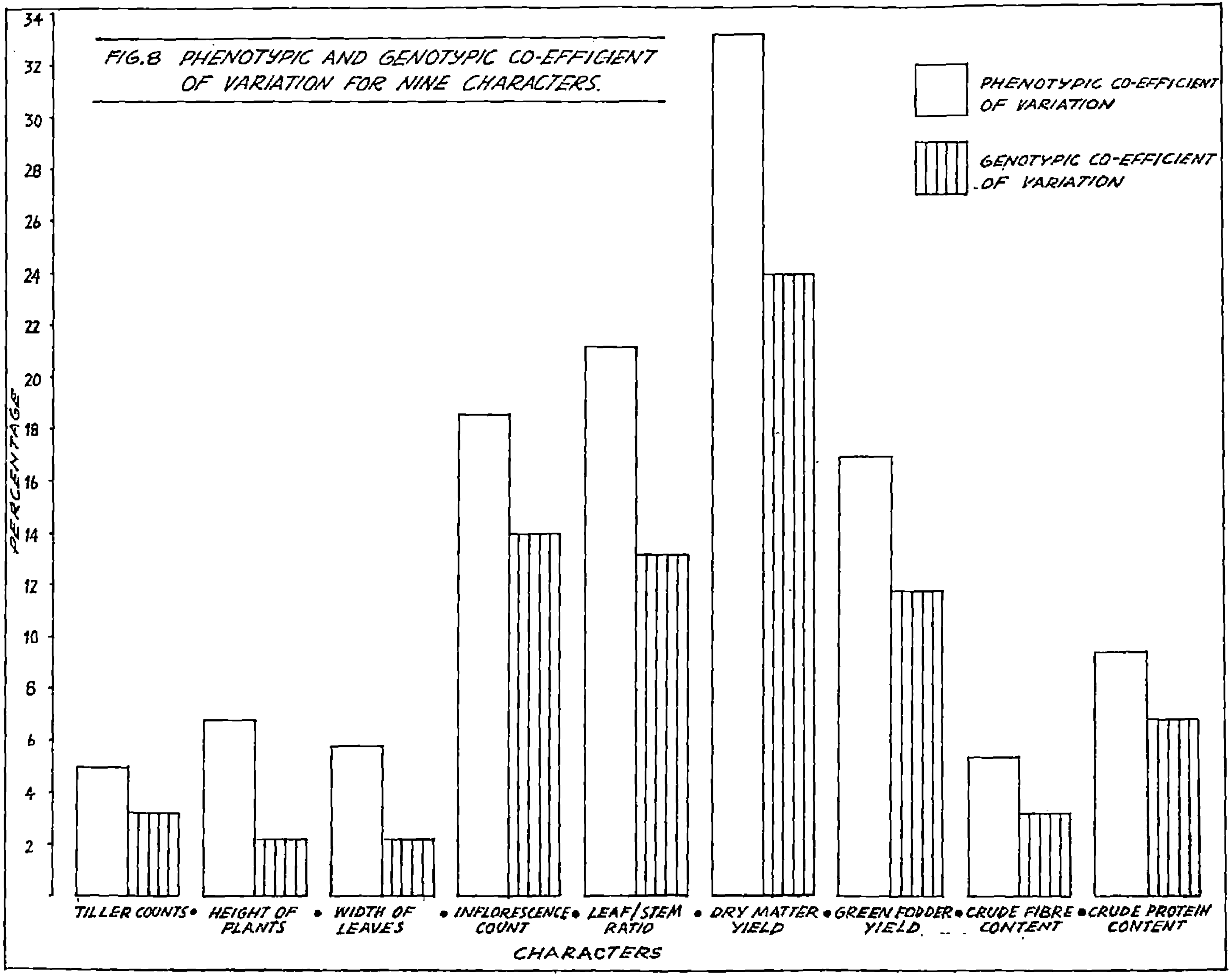


FIG.8 PHENOTYPIC AND GENOTYPIC CO-EFFICIENT OF VARIATION FOR NINE CHARACTERS.
PHENOTYPIC CO-EFFICIENT OF VARIATION
GENOTYPIC CO-EFFICIENT OF VARIATION
PERCENTAGE
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
TILLER COUNTS
HEIGHT OF PLANTS
WIDTH OF LEAVES
INFLORESCENCE COUNT
LEAF/STEM RATIO
DRY MATTER YIELD
GREEN FODDER YIELD
CRUDE FIBRE CONTENT
CRUDE PROTEIN CONTENT
CHARACTERS

GCV values of 3.3, 3.23 and 2.3 per cent respectively. Width of the leaves recorded the least GCV value (2.1 per cent).

C. Genetic parameters

The genetic parameters such as heritability and genetic advance expressed as percentage of mean value were computed and presented in Table 12 and graphically presented in Fig.9..

1. Heritability

The highest estimate of heritability was recorded for crude protein content (56.98 per cent) followed by inflorescence count (56.16 per cent), dry matter yield (55.56 per cent) and green fodder yield (51.81 per cent). A moderate heritability estimate of 43.67 per cent, 39.37 per cent and 36.59 per cent were recorded respectively for tiller counts, leaf-stem ratio and crude fibre content. A low estimate of 13.95 per cent heritability was recorded for width of leaves while the least heritability estimate was shown by plant height (11.7 per cent).

