PRODUCTION POTENTIAL OF GUINEA GRASS CLONES UNDER PARTIAL SHADE IN COCONUT GARDENS

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Production potential of guinea grass clones under partial shade in coconut gardens" is a bonafide record of research work done by me 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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25-11-88

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CERTIFICATE

Certified that this thesis, entitled "Production potential of guinea grass clones under partial shade in coconut gardens" is a record of research work done independently by KUM. THEJASEEBHAI, V. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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INTRODUCTION

INTRODUCTION

Guinea grass (*Panicum maximum* Jacq.) is a highly variable perennial bunch grass, native to Tropical Africa. It is widely grown in many tropical and subtropical areas as a fodder grass considering its high adaptability, persistence, productivity and palatability (Bogdan, 1977 and Javier, 1970). Its highly nutritious green fodder is relished by all kinds of livestock. It was introduced to India as early as 1793 but its cultivation started in South India only during 1870's. Guinea grass has now become well acclimatized in this region so as to become the most popular fodder grass grown in Kerala. The drought resistance and hardy nature of this plant have facilitated its cultivation as a rainfed crop under partial shaded conditions of the coconut gardens in Kerala.

The performance of tropical pastures under shaded conditions needs investigation for various reasons. In South East Asia, plantation crops are an important form of land use. They are normally established at wide spacing and a complete stand of the plantation is not achieved until after 4-5 years. Considerable interest has been generated in the use of the large inter-tree areas for pasture, in an endeavour to intensify and diversify agricultural production per unit land area (Thomas, 1978).

Coconut is an important cash and food crop. In Kerala, it is grown in an area of about 7.04 lakh hectares. Mixed farming programme is very much suited to coconut plantations which involves the cultivation of fodder crops in the inter spaces of coconut gardens and can maintain milch animals. There has been relatively little detailed investigation of the response in growth of tropical grasses in shaded conditions. Tropical grasses potentially have a higher growth rate than legumes because of their higher rate of photosynthesis (Ludlow and Wilson, 1970).

Verghese (1976) and Sahasranaman and Pillai (1976) reported that only 23 per cent of the soil on area basis was utilised by the coconut roots in a coconut plantation planted at 7.5 m spacing. Fodder crops are mostly surface feeders and grass roots traverse extensively in the top soil. During early stages of growth of the palm and after about 25 years of age, major portion of the incident solar energy is not intercepted by coconut leaves. Making use of this unintercepted sunlight, various crops adaptable to such conditions can be grown in the interspaces of coconut palms. Such cropping programme enables to raise the productivity from the land considerably. This increase in productivity is often more than proportional to the expenses and consequently the net return per unit amount of investment is considerably enhanced.

Patil et al. (1979) reported fodder yield of 60 t ha^{-1} for grass grown as intercrop in coconut garden. Nair et al. (1975) reported that Guatemala (Tripsacum laxum), hybrid napier var. NB-21 and guinea (Panicum maximum) gave 50-60 t ha^{-1} green fodder. Pillai et al. (1980) asserted that grasses grown under coconut palms as intercrop gave 75 per cent green fodder over the yield obtained from open fields. The superior adaptability of guinea grass over other fodder grasses under coconut garden environment was reported by Reynolds (1978). But under Kerala conditions, the green fodder yielding ability of this grass in the partial shade of coconut garden was found to be not up to the mark especially during summer months. With considerable interest being shown in the improvement of this crop for fodder purposes, it would be worthwhile to have an idea of the component traits influencing the green fodder yield under partial shade of coconut gardens.

An efficient plant type is a combination of the desirable morphological and physiological traits that influence the dry matter production. An improvement in yield may, therefore, be speculated if selection for physiological traits is also taken into consideration besides the major yield components. An assessment of the magnitude of genetic variability and inter-relationship among different variables would be useful for making effective selection for the improvement of these traits. Although correlation between green fodder yield and other plant characteristics in guinea grass have been studied by a few workers, information regarding physiological traits is still rather scanty. The present study was undertaken to ascertain the nature and magnitude of inter-relationship among different morphological and physiological traits in guinea grass under partial shade in coconut gardens. The identification of important yield components will help in the selection of superior guinea grass genotypes for higher yield and better adaptability.

The major objectives of the study were

1. Evaluation of the expression of the production potential of guinea grass clones suited to partially shaded conditions in coconut gardens.

2. Study of genetic variability by estimating the parameters like genotypic coefficient of variation, heritability, genetic advance and genetic gain.

3. Determination of association of fodder yield with other yield components and also among the yield components through correlation study.

4. Assessment of direct and indirect influence of different component characters on fodder yield using path analysis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Improvement of fodder grasses is a field of investigation which has not received adequate attention. Recent advancement in biometrics has helped the plant breeder to obtain a better understanding of the genetics of yield and its components in cultivated crops. Fodder yield is a complex character, the magnitude of expression of which depends on the influence of yield component characters. Besides, fodder yield and its components are influenced by both heritable and non-heritable factors. As such, it becomes necessary to determine the association of the yield components with fodder yield and also the extent to which the yield and yield components are governed by genetic and environmental factors. Further, fodder yield is not only affected directly by each component character but also indirectly by each through other component characters.

Statistical techniques have been developed and employed extensively to determine separately the influence of heritable and non-heritable factors on the variability of characters, association of component characters with fodder yield and the direct influence of each character and the indirect influence of each character through other characters on fodder yield. The reliability of each of the yield components has to be further identified with reference to maximum genetic influence, least susceptibility to the environmental influence and maximum direct effect and indirect effect on the fodder yield. Studies relating to variability on guinea grass (Panicum maximum Jacq.) in India is rather meagre. The work so far carried out were reviewed with particular reference to cereal fodders and grasses.

2.1. Variability studies

Plant breeding in its true sense relates to the efficient management and utilization of variability. Economic characters in any crop plant are highly influenced by the environment. It is thus difficult to conclude whether the observed variability is heritable or not. Therefore it is essential to partition the observed variability into heritable and non-heritable components by means of suitable genetic parameters. The extent of variability in various fodder crops has been studied by many workers by estimating the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV).

A comparison of coefficients of phenotypic and genotypic variations in ragi was made by Kempanna and Thirumalachar (1968) and it revealed that the tiller number per plant was very much under the influence of environment. Patnaik (1968) noted greater phenotypic variation for number of tillers and high genotypic variation for plant height in finger millet.

Dhagat et al. (1971) obtained genotypic coefficient of variation values below 15 per cent for the number of panicles in Kodo millet (Paspalum scorbiculatum). Kempanna et al. (1971) observed genotypic coefficient of variation exceeding 30 per cent for number of productive tillers and less than 15 per cent for plant height in fodder ragi.

Phul et al. (1972) reported maximum values of genotypic coefficient of variation for fodder yield (14.65 per cent and tiller number (10.31 per cent) in fodder oats. They also noted that the genetic variances for plant height, tiller number and fodder yield were much lower than the phenotypic variances indicating considerable environmental influence on the expression of these characters.

Sangha and Singh (1973), in bajra, observed that fodder yield had maximum phenotypic (19.41 per cent) as well as genotypic coefficient of variation (18.72 per cent) and genotypic coefficient of variation of less than 15 per cent for the number of tillers. Patnaik and Jana (1973) reported genotypic coefficient of variation of less than 15 per cent for plant height, number of tillers and number of panicles in fodder ragi. Mahudeswaran and Murugesan (1973) obtained similar result for plant height but they found genotypic coefficient of variation exceeding 30 per cent for number of productive tillers and 15.30 per cent for number of panicles in fodder ragi itself.