Table 12. Heritability and genetic advance for the nine characters studied in the main field

Sl. No.	Characters	Heritability (percentage)	Genetic advance (percentage of mean)
1.	Tiller counts	43.67	4.39
2.	Plant height	11.70	1.63
3.	Width of leaves	13.95	1.67
4.	Inflorescence count	56.16	21.51
5.	Leaf-stem ratio	39.37	17.23
6.	Dry matter yield	55.56	3.46
7.	Green fodder yield	51.81	17.30
8.	Crude fibre content	36.59	4.15
9.	Crude protein content	56.98	10.74

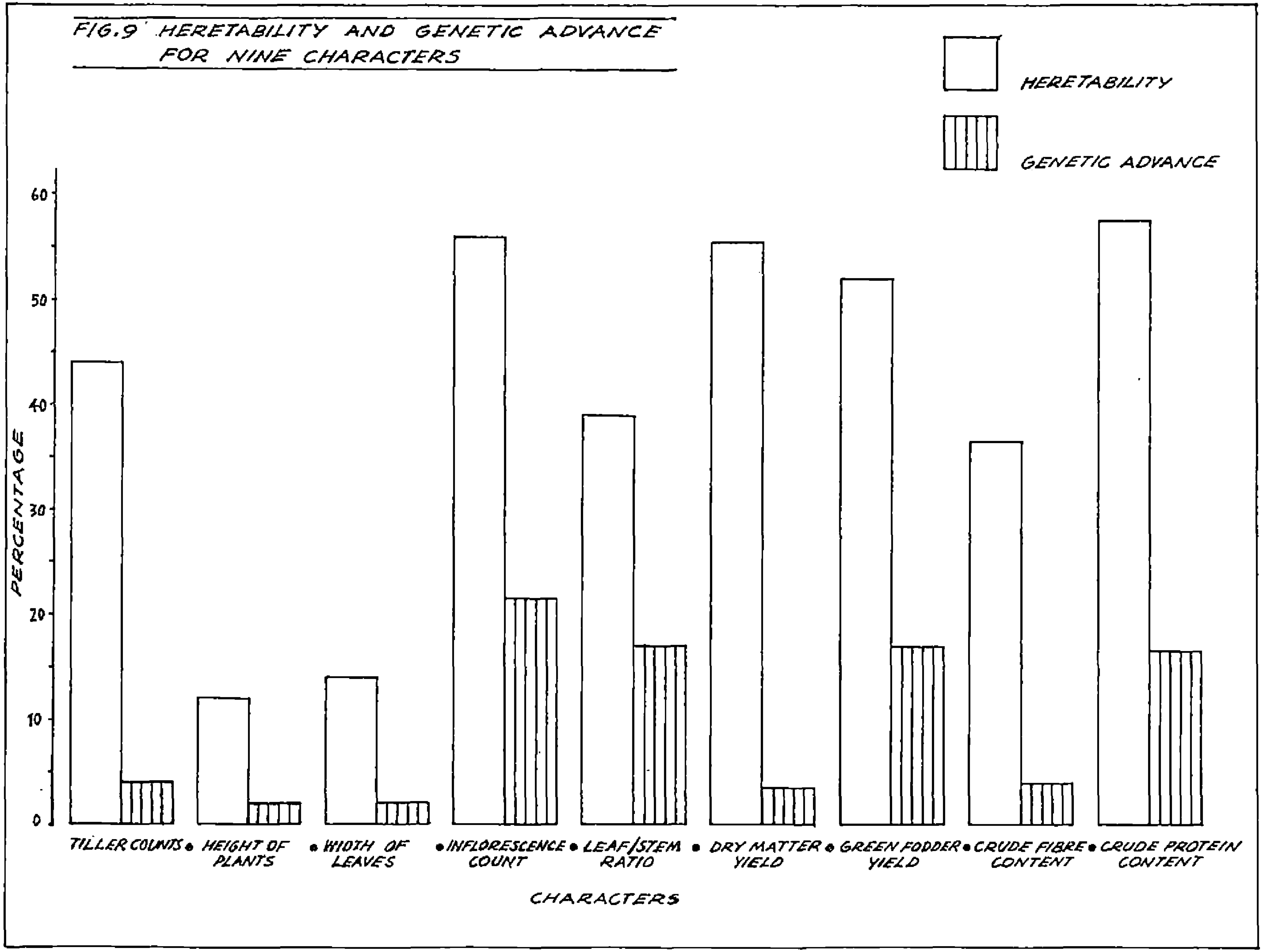


FIG.9 HERETABILITY AND GENETIC ADVANCE FOR NINE CHARACTERS
HERETABILITY
GENETIC ADVANCE
PERCENTAGE
0
10
20
30
40
50
60
TILLER COUNTS
HEIGHT OF PLANTS
WIDTH OF LEAVES
INFLORESCENCE COUNT
LEAF/STEM RATIO
DRY MATTER YIELD
GREEN FODDER YIELD
CRUDE FIBRE CONTENT
CRUDE PROTEIN CONTENT
CHARACTERS

2. Genetic advance

The genetic advance was the highest for the inflorescence count (21.51 per cent) followed by green fodder yield (17.30 per cent) and leaf-stem ratio (17.23 per cent). Crude protein content recorded a genetic advance of 10.74 per cent while the characters tiller count, crude fibre content, plant height and width of leaves showed very low estimates of genetic advance which ranged from 4.39 to 1.63.

D. Association of characters

The covariance analysis was done for all the $9C_2$ pairs of characters. Simple correlations were worked out and the estimates on correlation co-efficients are presented in Tables 13 and 14.

1. Correlation of yield with other characters

The correlation co-efficients of yield with other characters are presented in Table 13 and graphically presented in Fig.10.