Gill and Randhawa (1975) found genotypic coefficient of variation exceeding 30 per cent for plant height and between 15.30 per cent for the number of inflorescences in foxtail millet. The genotypic coefficient of variation for tiller number was also found to be substantially high.

Yadav and Srivastava (1976) reported higher values of genotypic coefficient of variation for straw yield/plant, between 15 to 30 per cent for number of panicles and less than 15 per cent for plant height in little millet (Panicum miliare). Rana et al. (1976) observed genotypic coefficient of variation of less than 15 per cent for plant height and more than 30 per cent for green fodder yield in forage sorghum.

Goud and Lakshmi (1977) reported wide range of phenotypic variation for most of the yield components in finger millet. The genetic variance among the varieties was very high for the different yield components. They observed genotypic coefficient of variation between 15 to 30 per cent for total number of tillers in the same crop. Appadurai et al. (1977) reported genotypic coefficient of variation of less than 15 per cent, 15-30 per cent and more than 30 per cent respectively for plant height, number of panicles and number of productive tillers in fodder ragi. Nair and Gupta (1977) in fodder oats observed genotypic coefficient of variation exceeding 30 per cent for plant height and tiller number, while Tyagi et al. (1977) reported genotypic coefficient of variation of less than 15 per cent for plant height and 15-30 per cent for number of tillers, leaf: stem ratio, dry matter yield and green fodder yield in fodder oats.

Twenty five predominantly asexual and three highly sexual populations of Panicum maximum were studied for variability in total tiller number and plant height by Usberti and Jain (1978). Population means and coefficients of variation for these characters showed significant diversity among populations. Quesenberry et al. (1978) found significant variability for plant height in rhodes grass. Mishra et al. (1978) reported genotypic coefficient of variation of less than 15 per cent for plant height and number of effective tillers in fodder ragi. Similar result for plant height was reported by Sethi and Singh (1978) in barley but they obtained genotypic coefficient of variation between 15 to 30 per cent for the number of tillers and green fodder yield in fodder ragi. Manoharan (1978) observed genotypic coefficient of variation exceeding 30 per cent for the number of tillers in proso millet.

Agalodia et al. (1979) found genotypic coefficient of variation of less than 15 per cent for plant height and 15 to 30 per cent for total number of tillers in fodder ragi. Subramaniam (1979) noted high genotypic variance for plant height in little millet (Panicum miliare). The maximum genotypic coefficient of variation (24.63 per cent) was obtained for panicle number followed by tiller number (22.38 per cent). The phenotypic coefficient of variation was maximum (25.31 per cent) for panicle number.

Tyagi et al. (1980) reported maximum amount of genetic variability for green fodder yield (14.71) in pearl millet. Dhanakodi (1980) recorded largest phenotypic variance for plant height in ragi. He also noted that fodder yield exhibited maximum genotypic variance. The lowest phenotypic as well as genotypic variances were noticed in leaf: stem ratio. The highest phenotypic coefficient of variation (91.59 per cent) was observed for plant height. Fodder yield, leaf: stem ratio and tiller number recorded phenotypic coefficient of variations of 36.03 per cent, 21.24 per cent and 19.53 per cent respectively. Fodder yield registered the highest genotypic coefficient of variation (30.43 per cent). The corresponding values for plant height, leaf: stem ratio and tiller number were 22.15 per cent, 16.56 per cent and 14.06 per cent respectively.

Araujo et al. (1983) observed significant differences for annual dry matter yield and plant height among 67 accessions of tall fescue (<u>Festuca arundinacea</u>). Sreenivasan (1983) reported considerable variability both at phenotypic and genotypic levels for green fodder yield, dry fodder yield and Leaf Area Index in guinea grass. Variability analysis also revealed that leaf: stem ratio and green fodder yield are the characters least affected by the environment and genetic factors play a greater role in determining the expression of these traits. But in the case of number of tillers, the environmental factors have a greater role in its expression. The maximum genotypic coefficient of variation was observed for dry weight (74.58 per cent). The genotypic coefficient of variation for green fodder yield was 71.29 per cent, Leaf Area Index 63.61 per cent,plant height 31.93 per cent, leaf: stem ratio 27.75 per cent and number of tillers 21.83 per cent. The highest phenotypic coefficient of variation was observed for dry weight (78.28 per cent). The phenotypic coefficient of variation for other characters were, green fodder yield (72.15 per cent),Leaf Area Index (64.93 per cent), plant height (34.19 per cent), number of tillers (30.43 per cent) and leaf: stem ratio (27.79 per cent).

Arturi et al. (1983) found high variability for leaf and tiller characters related to forage yield in 120 entries of *Bromus catharticus*. Kunjir and Patil (1986) observed higher genotypic and phenotypic variability for tiller number in pearl millet.

2.2. Heritability and genetic advance

The extent to which the variability of a quantitative character is transferable to the progeny is referred to as heritability for that particular character. Lush (1940) has defined heritability both in broad and narrow senses. According to him, heritability in the broad sense implies the percentage of total genotypic variance over phenotypic variance. In the narrow sense, heritability is the ratio of additive genetic variance to total variance and it takes into account only average effects of genes transmitted from parents to offspring. The high value of heritability for quantitative characters enables the plant breeder to base his selection programme on the phenotypic value of a specific character for its further improvement. Heritability estimates along with genetic gain are usually more helpful than heritability alone in predicting the resultant effect from selecting the best genotypes.

Patnaik (1968) found high heritability value for plant height (68.4 per cent) and low value for number of tillers (15 per cent) in finger millet. Kempanna and Thirumalachar

(1968) reported heritability value of 32.28 per cent for number of tillers per plant in ragi. Mal et al. (1970) observed moderate to high genetic gain in respect of tiller number and fodder yield in oats.

Dhagat et al. (1971) found low heritability value for the number of productive tillers (25.92 per cent) in Kodo millet. The genetic advance as percentage of mean was 10.5 in this crop. Gupta and Nanda (1971) reported heritability value of 29.96 per cent for yield, 43.28 per cent for plant height and 28.79 per cent for tiller number in bajra. Gupta and Gupta (1971) found high heritability values for green fodder yield (61.1 per cent) and plant height (62.78 per cent) in pearl millet.

Phul et al. (1972) evaluated the genetic stocks of fodder oats for six characters, viz., plant height, number of leaves, length and breadth of leaf, tiller number and fodder yield. Plant height exhibited maximum heritability (45.51 per cent). The heritability estimate for fodder yield was 31.69 per cent whereas the value for tiller number is low (18.37 per cent). The maximum gain in selection expressed as genetic advance as per cent of mean could be expected for fodder yield (16.99) and tiller number (9.15).

Sangha and Singh (1973) based on the information from six bajra varieties revealed that fodder yield had maximum heritability (93 per cent) and genetic gain (37.18 per cent). Patnaik and Jana (1973) studied genetic and environmental variability in 18 ragi varieties and found the heritability values for plant height as 37.69 per cent and for number of tillers as 27.82 per cent. The corresponding values for genetic gain were 93.65 per cent and 13.29 per cent. Mahudeswaran and Murugesan (1973) reported high heritability values for plant height (90.3 per cent) and number of productive tillers (78.1 per cent) in ragi. The corresponding values for genetic advance were 19.5 and 2.3.