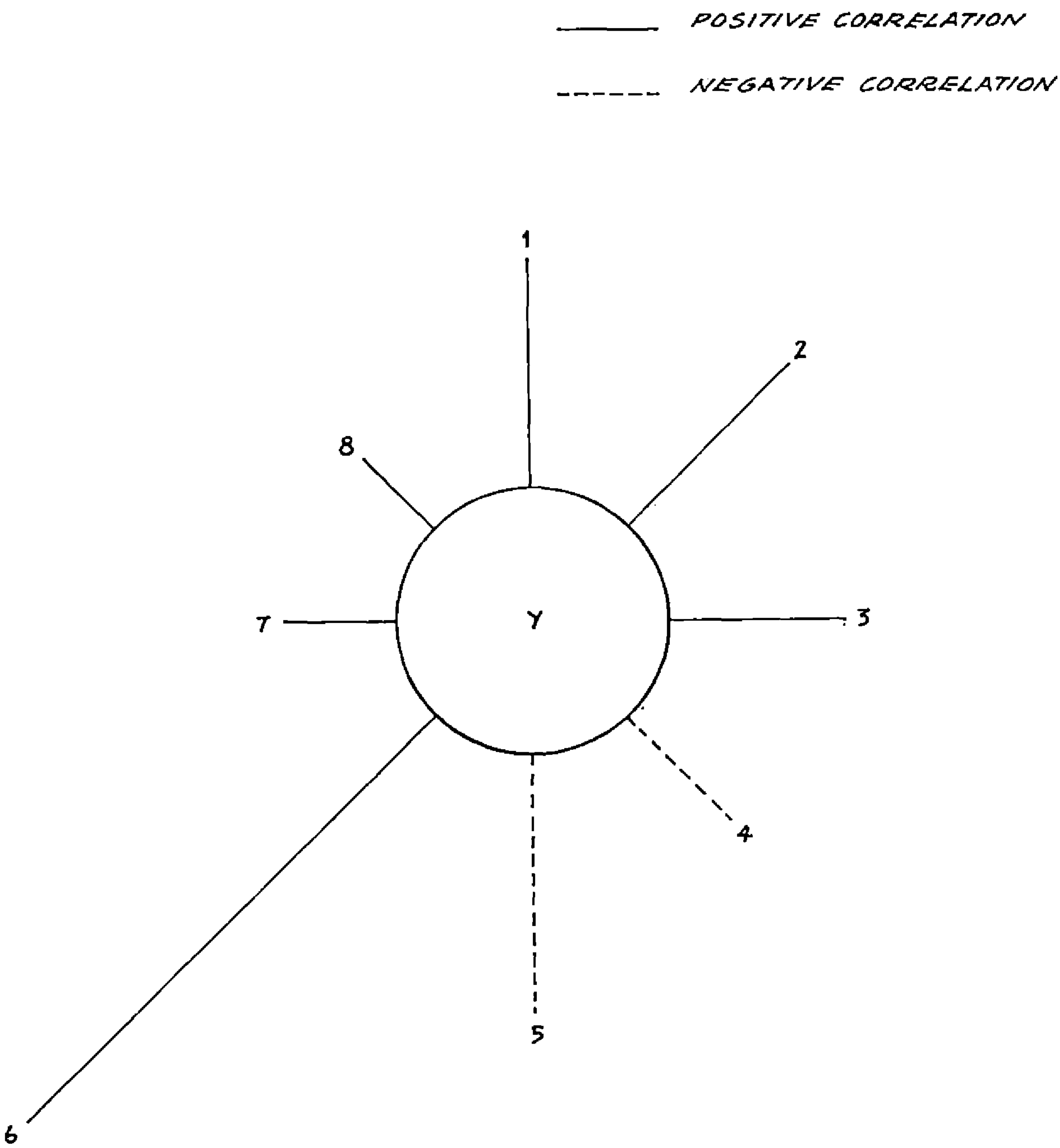
Green fodder yield showed positive correlation with all characters except leaf-stem ratio and inflorescence count. It showed highly significant positive association

Table 13. Correlation coefficient of green fodder yield with other characters

Characters	Correlation coefficient
Tiller counts	0.3478
Height of plants	0.3489
Width of leaves	0.2672
Leaf-stem ratio	-0.4041
Dry matter yield	0.8630**
Inflorescence count	-0.2207
Crude protein content	0.1508
Crude fibre content	0.1721

** Significant at 5% level of probability

FIG.10 CORRELATION CO-EFFICIENT OF GREEN FODDER YIELD PER PLOT WITH EIGHT CHARACTERS



1. TILLER COUNTS
2. HEIGHT OF PLANTS
3. WIDTH OF LEAVES
4. INFLORESCENCE COUNT
5. LEAF/STEM RATIO
6. DRY MATTER YIELD
7. CRUDE FIBRE CONTENT
8. CRUDE PROTEIN CONTENT

Y. GREEN FODDER YIELD

with dry matter yield (r = 0.8830) while height of plant, tiller counts, width of leaves, crude fibre and crude protein showed positive non-significant association with green fodder yield. Leaf-stem ratio and inflorescence count showed non-significant negative aossication with green fodder yield.

2. Correlation among characters other than green fodder yield

The data are presented in Table 14 and graphically presented in Fig.11.