Prakash et al. (1974) in pearl millet found low narrow sense heritability estimate for chlorophyll content (7.04 per cent). Singh and Prasad (1974/75) found high estimates of heritability and genetic gain for tiller number (81.46 per cent and 31.27 per cent, respectively) and low values for green fodder (28.17 per cent and 18.41 per cent, respectively) and drymatter yield (15.38 per cent and 24.9 per cent, respectively) in <u>Pennisetum pedicellatum</u>.

Cill and Randhawa (1975) reported high heritability estimates for plant height (78.21 per cent) and tiller number (72.67 per cent) in fox-tail millet (<u>Setaria italica</u>). The highest genetic advance was recorded for tiller number (39.05).

Yadav et al. (1976) studied heritability and expected genetic advance among six characters in a pasture grass, Dichanthium annulatum and found that tiller number (65.67 per cent) and fodder yield (53.1 per cent) had comparatively high heritabilities and genetic gain.

Yadav and Srivastava (1976) estimated high heritabilities for plant height (92.49 per cent) and number of tillers (80.18 per cent) in Panicum miliare. Jhorar and Paroda (1976) noticed high heritability estimates for plant height (87.93 per cent), number of tillers per plant (88.63 per cent), leaf area (93.32 per cent), green forage yield (87.5 per cent) and dry matter yield (86.93 per cent) in forage sorghum. The highest value of genetic gain was recorded for green forage yield (57.57 per cent). Rana et al. (1976) obtained high heritability estimates for green fodder yield (64.5 per cent) and plant height (62.7 per cent) in forage sorghum.

Goud and Lakshmi (1977) observed high heritability values for plant height (75.97 per cent) and moderate heritability (52.95 per cent) for tiller number which was associated with high genetic gain (42.88 per cent) in ragi. Singhania et al. (1977) found that the dry matter content was highly heritable in sorghum but leaf: stem ratio, leaf area and green fodder yield per plant were less heritable.

Appadurai et al. (1977) observed moderate heritability (37.2 per cent) and low genetic gain (12.4 per cent) for plant height in ragi. Tyagi et al. (1977) reported high heritability for leaf: stem ratio (99.78 per cent) in fodder oats. Reasonably high heritability accompanied by high genetic gain was observed for green fodder yield, dry matter yield and leaf: stem ratio indicating that these traits are predominantly governed by additive gene effects and selection would be most effective for genetic improvement of these traits in oats.

Quesenberry et al. (1978) noticed sufficiently high heritability for plant height in rhodes grass and suggested that relatively rapid initial progress could be made in selecting for this trait. According to Sethi and Singh (1978), green as well as dry matter production, leaf area and plant height exhibited high heritabilities and genetic advance in barley.

Salak-Warzecha and Goral (1979) estimated high heritability values for plant height (75.5 per cent) and number of vegetative tillers (61.85 per cent) in timothy (Phleum pratense). Tyagi et al. (1980) in pearl millet reported high heritability for green fodder yield (66.48 per cent) and plant height (65.05 per cent) and low heritability for number of tillers (37.27 per cent) and dry matter yield (22.01 per cent).

In the same study high genetic gain was recorded for green fodder yield (24.64 per cent). This suggests the evolution of high fodder yielding genotypes through mass selection. Vogel et al. (1981) found narrow sense heritability value of 75 per cent for plant height in Indian grass.

Talbert et al. (1983) in switchgrass noticed that dry weight was less heritable with an individual narrow sense heritability of only 25 per cent. Arturi et al. (1983) reported relatively high heritability for leaf width in Bromus catharticus. Riley and Vogel (1983) estimated heritability values of 28 per cent and 33 per cent respectively for yield and dry matter content in sand blue stem. Hussey (1983) evaluated 18 half-sib families of Panicum coloratum for tiller height and yield per tiller and found that the heritability estimates were greatly affected by season.

Bugge (1984) estimated heritability value of 48 per cent for dry matter yield per plant in Lolium multiflorum. Shankar (1986) in finger millet reported high heritability for plant height and number of spikes. Kunjir and Patil (1986) observed high heritability estimates for tiller number (64.8 per cent) and plant height (56.09 per cent) in pearl millet. The genetic advance for these characters were also found to be high indicating additive gene action.

2.3. Correlation studies

Correlation studies provide estimates of the degree of association of a character with its components and also among the components. Yield is a complex character, since it is the expression of the sum total effects of all other associated characters. Therefore, it is necessary to have a knowledge about the relationship existing between yield and its components and their magnitude, before initiating a crop improvement programme.

2.3.1. Green fodder yield and its association with component characters

Wakankar et al. (1970) reported positive association of plant height and leaf area with fodder yield in sorghum. Gupta and Nanda (1971) evaluated 176 lines of bajra germplasm and observed positive association of plant height and tiller number with green fodder yield. In an experiment with 11 cultivars of guinea grass by Sotomayor Rios et al. (1971), it was found that annual yields of fresh herbage was positively correlated with tillering ability. Sotomayor Rios et al. (1971) in Digitaria selections observed that plant vigour and dry matter yield were positively correlated with green forage yield. Mehra et al. (1971) observed significant positive correlation of fodder yield with leaf area in oats.

Naphade (1972) studied the yield of fodder and other yield contributing characters in 20 sorghum varieties and found that fodder yield was positively and significantly correlated with leaf number and plant height at one per cent but leaf area and yield were not significantly correlated. Rhodes (1972) measured yield, critical Leaf Area Index and apparent photosynthetic rate per unit leaf area in four F_1-generation selections of perennial ryegrass CV.3321. Differences in yield were attributable to variations in canopy structure producing different critical Leaf Area Index. The most productive selections had the largest critical Leaf Area Index but the lowest photosynthetic rate.

Pokle et al. (1973) reported positive association of plant height and fodder yield in jowar. Patel et al. (1973) computed genotypic correlations among various characters in 18 varieties of sorghum and observed that fodder yield was positively correlated with plant height and total leaf area. Hussain and Khan (1973) reported highly significant and positive correlation of fodder yield with tiller number, plant height and leaf number in sorghum sudangrass hybrid forage. An analysis of natural and induced variation in respect of attributes related to fodder production in blue panic grass (<u>Panicum antidotale</u>) was made by Vaidyanathan (1973). In all the eight clones studied, yield is significantly correlated with the number of tillers and height of the plant.

In studies involving 28 varieties of Cenchrus ciliaris conducted by Yadav et al. (1974), it was observed that plant height, leaf breadth and fodder yield were positively and significantly correlated with each other both genotypically and phenotypically. Tiller number was positively correlated with yield. Pillai et al. (1974) reported that there is no correlation between yield and leaf: stem ratio in Guinea grass. In the genus Cenchrus, Ramaswamy (1974) observed that number of tillers, length and breadth of leaves and height of the clones were positively correlated with green fodder yield.

Correlation analysis both at the genotypic and phenotypic levels made by Paroda et al. (1975) in forage sorghum revealed that plant height, leaf length and leaf breadth were positively correlated with green fodder yield. The positive association of plant height and leaf number with fodder yield was reported by Chauhan and Singh (1975) in sorghum. Sood (1975) noticed a negative correlation between plant height and fodder yield in forage sorghum.

Yadav et al. (1976) reported positive and significant association of tiller number with fodder yield at the phenotypic level in a pasture grass, Dichanthium annulatum. Jhorar and Paroda (1976) studied genotypic and phenotypic correlations in ten selected hybrids of sorghum and reported positive association of plant height and number of tillers with green fodder yield. Dry matter showed significant positive association with green fodder yield.