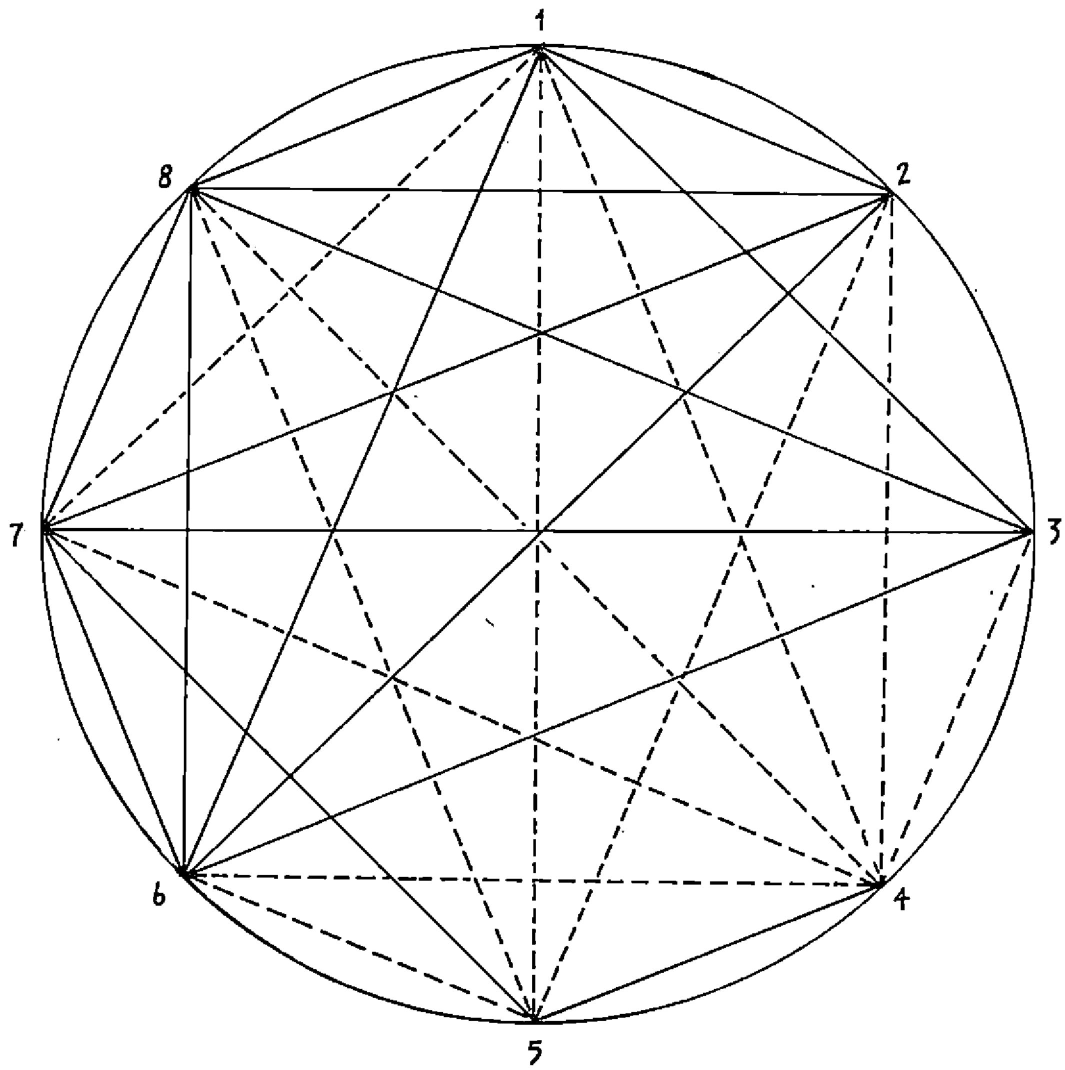
The tiller counts showed positive association with width of leaves, height of plants, dry matter yield, crude fibre and crude protein content. It showed negative association with leaf-stem ratio and inflorescence count. Height of the plant showed positive non-significant association with all the characters except leaf-stem ratio and crude protein content. Its association with dry matter yield was the highest (0.4367). The width of the leaves had positive association with tiller count (0.2609), height of plants (0.3981) and crude fibre content (0.4499)

Table 14. Correlation among characters other than green fodder yield

Sl. No.	Characters	Width of leaves	Tiller counts	Height of plants	Leaf-stem ratio	Inflore-scence count	Dry matter yield	Crude protein content	Crude fibre content
1.	Width of leaves	-	0.2609	0.3981	-0.1451	-0.1150	0.2237	-0.0513	0.4499*
2.	Tiller counts			0.2005	-0.1503	-0.2202	0.1969	0.0668	0.0676
3.	Height of plants				-0.3748	0.1282	0.4367	-0.3468	0.1203
4.	Leaf-stem ratio					0.1731	-0.4658*	-0.1436	-0.1715
5.	Inflorescence count						-0.0398	0.3043	-0.0458
6.	Dry matter yield							0.3418	-0.0429
7.	Crude protein content								0.3673
8.	Crude fibre content								-

* Significant at 5% level   r = 0.4394

FIG.11 CORRELATION OF CHARACTERS OTHER THAN GREEN FODDER YIELD WITH EACH OTHER



1. WIDTH OF LEAVES
2. TILLER COUNTS
3. HEIGHT OF PLANTS
4. LEAF/STEM RATIO
5. INFLORESCENCE COUNT
6. DRY MATTER YIELD
7. CRUDE PROTEIN CONTENT
8. CRUDE FIBRE CONTENT

but it showed negative association with inflorescence count (-0.1150), leaf-stem ratio (-0.1451) and crude protein content (-0.0513). The dry matter yield showed positive non-significant correlation with plant height (0.4367) and significant negative correlation with leaf-stem ratio (-0.4658). Non-significant negative correlation was observed between dry matter yield and crude fibre content (-0.0429). The dry matter yield showed positive association with width of leaves (0.2237), tiller counts (0.1969) and crude protein content (0.3418) and low negative association with the inflorescence count (-0.0398). The leaf-stem ratio showed negative correlation with all characters except inflorescence count. It had the highest negative association with dry matter yield (-0.4658) which was significant at 5 per cent level of probability. The inflorescence count showed positive association with crude protein (0.3043), leaf-stem ratio (0.1731) and height of plants (0.1282) while all other characters showed negative correlation with it.

E. D^2 analysis

The results of the D^2 analysis are presented in Tables 15, 16, 17 and 18. The six varieties were grouped into three clusters depending upon their genetic divergence.

Table 15. Clustering pattern of the six clones of guinea grass

Cluster Number	Number of varieties included	Name of varieties
I	3	Mackeunii, MC-14 and MC-16
II	2	MC-23 and FR-600
III	1	MC-2

Table 16. Average intra cluster D^2 distance in the clusters

Cluster	D^2 Distance
I	39.46
II	20.56
III	0.0

Table 17. Average inter cluster D^2 distance between clusters

Cluster	I	II	III
I	0	179.45	109.22
II		0	419.95
III			0

Table 18. Contribution of each character towards divergence

Characters	Percentage of contribution
Green fodder yield	Nil
Tiller counts	33.33
Height of plants	6.66
Width of leaves	Nil
Leaf-stem ratio	Nil
Dry matter yield	Nil
Inflorescence count	40
Crude protein content	20
Crude fibre content	Nil

Among the clusters, cluster I was the largest with three varieties. Cluster II was represented by two varieties and cluster III by a single variety.

The average inter and intra cluster D^2 values are presented in Tables 16 and 17. The intra cluster D^2 value ranged from the maximum 39.46 in cluster I to the minimum zero in cluster III. The inter cluster D^2 value was maximum between cluster II and III (419.95) and minimum between I and III (109.22).

Contribution of characters in creating diversity

The contribution of various characters in diversity was measured and presented in Table 18. The results revealed that the inflorescence count was the largest contributor towards divergence (40 per cent) followed by tiller counts (33.33 per cent). The crude protein content contributed 20 and height of the plants 6.66 per cent towards divergence. The contribution of other characters towards divergence was nil.

DISCUSSION

DISCUSSION

The success of crop improvement programmes depends on the existence and exploitation of genetic variability present in a given population. Variability, heritability, genetic advance, association of characters and divergence analysis are some of the major parameters which help in the evaluation of the extent of genetic variability and association present in a population. In guinea grass only meagre information is available on the genetic variability present. Considering the convenience in handling the planting material, seed propagation is fast becoming popular in guinea grass. However very little work has been done in this crop with seeds as planting material. Hence the present study was undertaken to obtain the basic information regarding the variability, inheritance and correlations of important quantitative characters and divergence relationship between the varieties selected for the study.

1. Studies on seedling characters

The studies on seedling characters revealed significant difference among the genotypes with respect to the germination count (Table 4). The percentage of germination was low in all the genotypes which ranged from 32.25 to 45.25 per cent. The highest mean value was recorded by FR-600 (45.25) followed by MC-16 (40.75) which were on par and the lowest value by Mackeunii (32.25). The probable cause of such low germination may be the presence of some inhibitory substance in the lemma and palea as suggested by Smith (1970).

The precocity in tillering is a general indication of vigour and adaptability in fodder grasses. Significant difference was observed among the different varieties for this character (Table 4). The variety FR-600 showed maximum early tillering tendency compared to other varieties. Mackeunii had the least number of early tillered seedlings in the nursery which was on par with MC-2 and MC-14. The trend of early tillering was found closely related to that of germination. The varieties having the highest germination percentage produced the highest number of early tillered seedlings also.

In seedling height and width of leaves the six varieties did not show any significant difference.

In the main field experiment also these two characters did not show any significant difference among the varieties. Sreenivasan (1983) in guinea grass and Tyagi _et_ _al_. (1977) in fodder oats have estimated only medium genotypic and phenotypic coefficient variation for plant height. The leaf width and plant height of guinea grass both at seedling and adult stage are seen here keeping a high degree of genetic homogeneity among the different varieties.

With respect to the appearance of glabrous and pubescent types among the seedling progeny it was observed that the segregation of the seedling into the pubescent and glabrous types was noticed only in pubescent types. The χ^2 values against 3 : 1 ratio of pubescent to glabrous in all the three cases were significant either at one per cent or five per cent level of probability. This eliminates the possibility of a heterozygous locus for this character segregating through selfing. If we assume that glabrous character is monogenically dominant over pubescent nature, probably the variety Mackeunii and the two mutants MC-14 and MC-23 which originated from FR-600 through mutation breeding were recessive mutants carrying double recessive genes for the pubescent character. Since the seed materials for the present study were collected from an experimental field where these pubescent clones were closely planted with glabrous types like FR-600, MC-2 and MC-16, cross pollination with pollen carrying dominant genes for glabrous nature might have occurred at a higher frequency than reported earlier (Dutt and Pugh in 1940, Whyte in 1958 and Purseglove in 1975). Eventhough this hypothesis requires further verification through pollination studies, the results indicate the break down of genetic purity in mutant guinea grass clones if we resort to seed propagation. One of the main objective of the present study was to evaluate the population structure of the seed progeny of the six guinea grass clones in relation to hairiness of leaves and other quality aspects. The results clearly show that atleast the pubescent types are vulnerable to the effect of random cross pollination leading to the appearance of glabrous types among their progeny. This situation is actually a blessing in disguise since it opens the possibility of recovering glabrous types from pubescent types. This finding can be commercially utilised for the production of superior hybrid guinea grass clones using the glabrous character as marker gene.

2. Variability in the main field

Guinea grass is reported to be a facultative apomictic type with only five per cent cross pollination. The continuous vegetative propagation adopted in this crop has further reduced the extent of variability.

In the present study, the analysis of variance revealed significant difference among the genotypes with respect to green fodder yield, tiller counts, leaf-stem ratio, inflorescence count, dry matter yield, crude protein and crude fibre content. There was no significant difference among the varieties for width of leaves and height of plants.

The study on the mean performance of individual traits in the main field revealed the overall superiority of the mutant clone MC-16 over others in green fodder yield, tiller counts, leaf-stem ratio and dry matter yield (Table 8 and 10). MC-16 produced an average of 45.18 kilograms of green fodder per plot per year which was significantly superior to the green fodder yield of all other varieties except MC-2 which was on par with

MC-16 in this character. But when we consider the quality aspects like crude fibre and protein content, MC-2 was found superior to MC-16.

The crop improvement programme in general is the exploitation of the genetic variability available in a population. The total variability present could be partitioned into heritable and non heritable components with the aid of genetic parameters like genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), heritability (h^2) and genetic advance (GA) which serve as useful guidelines for selection.

In the present study the PCV was in general high for all the characters compared to GCV. Wide difference was observed between the estimates of PCV and GCV for characters such as dry matter yield, and leaf-stem ratio indicating that they are influenced more by environment than by the genetic make up. The inflorescence count, green fodder yield, height of plants, tiller counts, width of leaves and crude protein content exhibited little difference between GCV and PCV indicating that the variations observed in these characters are more influenced by genetic causes than environment.

In general the estimates of GCV and PCV recorded were low for all the characters in the present study. Among the nine characters studied the highest estimates of GCV and PCV were observed for dry matter yield indicating that there is better scope for improvement of this character through selection when compared to other characters. In all other characters comparatively low estimates of PCV and GCV values were recorded. Tyagi et al. (1977) in fodder oats, Tyagi et al. (1980) in pearl millet, Sanghai and Singh (1973) in fodder bajra had reported similar findings with respect to green fodder yield. However, Sreenivasan (1983) in guinea grass and Swarup and Chaugale (1962,a) in sorghum had reported high value of GCV for green fodder yield. The low GCV and PCV values (11.68 and 16.99 per cent respectively) observed for green fodder yield in the present study may be due to the shaded condition under which the experiment was laid out. In the case of leaf-stem ratio low estimate of GCV and PCV were recorded by Sreenivasan (1983) in guinea grass. Similar finding was also reported by Nair and Gupta (1977) and Tyagi *et al*. (1977) in fodder oats. These findings are in agreement with the present study.