Singh and Prasad (1976) reported positive correlation of plant height and tiller number with green fodder yield at the genotypic level in Pennisetum pedicellatum. Rana et al. (1976) noticed positive association of plant height and leaf width with fodder yield in forage sorghum. Fujimoth and Susuki (1976) observed high genotypic correlation of dry matter yield, plant height and number of tillers with green fodder yield in Italian rye grass (Lolium multiflorum).

Positive association was obtained for plant height and fifth leaf area with forage yield in sorghum by Singhania et al. (1977). Vasudeva Rao and Ahluwalia (1977) observed that green fodder yield was positively associated with plant height and leaf: stem ratio in sorghum. In fodder oats, Nair and Gupta (1977) reported that leaf area and number of tillers were positively correlated with fodder yield.

Correlation studies between yield and yield components were conducted in 23 lines of fodder sorghum by Gopalan and Balasubramanian (1978). Among the characters studied, number of leaves, length and breadth of leaf and thickness of stem were positively correlated with green fodder yield. Titov et al. (1978) studied the correlations between 20 pairs of characters in Festuca pratensis and found a high correlation between number of reproductive shoots and yield and a moderate correlation between plant height and yield and between length of leaf blade and yield.

Sethi and Singh (1978) made correlation studies for seven characters in barley and found that green fodder yield was highly correlated with tillers per plant and plant height. Saxena et al. (1978) observed that high tillering and seedling vigour were positively associated with fodder yield in bajra. Rao et al. (1978) observed positive association between plant height and fodder yield in oats. Dhumale and Mishra (1978) reported positive association of the characters plant height, leaf width and tiller number with fodder yield in oats.

Tan et al. (1979) studied the morphological characters and their association with forage yield in smooth brome grass and found that both tiller density and height were significantly correlated with yield. Salak-Warzecha and Goral (1979) reported stronger positive correlation between green fodder yield with the number of fertile tillers in timothy (Phleum pratense). Murtaza et al. (1979) studied the components of fodder yield in oats and observed that the number of tillers per plant had positive and significant association with green fodder yield both at the genotypic and phenotypic levels.

Positive and significant correlation was also observed between green fodder and dry matter yield. This indicated that these characters are mutually associated to each other.

In tall fescue, Jones et al. (1979) reported that low rate of tiller production was associated with forage yield. In forage sorghum,a positive correlation between fodder yield and plant height was observed by Ross et al. (1979). Vaithialingam (1979) reported that plant height, fourth leaf area and dry fodder yield were positively associated with green fodder yield in sorghum.

Dhanakodi (1980) reported higher values for genotypic correlation coefficients than phenotypic correlation coefficients for all character pair except for the combination leaf length and leaf: stem ratio in ragi. Leaf: stem ratio did not show any significant relation with fodder yield.

Component analysis for green fodder yield in pearl millet was made by Tyagi et al. (1980) and observed that the dry matter had a positive and significant association with green fodder yield both at the genotypic and phenotypic levels. This suggested true genetic relationship between these traits. Leaf area and number of tillers also showed positive correlation with green fodder yield. In fodder oats, Singh et al. (1980) have reported that plant height at flowering and tiller number per plant are positively correlated with green forage yield, both per day and per hectare basis.

Vogel et al. (1981) reported significant correlation of plant height, leafiness and vigour with forage yield in Indian grass. Vaidyanathan (1982) obtained positive correlation between height and green fodder yield and negative correlation between leaf: stem ratio and fodder yield in sorghum. Sreenivasan (1983) observed that dry weight, Leaf Area Index and plant height had high positive association with green fodder yield in guinea grass. Berg and Hill (1983) conducted correlation studies in timothy and reported significant and positive genotypic correlation between forage yield and percentage dry matter. Bainiwal et al. (1983) investigated the association pattern between forage attributes in 50 diverse genotypes of barley under spaced planting and drilled conditions for two years. The studies indicated a close association between green fodder and dry matter yield, plant height showed positive association with green fodder yield.

Paramathma and Balasubramanian (1986) computed correlation coefficients for yield components in parents and hybrids of forage maize. The results indicated that plant height, stem girth, leaf length, leaf breadth and leaf number were highly associated with fodder yield, both in parents and hybrids. 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.

2.3.2. Association among the yield components

Patnaik (1968) reported negative correlation of plant height and number of tillers in finger millet. Narasimha Rao and Pardhasaradhi (1968) noted positive correlation of plant height and tiller number in the same crop. Ostgard (1971) observed in *Phleum pratense*, *Festuca pratense*, *Dactylis glomerata* and *Poa pratensis* that chlorophyll content per unit leaf area was least in varieties with the highest growth rate. There was a significant positive correlation between chlorophyll content per unit leaf area and specific leaf weight in all the materials except for the northern *Phleum* variety Engnoo Mehra et al. (1971) observed positive correlation between tillers per plant with leaf area in oats.

Naphade (1972) in sorghum found positive and non-significant association of plant height and leaf area. Yoshida (1972) suggested that greater dry matter production could be expected in erect genotypes provided Leaf Area Index is large. Mahudeswaran and Murugesan (1973) studied correlations in 20 varieties of ragi and found negative association between plant height and number of productive tillers. Phul et al. (1974) noticed positive and significant association between plant height and tiller number in pearl millet. He also found a highly significant correlation between chlorophyll 'a' and 'b'. Ramaswamy (1974) reported that there was no association between plant height and number of tillers in the genus Cenchrus.

Gill and Randhawa (1975) in fox-tail millet reported significant negative association of tiller number and plant height. Correlation analysis conducted both at the genotypic and phenotypic levels by Paroda et al. (1975) in forage sorghum revealed significant positive correlation of dry matter yield with plant height, leaf length and leaf breadth. Jhorar and Paroda (1976) in forage sorghum reported negative correlation of plant height with tiller number.

Genetic analysis of forage yield and quality in sorghum conducted by Singhania et al. (1977) indicated that plant height and fifth leaf area were positively correlated between each other. In ragi, Appadurai et al. (1977) reported positive correlation between plant height and number of productive tillers. Goud and Lakshmi (1977) observed negative correlation between plant height and tiller number in finger millet.

Aase (1978) reported close correlation between leaf area and plant dry matter in winter wheat. Kusutani and Gotoh (1978) conducted studies on 12 cocksfoot cultivars and reported that plant dry weight was significantly correlated with tiller dry weight, but not with number of tillers per plant. Tiller dry weight was negatively correlated with number of tillers per plant. Nelson and Sleeper (1978) found an inverse correlation between yield per tiller and tiller number in *Festuca arundinacea*. Sethi and Singh (1978) noticed that dry matter yield was highly correlated with tillers per plant and plant height in barley. According to Rao et al. (1978) dry matter accumulation from tillering to flowering showed significant positive correlation with mean Leaf Area Index and net assimilation rate in erect and spreading types of oats.

Salak-Warzecha and Goral (1979) reported stronger positive correlation between dry matter yield and number of fertile tillers and negative correlation between plant height and number of vegetative tillers in timothy. Investigations conducted by Murtaza et al. (1979) in oats revealed positive and significant association between number of tillers per plant and dry matter yield both at the genotypic and phenotypic levels. Negative and significant relationship was recorded between the number of tillers per plant and plant height.

Negative non-significant association between plant height and tiller number both at the genotypic and phenotypic levels was observed by Subramaniam (1979) in little millet. Panicle number and straw yield showed negative correlation with plant height at genotypic, phenotypic and environmental levels. Tiller number recorded positive and significant genotypic and phenotypic correlation with panicle number and straw yield.