For dry matter yield low estimate of GCV value was recorded by Tyagi *et al*. (1980) in pearl millet and Nair and Gupta (1977) in fodder oats. However, Sreenivasan (1983) in guinea grass reported high estimate of GCV for this character which is in agreement with the present results.

In the present study plant height, tiller counts, crude fibre content, width of leaves and crude protein content showed very low PCV and GCV values ranging from 2.17 to 9.57. Tyagi *et al*. (1980) in pearl millet and Nair and Gupta (1977) in fodder oats have also observed similar findings. Contrary to this Sreenivasan (1983) in guinea grass, Swarup and Chaugale (1962,a) in sorghum; Tyagi *et al*. (1977) in fodder oats observed high estimates of GCV for plant height. Sanghai and Singh (1973) have reported very low estimates of GCV for tiller counts in bajra. Tyagi *et al*. (1977) in fodder oats and Tyagi *et al*. (1980) in pearl millet have also reported similar findings. However, Nair and Gupta (1977) in fodder oats had reported high estimates of GCV value for tiller counts. Low estimates of GCV value was recorded for both crude fibre and protein content by Sreenivasan (1983) in guinea grass which is in agreement with the present study.

3. <u>Heritability</u>

Heritability is an index of transmissibility of characters from one generation to other and it provides a measure of the value of selection for different attributes in various types of progenies.

In the present study the highest heritability estimate was reported for crude protein content (56.98 per cent) indicating that one can attempt selection for this character directly based on phenotypic performance. Contrary to this finding, Singhania <u>et al</u>. (1977) in fodder sorghum reported low heritability estimate for this character.

The inflorescence count, dry matter yield and green fodder yield have also expressed comparatively higher heritability estimates (56.16, 55.56 and 51.81 per cent respectively) in the present study.

Kazuba *et al*. (1981) in *Phleum pratense* had reported heritability estimate exceeding 60 per cent for the number and length of flowering shoots. Swarup and Chaugale (1962,a) in fodder sorghum reported a heritability estimate of 84.33 per cent for green fodder yield. Sindagi *et al*. (1970) had also reported high heritability estimate for this character in sorghum. Sanghai and Singh (1973) in bajra, Tyagi *et al*. (1980) in pearl millet, Nair and Gupta (1977) and Tyagi *et al*. (1977) in fodder oats have reported high heritability estimates for green fodder yield and dry matter yield. Contrary to this, Singhania *et al*. (1977) and Sainy and Paroda (1975) in sorghum have reported low heritability estimates for these characters.

In the present study moderate heritability estimates were obtained for tiller counts (43.67 per cent) leaf-stem ratio (39.37 per cent) and crude fibre content (36.59 per cent). Similar results were reported by Sainy and Paroda (1975) in fodder sorghum. However, Salach-Warecha and Goral (1979) in *Phleum pratense*, Singhania *et al*.(1977) in bajra, Tyagi *et al*. (1977) and Nair and Gupta (1977) in fodder oats have reported high heritability estimates for these characters. However, low heritability was reported for leaf-stem ratio in fodder sorghum by

Singhania *et al.* (1977).

In the present study plant height and width of leaves recorded low heritability values indicating that environment plays a major role in the expression of these characters. High estimates of heritability for plant height was reported by Salach-Warecha and Goral (1979) and Kazuba *et al.* (1981) in *Phleum pratense*, Swarup and Chaugale (1962,a) and Singhania *et al.* (1977) in fodder sorghum and Nair and Gupta (1977) and Tyagi *et al.* (1977) in fodder oats. Wafford (1983) in Bermuda grass and Tyagi *et al.* (1980) in *Pennesetum typhoides* have reported medium heritability estimates for leaf breadth.

4. Genetic advance

The heritability estimates alone does not give a precise measure of the transmissibility of characters. For this the genetic advance has to be considered along with heritability estimates. In the present study the genetic advance expressed as percentage mean of the population was low for all the characters. Among the nine characters studied the inflorescence count recorded the highest estimate of genetic advance followed by green fodder yield and leaf-stem ratio. Sindagi *et al.* (1970)

in fodder sorghum and Nair and Gupta (1977) in fodder oats have reported high estimate of genetic advance for green fodder yield. Moderate estimate of genetic advance for this character was reported by Sanghai and Singh (1973) and Tyagi et al. (1980) in fodder bajra. Tyagi et al. (1977) in fodder oats reported genetic advance exceeding 30 per cent for green fodder yield.

Tyagi et al. (1977) in fodder oats have reported a value exceeding 30 per cent for genetic advance in leaf-stem ratio while Nair and Gupta (1977) have reported a very low value of genetic advance for this character.

In the present study tiller counts, height of plants, width of leaves, crude fibre and crude protein content showed very low genetic advance. Contrary to this, Swarup and Chaugale (1962,a) have reported high estimates of genetic advance for plant height in fodder sorghum. But the low estimate of genetic advance for plant height reported by Tyagi et al. (1977) in fodder oats is in agreement with the present finding. Nair and Gupta (1977) in fodder oats have reported low estimate of genetic advance for tiller number while moderate value was reported for this character in sorghum by Singhania et al. (1977). The low genetic advance for the leaf breadth reported in the present study is in agreement with the finding of Tyagi et al. (1980) in fodder bajra. However, Tyagi et al. (1977) in fodder oats have reported a value exceeding 30 per cent for this character as well as for dry matter yield.

5. Correlation

Correlation study was conducted to obtain an estimate of the degree of association of green fodder yield with its components so as to obtain information regarding the inter-relationship between various yield contributing attributes.

In the present study green fodder yield showed positive correlation with all the characters except leaf-stem ratio and inflorescence count. This indicates that majority of yield components chosen for the study may probably be directly associated with fodder yield.