Dhanakodi (1980) showed negative correlation between leaf: stem ratio and plant height and positive correlation between tiller number and leaf: stem ratio in ragi. Tyagi et al. (1980) in pearl millet observed that leaf breadth had a positive and significant association with the number of tillers. Vaidyanathan (1982) reported negative correlation between leaf: stem ratio and plant height in sorghum. Sood and Singh (1982) computed correlation coefficients in 30 napier-bajra hybrids and found that dry matter yield per plant had a strong and positive genotypic association with leaf: stem ratio.

Bainiwal et al. (1983) observed positive association between plant height and dry matter yield and negative association between tiller number and height in barley. Araujo et al. (1983) studied 67 accessions of tall fescue for phenotypic and genotypic correlations among eight traits. Out of 56 possible combinations, 26 were > 1 or < -1; these results appear when either the genotypic or phenotypic accession covariances are much larger than either genotypic or phenotypic accession variances leading to a small denominator in the calculation of the correlation coefficient. He obtained positive correlation between annual dry matter yield and plant height. Correlation analysis among yield components in guinea grass by Sreenivasan (1983) showed that plant height, dry weight, Leaf Area Index and leaf: stem ratio had significant positive association among themselves.

Gaborcik (1986) 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 tillers per plant. Investigations conducted by Jatasra and Thakral (1986) in *Cenchrus ciliaris* on the inter relationship between yield and other agronomic characters observed that plant height was positively correlated with dry matter yield. The number of tillers per plant also had highly significant and positive correlation with dry matter yield. However, plant height, tiller number and dry matter yield showed negative association with leaf: stem ratio. Plant height and number of tillers were positively associated to each other.

2.4. Path analysis

The study of association of component characters with fodder yield has immense value in selecting suitable plant types. When more number of characters are included in the correlation study, the direct association becomes more complex. In such a situation the path analysis devised by Wright (1921) provides an effective measure to find out the direct and indirect effects permitting a critical examination of the specific factors that produce a given correlation.

Naphade (1972) studied fodder yield and other yield contributing characters in 20 sorghum varieties. In path analysis, the number of leaves per plant was the most important component of fodder yield followed by plant height and leaf area. Path analysis studies by Patel et al. (1973) in sorghum revealed that plant height had a positive direct influence on fodder yield. Leaf area influenced the fodder yield largely indirectly through plant height and stalk diameter. According to Pokle et al. (1973), plant height had a high direct effect on the fodder yield in sorghum.

Investigations conducted by Ramaswamy (1974) on <u>Cenchrus ciliaris</u> and <u>Cenchrus setegerus</u> revealed that the number of tillers exerted the maximum direct effect on yield followed by length of leaf, thickness of internode, length of internode and height of the clone. Path coefficient analysis by Paroda et al. (1975) in forage sorghum revealed that leaf breadth had high positive effect on both green and dry matter yield and thus appeared to be a more reliable component character. Direct effect of leaf length was also high on dry matter yield. Plant height showed negative direct effect on both yield characters.

Path analysis in Pennisetum pedicellatum by Singh and Prasad (1976) showed a direct effect of leaf length and plant height on yield but tiller number and stem girth have only indirect effect. Nair and Gupta (1976) in their studies on fodder oats observed that the various second order components like number of tillers, leaf area and number of leaves had a major role in the accumulation of dry matter through the first order components namely green weight of stem and green weight of leaves.

Genetic studies on oats by Solanki (1977) revealed that plant height, number of tillers per plant, number of leaves per plant and leaf breadth are important component characters for green as well as dry fodder yield.

Path coefficient analysis in fodder sorghum by Gopalan and Balasubramanian (1978) revealed that leaf length and breadth showed high positive direct effect on green fodder yield. Dhumale and Mishra (1978) observed in forage oats that the plant height had a high positive direct effect while all the other characters studied except number of tillers per plant had indirect effect through plant height.

Path coefficient analysis in smooth brome grass by Tan et al. (1979) showed that tiller density followed by leaf area and tiller dry weight exerted the greatest direct influence on yield. Selection for large leaf and more and heavier tillers per unit area would increase productivity. Murtaza et al. (1979) in fodder oats reported positive and significant association between green fodder yield and the number of tillers due to high positive direct effect of number of tillers on green fodder yield. This indicated that number of tillers is an important component character in fodder oats. Plant height showed significant negative association with green fodder yield due to high negative indirect effect through number of tillers, leaf length and leaf breadth though the direct effect of plant height was positive.

Singh and Prasad (1980) from path coefficient and factor analysis of data in <u>Pennisetum pedicellatum</u> concluded that selection for stem girth, leaf number, leaf length and tiller number should result in high fodder yield. Dhanakodi (1980) reported the positive direct effects of days to flowering, number of tillers and leaf number; and the high and positive indirect effects of plant height, leaf breadth and length of internode through days to flowering in the fodder yield of ragi (*Eleusine coracana*).

Tyagi et al. (1980) conducted component analysis for green fodder yield in pearl millet and indicated that dry matter yield had the highest positive direct effect on green fodder yield. The positive and significant association between green fodder and dry matter yield was due to a high positive direct effect of dry matter yield on green fodder yield. The direct effects of leaf length and leaf breadth were also positive towards green fodder yield, but their association with green fodder yield were negative. The negative indirect effects through plant height, days to flowering, number of leaves per plant and dry matter yield nullified the positive direct effects of these traits on green fodder yield and changed the relationship into negative. The number of tillers had a positive direct effect on green fodder yield. Plant height had a negative direct effect on green fodder yield and a positive direct effect on dry matter yield.

Path analysis in guinea grass by Sreenivasan (1983) revealed that the maximum contribution to green fodder yield was through plant height, since it recorded maximum positive direct effect on yield. This was followed by girth of internode and number of tillers.

Paramathma and Balasubramanian (1986) computed path coefficients for yield components in parents and hybrids of forage maize and indicated that stem girth followed by plant height had direct effects in parents, while leaf breadth followed by stem girth had the highest direct effect in hybrids on fodder yield.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present research programme was carried out at the Department of Plant Breeding, College of Agriculture, Vellayani from June to December 1987.

3.1. Materials

Fifteen morphologically diverse types of guineagrass (*Panicum maximum* Jacq.) obtained from the germplasm collection maintained under the All India Co-ordinated Project for Research on Forage Crops at the College of Agriculture, Vellayani were used for the study.

3.2. Methods

The 15 selected types were raised under partial shade in coconut gardens at the College of Agriculture, Vellayani, from June to December 1987, in a randomised block design replicated thrice. In each plot of 3 x 2 m size, 80 plants were grown at 40 x 20 cm spacing. Vigorous and healthy slips were planted during the third week of June, 1987. The management practices were given according to Package of Practices Recommendations of Kerala Agricultural University (1986). The first harvesting was done 75 days after planting and the subsequent two harvests at 45 days interval.

Five hills were selected at random for each type in each replication and observations recorded for the following characters.

1. Plant height

Measured in centimetre from the ground level to the tip of the tallest leaf/primary panicle at the time of harvest.

2. Tiller number

Total number of tillers were counted per hill at the time of harvest.

3. Panicle number

Total number of panicles per plot were counted at the time of harvest.

4. Leaf:stem ratio

Five plants were selected at random from each of the 15 types in three replications and the weight of the stem and leaf were recorded and the leaf : stem ratios on fresh weight basis were computed. The leaf : stem ratios on dry weight basis were computed by recording the weight after drying the leaf and stem portions separately.

5. Green fodder yield per hill and per plot

The weight of green matter per hill was recorded in gram by cutting the hill at 10-15 cm above ground level and the weight of green fodder yield per plot was recorded in kilogram from the net plot area immediately after harvest.

6. Dry matter yield and photosynthetic efficiency

The samples from each hill were first sundried and then oven dried to a constant weight at 80°C and the weight recorded in gram. The per plot yield of dry matter corresponding to the green fodder yield was estimated from the weight of this oven dried material, corresponding to its fresh weight.

7. Leaf Area Index

Leaf area was calculated in square centimetre by plotting the area of all the leaves in the graph paper. The Leaf Area Index (LAI) was computed following the formula suggested by William (1946).

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

8. Shade intensity

Shade intensity was measured by using a Luxmeter (Photomet 300 x Remco India). The intensity of light in the open condition was first recorded and then the light intensity in each plot was measured from two random spots at different temporal phases of the day and the average was worked out.

$$\text{Shade intensity} = \frac{(L_1 - L_2)}{L_1} \times 100$$

where L_1 = Light intensity in open condition

L_2 = Light intensity in shade

9. Chlorophyll content of leaves

Chlorophyll 'a', Chlorophyll 'b' and total pigments were estimated from mature leaves at each harvest by utilising Spectro-photometric method. The contents of chlorophyll 'a', chlorophyll 'b' and total pigments (mg/litre) were then estimated using the following relationships (Arnon, 1949).

$$\text{Chlorophyll 'a'} = \left[12.7 \text{ (OD at 663)} - 2.69 \text{ (OD at 645)}\right] \times \frac{V}{W \times 1000} \text{ mg/litre.}$$

$$\text{Chlorophyll 'b'} = \left[22.9 \text{ (OD at 645)} - 4.68 \text{ (OD at 663)}\right] \times \frac{V}{W \times 1000} \text{ mg/litre.}$$

$$\text{Total pigments} = \text{(OD at 652)} \times \frac{V}{W} \text{ mg/litre.}$$

where

V = Volume made up

W = Weight of the plant sample taken

OD = Optical density

3.2.1. Statistical analysis

The data collected were subjected to the following statistical analyses.

3.2.1.1. Analysis of variance and covariance

The observations recorded with respect to each character were subjected to analysis of variance and covariance as given in Table 1 (Panse and Sukhatme, 1957).

Table 1. Analysis of variance/covariance

Source	Degrees of freedom	Mean sum of squares	Mean sum of products
Block	(r-1)	MS_B	MSP_B
Treatment	(v-1)	MS_V	MSP_V
Error	(v-1) (r-1)	MS_E	MSP_E

where r = Number of replications

v = Number of treatments

3.2.1.2. Variance

Components of variance for each character was worked out following the procedure of Johnson et al. (1955).

Genotypic variance (Vg)

$$V_g = \frac{MS_V - MS_E}{r}$$

where MS_V = Mean square for treatment

MS_E = Mean square for error

r = Number of replications

Error (Environmental) variance (Ve)

$$Ve = MS_E$$

where MS_E = Mean square for error

Phenotypic variance (Vp)

$$Vp = Vg + Ve$$

where

Vg = Genotypic variance

Ve = Error (environmental) variance

3.2.1.3. Coefficient of variation

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

Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{Vp} \times 100}{Mean}$$

where Vp = Phenotypic variance

Genotypic coefficient of variation (GCV)

$$GCV = \frac{\sqrt{Vg} \times 100}{Mean}$$

where Vg = Genotypic variance

3.2.1.4. Heritability and Genetic advance

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

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

where h^2 = Heritability coefficient

Vg = Genotypic variance

Vp = Phenotypic variance

Expected Genetic Advance (GA) under selection (Lush, 1940 and Johnson et al., 1955).

$$\text{Genetic Advance (GA)} = K.h^2 \sqrt{Vp}$$

where

h^2 = Heritability in the broad-sense

Vp = Phenotypic variance

K = Selection differential which is 2.06 in the case of 5% selection in large samples (Miller et al., 1958 and Allard, 1960).

Expected Genetic Gain (GG) under selection (Johnson et al., 1955)

$$\text{Genetic gain (GG)} = \frac{GA \times 100}{Mean}$$

where

GA = Genetic Advance

3.2.1.5. Covariance

Genotypic covariance (CoVg)

$$CoVg = \frac{MSP_V - MSP_E}{r}$$

where

MSP_V = Mean sum of products for treatment

MSP_E = Mean sum of products for error

r = No. of replications

Error (Environmental) covariance (CoVe)

$CoVe = MSP_E$

MSP_E = Mean sum of products for error

Phenotypic covariance (CoVp)

$CoVp = CoVg + CoVe$

where

CoVg = Genotypic covariance

CoVe = Error (Environmental) covariance

3.2.1.6. Correlation coefficients

Genotypic correlation coefficient (Al-jibouri et al., 1958)

$$\text{Genotypic correlation coefficient } (r_g) = \frac{CoVg\ (x_i,\ x_j)}{\sqrt{Vg\ (x_i) \times Vg\ (x_j)}}$$

where

$CoVg\ (x_i,\ x_j)$ = Genotypic covariance of traits x_i & x_j

$Vg\ (x_i)$ = Genotypic variance of trait x_i

$Vg\ (x_j)$ = Genotypic variance of trait x_j

Phenotypic correlation coefficient (r_p)

$$r_p = \frac{CoVp\ (x_i,\ x_j)}{\sqrt{Vp\ (x_i) \times Vp\ (x_j)}}$$

where

$CoVp\ (x_i,\ x_j)$ = Phenotypic covariance of traits x_i & x_j

$Vp\ (x_i)$ = Phenotypic variance of trait x_i

$Vp\ (x_j)$ = Phenotypic variance of trait x_j

3.2.1.7. Path coefficient analysis

The path coefficients were worked out by the method suggested by Dewey and Lu (1959). The simultaneous equations which express the base relationship between correlation and path coefficient were given below.

$$\begin{Bmatrix} r_{1y} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ r_{ky} \end{Bmatrix} = \begin{Bmatrix} 1 & r_{12} & r_{13} \cdots\cdots & r_{1k} \\ & 1 & r_{23} \cdots\cdots & r_{2k} \\ & & & \cdot \\ & & & \cdot \\ & & & 1 \end{Bmatrix} \begin{Bmatrix} p_{1y} \\ p_{2y} \\ \\ p_{ky} \end{Bmatrix}$$

where r_{1y} to r_{ky} denote the genotypic correlation coefficients between causal factors 1 to k and dependent variable (y); r_{12} to $r_{k-1,\ k}$ denote the correlation coefficients among all possible combinations of causal factors and p_{1y} to p_{ky} denote the direct effects of characters 1 to k on yield (y).

The solution of these equations give the values of the path coefficients (p_k)

The residual factor (R) which measures the contribution of the traits not included in the causal scheme and sampling error was estimated as

$$P_{xy} = \sqrt{1-R^2}$$

where $$R^2 = \sqrt{1 - (p_{1y}r_{1y} + p_{2y}r_{2y} + \ldots\ldots p_{ky}r_{ky}}$$

Indirect effects of different characters on yield were obtained as follows.

Indirect effect of the i^{th} character on yield through j^{th} character = $p_{iy}r_{ij}$

RESULTS

RESULTS

The data recorded on the various morphological, physiological and chemical attributes were statistically analysed and the results are presented.