Green fodder yield showed the highest positive correlation with dry matter yield. This is in agreement with the findings of Sreenivasan (1983) in guinea grass, Sotomayour-Rios et al. (1971) in Digitaria spp, Fujimato and Susuki (1975) in rye grass, Schitea (1983) in Italian rye grass, Rao and Ahluwalia (1977) in sorghum and Nair and Gupta (1977) in fodder oats.

In the present study green fodder yield was found to have negative correlation with leaf-stem ratio(-0.4041). As the weight of stem portion increases the ratio become narrow while the green fodder yield increase although the quality of such fodder is substantially reduced. Hence a negative correlation between leaf-stem ratio and green fodder yield is logical. Singhania et al. (1977) in fodder sorghum and Pillai et al. (1974) in guinea grass have also reported similar findings.

Another character which showed positive association with green fodder yield in the present study was plant height. Sreenivasan (1983) in guinea grass has also reported similar findings. Yadav et al. (1974) in Cenchrus ciliaris, Sokolova and Turkina (1979) in timothy grass, Schitea (1983) in Italian rye grass, Swarup and Chaugale (1962,b); Rohewal et al. (1964) and Singhania et al. (1977) in fodder sorghum and Singh and Prasad (1976) in fodder bajra have also reported positive correlation between green fodder yield and plant height. In fodder oats Singh *et al.* (1980) reported that the green fodder yield was positively correlated with the plant height at flowering stage.

Positive association was recorded between green fodder yield and tiller counts in the present study. Similar observation was made by Sotomayour-Rios *et al.* (1972) in guinea grass, Yadav *et al.* (1974) in *Cenchrus ciliaris*, and Sleper *et al.* (1977) in *Festuca arundinacea.* Salach-Warecha and Goral (1979) in *Phleum pratense* observed strong positive correlation of green fodder yield with number of fertile tillers. Contrary to this finding, Sreenivasan (1983) in guinea grass has observed negative correlation of tillers with green fodder yield. Nelson and Sleper (1977) in *Festuca arundinacea* have reported an inverse relationship between yield per tiller and tiller number.

In the present study crude protein and crude fibre content showed positive correlation with green fodder yield eventhough of a very low magnitude. Sreenivasan (1983) has reported negative correlation between green fodder yield and crude protein in guinea grass. Riley and Vogel(1983) in *Andropogon halli* cv. gold strike and Berg and Hill (1983) in timothy grass and Vogel (1983) in brome grass have also reported similar findings. Contrary to this Schitea (1983) in Italian rye grass observed significant positive correlation between green matter and crude protein content.

In the present study width of leaves exhibited positive non-significant correlation with green fodder yield. This is in agreement with the findings of Yadav *et al.* (1976) in *Cenchrus ciliaris*. Similar correlation was also observed by Paroda *et al.* (1975), Rana *et al.* (1976) and Gopalan and Balasubramanian (1978) in sorghum.

The data on inter relations give more reliable information on the association of different characters among themselves.

In the present study, the different associations among tiller counts, dry matter yield, plant height, width of leaves and crude fibre content were positive. This suggests the possibility of simultaneous improvement of these characters in a selection programme involving any one of these traits.

Positive correlation was observed between tiller counts and dry matter yield in the present study. Salach-Warecha and Goral (1979) in timothy grass observed strong positive correlation between dry matter yield and number of fertile tillers. However, Jhorar and Paroda (1976) in sorghum have reported negative correlation between these two characters.

In the present study positive correlation was observed between dry matter yield and plant height. Sreenivasan (1983) in guinea grass and Fujimato and Susuki (1975) in Italian rye grass have reported positive correlation of dry matter yield with height.

Tiller counts showed weak positive association with leaf width and plant height in the present study. The finding of Sreenivasan (1983) was in agreement with this. However, Salach-Warecha and Goral (1979) in Phleum pratense reported negative correlation between height and number of vegetative tillers. The absence of the logical negative correlation between height and tiller counts in the present study as well as that of Sreenivasan (1983) may be due to the more shady condition in which the experiments were conducted.

Leaf-stem ratio had exhibited negative correlation with all characters except inflorescence count and tiller counts. Singhania et al. (1977) have reported negative correlation between leaf-stem ratio and height of plants in fodder sorghum. In guinea grass Sreenivasan (1983) has reported that leaf-stem ratio is showing negative correlation with tiller counts, height of plants, width of leaves and dry matter yield.

With regard to the quality characters the present study showed that crude fibre content was positively correlated with all characters except dry matter yield, leaf-stem ratio and inflorescence count while crude protein content showed negative correlation with width of leaves, height of plants and leaf-stem ratio and positive correlation with the rest of the characters. Sreenivasan (1983) has also reported similar findings in guinea grass with the exception of negative correlation shown by crude protein and tiller counts with crude fibre. In forage maize Maggiore et al. (1980) have reported no correlation between dry matter yield and crude fibre content with green fodder yield when taken separately but both were positively correlated when taken together. They have also reported that dry matter yield was negatively correlated with protein content.

6. Divergence analysis

The divergence analysis helps in the identification of diverse genotypes which could be used for hybridisation programmes. In the present study the six varieties were grouped into three genetic constellations with the assumption that the varieties within the cluster had smaller D^2 values among themselves than the varieties between the clusters. The inter cluster distance was maximum between cluster III and II showing considerable genetic distance between these groups, and was minimum between clusters I and II indicating that they are very close to each other.

With regard to the contribution of each character towards genetic divergence it was observed that the inflorescence count contributed maximum towards divergence followed by crude protein content, tiller counts and height of plants. Arunachalam and Ram (1967) in sorghum have reported that various characters like days to 50 per cent flowering, number of leaves per plant, height, number of whorls of rachis were found to be important for divergence. In

Pennesetum typhoides Shukla and Dua (1983) have reported that dry matter, days to flowering, stem weight and number of leaves were major factors contributing to divergence. In the present study characters such as width of leaves, dry matter yield, leaf-stem ratio, green fodder yield and crude fibre content found to have no influence at all in creating divergence, whereas, inflorescence count, tiller counts, crude protein content and height of plants have contributed towards divergence in that order of magnitude. Therefore selection of parents differing in inflorescence count, tiller counts, crude protein content and height of plants will result in the production of divergent material.