4.1. Mean performance of individual traits

The mean performance of each of the fifteen genotypes for the thirteen characters studied and the general mean and range are presented in Tables 2 and 3, respectively. The analysis of variance for the thirteen characters are presented in Table 4.

The fifteen varieties of guinea grass selected for the investigation exhibited significant differences for all the characters studied except dry matter yield per plot, the content of chlorophyll 'a' and chlorophyll 'b' and total pigments. The periodical light intensity measured in each plot at five different temporal phases of the day did not show significant difference in magnitude (Tables 5 and 6). This indicated the prevalence of uniform shade conditions in all the experimental plots. The mean values of shade intensity measured in each plot are presented in Tables 7 and 8.

The mean plant height of the varieties varied from 154 cm in TNGG-2 to 196.05 cm in PGG-9. The varieties PGG-6,

Table 3. General mean and range for thirteen characters studied in guinea grass

Sl. No.	Characters	General Mean	Range
1.	Plant height (cm)	179.480	154.000 - 196.050
2.	Number of tillers/ hill	9.460	6.290 - 12.950
3.	Number of panicles/ plot	252.230 (15.390)	99.440 - 441.670 (9.940 - 21.002)
4.	Leaf: stem ratio on fresh weight basis	0.656	0.459 - 0.849
5.	Leaf: stem ratio on dry weight basis	0.759	0.502 - 1.001
6.	Green fodder yield/ hill (g)	213.870	132.880 - 358.870
7.	Green fodder yield/ plot (kg)	34.007	20.827 - 45.216
8.	Dry matter yield/ hill (g)	44.640	29.003 - 62.480
9.	Dry matter yield/ plot (kg)	7.335	4.692 - 9.429
10.	Leaf Area Index	5.640	3.150 - 8.500
11.	Chlorophyll 'a' (mg/litre)	22.230	21.300 - 22.930
12.	Chlorophyll 'b' (mg/litre)	27.630	24.040 - 29.870
13.	Total pigments (mg/litre)	75.730	67.370 - 81.010

Table 4. Analysis of variance for 13 characters in guinea grass

Sl. No.	Characters	Mean sum of squares			F value for treat- ments
		Replication d.f. = 2	Treatments d.f. = 14	Error d.f. = 28	
1.	Plant height	257.5625	525.0446	113.7679	4.6151**
2.	Number of tillers/ hill	8.4625	6.7600	2.7678	2.4424*
3.	Number of pani- cles/plot	11.9248	41.9826	2.7805	15.0989**
4.	Leaf: stem ratio on fresh weight basis	0.0098	0.0453	0.0082	5.5244**
5.	Leaf: stem ratio on dry weight basis	0.0066	0.0767	0.0111	6.9099**
6.	Green fodder yield/hill	11131.4400	12146.4600	2716.1290	4.4719**
7.	Green fodder yield/plot	393.2136	135.7335	45.2124	3.0022**
8.	Dry matter yield/ hill	491.2852	282.4420	105.2986	2.6823*
9.	Dry matter yield/ plot	22.0608	4.3299	2.2437	1.9298
10.	Leaf Area Index	6.2585	7.9285	2.2685	3.4950**
11.	Chlorophyll 'a'	1.2363	0.6621	0.4000	1.6348
12.	Chlorophyll 'b'	19.3730	7.7227	4.6991	1.6434
13.	Total pigments	74.6719	50.6484	22.8739	2.2142

* Significant at 5 per cent level

** Significant at 1 per cent level

Hamil, PGG-4, PGG-7, PGG-3, PGG-5 and MC-14 were found to be on par with PGG-9 having the maximum height. The mean height of eight types were above the general mean height of 179.48 cm.

MC-16 recorded the highest mean number of tillers per hill (12.95) followed by PGG-6 (10.58) and FR-600 (10.33). The varieties PGG-6, FR-600 and MC-14 were statistically on par with MC-16. PGG-1 recorded the lowest mean value (6.29) for this character. Here the number of tillers of eight types were more than the general mean of 9.46.

The mean number of panicles per plot varied from 99.44 (9.94) in TNGG-2 to 441.67 (21.002) in PGG-7. The varieties PGG-8, PGG-3, PGG-5, PGG-9 and PGG-6 were on par with PGG-7 having the highest mean number of panicles per plot. Six types have more number of panicles than the general average of 252.23 (15.39). The mean leaf: stem ratio on fresh weight basis varied from 0.459 in PGG-9 to 0.849 in MC-16. Harith, TNGG-2, Mackuenii, PGG-4 and MC-14 were found to be on par with MC-16. Leaf: stem ratio was above the general mean of 0.656 for eight types.

The mean leaf: stem ratio on dry weight basis ranged from 0.502 to 1.001 with a general mean of 0.759. Among the varieties, Mackuenii recorded the maximum leaf: stem ratio (1.001) followed by MC-16 (0.954) and Harith (0.911). It was

Table 5. Analysis of variance for shade intensity (1)

Sl. No.	Shade intensity per cent	Mean sum of squares			F value for treatments
		Replication	Treatments	Error	
		d.f. = 2	d.f. = 14	d.f. = 28	
1.	At 8 o'clock	123.4961	32.4481	32.6091	0.9951
2.	At 10 o'clock	25.3418	33.2732	20.3325	1.6364
3.	At 12 o'clock	262.4844	25.7490	63.6835	0.4043
4.	At 2 o'clock	34.1035	45.1871	28.5154	1.5846
5.	At 4 o' clock	44.2148	56.9121	79.1506	0.7190

Table 6. Analysis of variance for shade intensity (2)

Sl. No.	Shade intensity per cent	Mean sum of squares			F value for treatments
		Replication d.f. = 2	Treatments d.f. = 14	Error d.f. = 28	
1.	At 8 o'clock	43.2011	32.9612	60.5878	0.5440
2.	At 10 o'clock	76.8339	55.5214	94.5611	0.5871
3.	At 12 o'clock	477.9737	58.2783	67.5283	0.8630
4.	At 2 o'clock	79.3222	68.6166	167.2097	0.4104
5.	At 4 o'clock	109.4141	126.8722	286.4788	0.4429

Table 7. Mean values of shade intensity measured (i)

Sl. No.	Cultivars	Shade intensity at 8 A.M. (per cent)	Shade intensity at 10 A.M. (per cent)	Shade intensity at 12 noon (per cent)	Shade intensity at 2 P.M. (per cent)	Shade intensity at 4 P.M. (per cent)
1.	PGG-1	32.64	37.87	23.50	32.78	45.24
2.	Hamil	36.11	29.79	24.36	21.66	32.54
3.	PGG-3	39.58	28.79	30.77	19.44	33.33
4.	PGG-4	36.11	30.81	23.50	24.44	34.13
5.	PGG-5	40.97	31.31	26.07	26.66	40.48
6.	PGG-6	41.66	31.82	24.36	31.67	34.92
7.	PGG-7	38.89	30.30	23.07	28.89	34.12
8.	PGG-8	41.67	26.26	31.19	29.44	34.92
9.	PGG-9	40.97	23.23	29.06	26.67	36.50
10.	TNGG-2	33.33	30.30	29.06	25.55	31.74
11.	FR-600	41.66	28.78	23.93	26.11	40.47
12.	Mackuenii	36.11	28.28	27.77	21.11	38.89
13.	Harith	41.67	30.81	24.36	30.00	38.09
14.	MC-14	34.03	25.25	29.49	29.45	39.68
15.	MC-16	37.50	30.81	23.93	28.33	27.78

Table 8. Mean values of shade intensity measured (2)