SUMMARY

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Genetic evaluation of seed propagated progeny of six guinea grass clones was undertaken in the Department of Plant Breeding, College of Agriculture, Vellayani during the period from October 1985 to June 1987. Open pollinated seeds collected from four mutant clones namely MC-2, MC-14, MC-16 and MC-23 and the parent variety FR-600 and the existing high yielder Mackeunii were sown in nursery and random sample of seedlings from each treatment were grown in a 6 x 4 RBD field experiment with 49 clumps in each plot. Observations on germination, seedling height, number of early tillered seedlings, count of glabrous and pubescent types and width of leaves were taken in the nursery. Green fodder yield from the whole plot was taken at 45 days interval for one full year from the main field experiment. Tiller counts, inflorescence counts, leaf-stem ratio, height of plants, width of leaves and dry matter yield were also taken during the 2nd, 4th, 6th and 8th harvests from the main field. Quality aspects like protein content and crude fibre content were estimated on the pooled samples of dry matter obtained from the 2nd, 4th, 6th and 8th harvests.

The analysis of variance and covariance, coefficient of variation, heritability, genetic advance, simple correlation studies and D^2 analysis were done on the data collected and the various findings from these studies are summarised below:

1. Studies on seedling characters

The germination of the open pollinated seeds collected from the six clones was in general very low ranging from 32.25 to 45.25 per cent. The probable cause of such low germination may be the presence of some inhibitory substances in the lemma and palea of the seed. The seedlings did not show any significant difference in plant height and width of leaves. The early tillering tendency was maximum in FR-600 and minimum in Mackeunii. The pubescent clones have produced glabrous segregants among their seedling progeny indicating the possibility of producing superior hybrid guinea grass clones using the glabrous character as marker gene.

2. Variability in the main field

The analysis of variance revealed significant difference among the genotypes with respect to green fodder yield, tiller counts, leaf-stem ratio, inflorescence count, dry matter yield, crude protein and crude fibre content. The study on the mean performance of individual traits in the main field revealed the overall superiority of the mutant clone MC-16 over others in green fodder yield, tiller counts, leaf-stem ratio and dry matter yield. MC-16 produced an average of 45.18 kilograms of green fodder plot per year which was significantly superior to the green fodder yield of all other varieties except MC-2 which was on par with MC-16 in this character. But in quality characters like crude fibre and crude protein content MC-2 was found superior to MC-16.

The phenotypic coefficient of variation was in general high for all characters compared to genotypic coefficient of variation. But the estimates of GCV and PCV were low for all characters in the present study. Among nine characters studied the highest estimates of GCV and PCV were observed for dry matter yield indicating scope for improvement of that character through selection.

3. Heritability and genetic advance

Highest heritability estimate was recorded for crude protein content (56.98 per cent) indicating its genetic improvement through phenotypic selection. The inflorescence count, dry matter yield and green fodder yield have also expressed comparatively higher heritability estimates in the present study. But the estimates of genetic advance expressed as percentage mean of the population was low for all the characters. The inflorescence count recorded the highest estimate of genetic advance followed by green fodder yield and leaf-stem ratio.

4. Correlation studies

The green fodder yield showed positive correlation with all other characters except leaf-stem ratio and inflorescence count. Dry matter yield was found contributing maximum towards green fodder yield. Plant height and tiller counts have also shown positive correlation with green fodder yield. The correlation of crude protein content and crude fibre content with green fodder yield was also positive but of very low magnitude.

The data on interrelations among different characters have shown that the different associations among tiller counts, dry matter yield, plant height, width of leaves and crude fibre content were positive. This has suggested the possibility of simultaneous improvement of these characters in a selection programme involving any one of these traits.

5. Divergence analysis

The six varieties were grouped into three genetic constellations with the assumption that the varieties within the cluster had smaller D^2 values among themselves than the varieties between the clusters. The inter-cluster distance was maximum between cluster II and III showing considerable genetic distance between these groups.

The inflorescence count contributed maximum towards divergence followed by crude protein content, tiller counts and height of plants indicating that selection of parents differing in these characters will result in the production of divergent material.

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* Originals not seen

ABSTRACT

Open pollinated seeds collected from six guinea grass clones were used for genetic evaluation of progeny through analysis of variance and covariance, coefficient of variation, heritability, genetic advance, simple correlation studies and D^2 analysis.

The progeny of pubescent clones were found segregating into pubescent and glabrous types indicating the possibility of producing superior hybrid guinea grass clones using the glabrous character as marker gene.

The study on the mean performance of individual traits revealed the overall superiority of the mutant clone MC-16 over others in green fodder yield, tiller counts, leaf-stem ratio and dry matter yield. But MC-2, which was on par with MC-16 in green fodder yield, was found superior over MC-16 in quality characters like crude fibre content and crude protein content.

The estimates of GCV and PCV were low for all characters. Among the nine characters studied the highest estimates of GCV and PCV were obtained for dry

matter yield indicating scope for improvement of that character through selection.

Highest heritability estimate was recorded for crude protein content indicating its genetic improvement through phenotypic selection. The estimates of genetic advance was low for all the characters.

Green fodder yield showed positive correlation with all other characters except leaf-stem ratio and inflorescence count. Dry matter yield was found contributing maximum towards green fodder yield. Plant height and tiller counts have also shown positive correlation with green fodder yield.

The data on interrelations among different characters have shown that the different associations among tiller counts, dry matter yield, plant height, width of leaves and crude fibre content were positive. This has suggested the possibility of simultaneous improvement of these characters in a selection programme involving any one of these traits.

Through divergence analysis of the six varieties were grouped into three genetic constellations with the assumption that the varieties within the cluster had smaller D^2 values among themselves than varieties between the clusters. The intercluster distance was maximum between cluster II and III showing considerable genetic distance between these groups.

The inflorescence count contributed maximum towards divergence followed by crude protein content, tiller counts and height of plants indicating that selection of parents differing in these characters will result in the production of divergent material.