Sl. No.	Cultivars	Shade intensity at 8 A.M. (per cent)	Shade intensity at 10 A.M. (per cent)	Shade intensity at 12 noon (per cent)	Shade intensity at 2 P.M. (per cent)	Shade intensity at 4 P.M. (per cent)
1.	PGG-1	33.33	29.41	25.53	34.40	49.20
2.	Hamil	31.94	40.19	24.56	21.50	44.44
3.	PGG-3	40.28	30.39	27.19	27.95	52.38
4.	PGG-4	37.50	30.39	20.17	25.80	44.44
5.	PGG-5	29.17	28.43	23.68	22.57	47.61
6.	PGG-6	37.50	37.25	21.05	25.80	44.44
7.	PGG-7	33.33	35.29	16.66	32.26	34.92
8.	PGG-8	40.28	30.39	23.68	31.18	52.38
9.	PGG-9	36.11	25.49	16.66	30.10	42.85
10.	TNGG-2	36.11	36.27	30.70	23.65	52.38
11.	FR-600	37.49	36.27	24.56	27.95	36.51
12.	Mackuenii	31.94	31.37	29.82	31.18	52.38
13.	Harith	37.50	38.23	24.56	39.78	39.68
14.	MC-14	31.94	28.43	29.82	30.10	41.26
15.	MC-16	37.50	34.31	20.17	26.88	57.14

lowest for the variety PGG-7 (0.502). MC-16, Harith, MC-14, PGG-4 and TNGG-2 were on par with Mackuenii.

In the case of green fodder yield per hill, the mean yield varied from 132.88 g in PGG-1 to 358.87 g in Hamil, the general mean being 213.87 g. The variety MC-16 was on par with Hamil. The average green fodder yield for five types exceeded the general average yield of 213.87 g.

Maximum green fodder yield per plot in three harvests were obtained for variety MC-14 (45.216 kg) followed by Harith (44.131 kg) and the minimum for PGG-1 (20.827 kg). The cumulative average yield of seven types exceeded the general average of 34.007 kg. Harith, FR-600, MC-16, Hamil, PGG-6 and PGG-9 were on par with MC-14.

The mean value for dry matter yield per hill varied from 29.003 g in PGG-1 to 62.48 g in Hamil. Varieties MC-16, MC-14, FR-600, Harith, PGG-6 and PGG-9 were on par with Hamil. Mean yield of eight varieties exceeded the general average of 44.64 g.

Though the dry matter yield per plot did not show significant differences among the varieties, the value was highest for MC-14 (9.429 kg) and lowest for PGG-1 (4.692 kg).

The mean Leaf Area Index varied from 3.15 in PGG-1 to 8.50 in MC-14. Varieties MC-16, FR-600, Hamil, Harith, Mackuenii and PGG-6 were on par with MC-14. Eight varieties had mean Leaf Area Index more than the general mean value of 5.64.

Though the content of chlorophyll 'a' did not show significant differences among the varieties, the mean value was highest for PGG-8 (22.93 mg/litre) and lowest for MC-14 (21.30 mg/litre).

PGG-8 also recorded the highest mean value for the content of chlorophyll 'b' (29.87 mg/litre) followed by PGG-6 (29.84 mg/litre) and PGG-7 (29.26 mg/litre). MC-14 recorded the lowest mean value for this character (24.04 mg/litre).

Mean values for total pigments varied from 67.37 mg/litre in MC-14 to 81.01 mg/litre in PGG-4. The mean values of eight types exceeded the general mean of 75.73 mg/litre.

4.2. Variability

The variability for the thirteen characters as estimated on the basis of phenotypic and genotypic variances and phenotypic and genotypic coefficients of variation (PCV and GCV) are furnished in Tables 9 and 10 respectively. The phenotypic coefficient of variation and genotypic coefficient of variation are also presented graphically (Fig. 1).

Table 9. Genotypic, Environmental and Phenotypic variances for thirteen characters studied in guinea grass

Sl. No.	Characters	Genotypic variance (V_g)	Environmental variance (V_e)	Phenotypic variance (V_p)
1.	Plant height	137.092	113.768	250.860
2.	Number of tillers/ hill	1.331	2.768	4.099
3.	Number of panicles/ plot	13.067	2.781	15.848
4.	Leaf: stem ratio on fresh weight basis	0.012	0.008	0.020
5.	Leaf: stem ratio on dry weight basis	0.022	0.011	0.033
6.	Green fodder yield/ hill	3143.445	2716.129	5859.574
7.	Green fodder yield/ plot	30.174	45.212	75.386
8.	Dry matter yield/ hill	59.048	105.298	164.346
9.	Dry matter yield/ plot	0.695	2.244	2.939
10.	Leaf Area Index	1.672	2.269	3.941
11.	Chlorophyll 'a'	0.086	0.405	0.491
12.	Chlorophyll 'b'	1.008	4.699	5.707
13.	Total pigments	9.258	22.874	32.132

Table 10. Phenotypic and Genotypic coefficient of variation (per cent) for thirteen characters studied

Sl. No.	Characters	Phenotypic coefficient of variation (PCV)	Genotypic coefficient of variation (GCV)
1.	Plant height	8.825	6.524
2.	Number of tillers/hill	21.406	12.198
3.	Number of panicles/plot	25.858	23.488
4.	Leaf: stem ratio on fresh weight basis	22.091	16.699
5.	Leaf: stem ratio on dry weight basis	23.934	19.542
6.	Green fodder yield/hill	35.792	26.215
7.	Green fodder yield/plot	25.531	16.153
8.	Dry matter yield/hill	28.718	17.214
9.	Dry matter yield/plot	23.372	11.368
10.	Leaf Area Index	35.198	22.926
11.	Chlorophyll 'a'	3.152	1.319
12.	Chlorophyll 'b'	8.646	3.633
13.	Total pigments	7.485	4.018

Green fodder yield per hill recorded the maximum phenotypic variance (5859.6) while leaf: stem ratio on fresh weight basis recorded the minimum value (0.020). Maximum genotypic variance (3143.4) was also obtained for green fodder yield per hill followed by plant height (107.092) and dry matter yield per hill (59.048). Leaf: stem ratio on fresh weight basis recorded the minimum genotypic variance (0.012). Since the phenotypic and genotypic variances are associated with units of measurement of the traits, the coefficients of variation were worked out to make valid comparisons among the characters.

Green fodder yield per hill showed the highest phenotypic coefficient of variation (35.792 per cent) followed by Leaf Area Index (35.198 per cent), dry matter yield per hill (28.718 per cent), number of panicles per plot (25.858 per cent) and green fodder yield per plot (25.531 per cent). Chlorophyll 'a' had the lowest value (3.152 per cent).

The highest genotypic coefficient of variation was also observed for green fodder yield per hill (26.215 per cent) followed by number of panicles per plot (23.488 per cent) and Leaf Area Index (22.926 per cent). Chlorophyll 'a' content was consistent among the varieties. Leaf: stem ratio on dry weight basis (19.542 per cent) and leaf: stem ratio on

Fig. 1 Phenotypic and Genotypic coefficient of variation for thirteen characters in guinea grass

X_1 - Plant height

X_2 - Number of tillers/hill

X_3 - Number of panicles/plot

X_4 - Leaf: stem ratio on fresh weight basis

X_5 - Leaf: stem ratio on dry weight basis

X_6 - Green fodder yield/hill

X_7 - Green fodder yield/plot

X_8 - Dry matter yield/hill

X_9 - Dry matter yield/plot

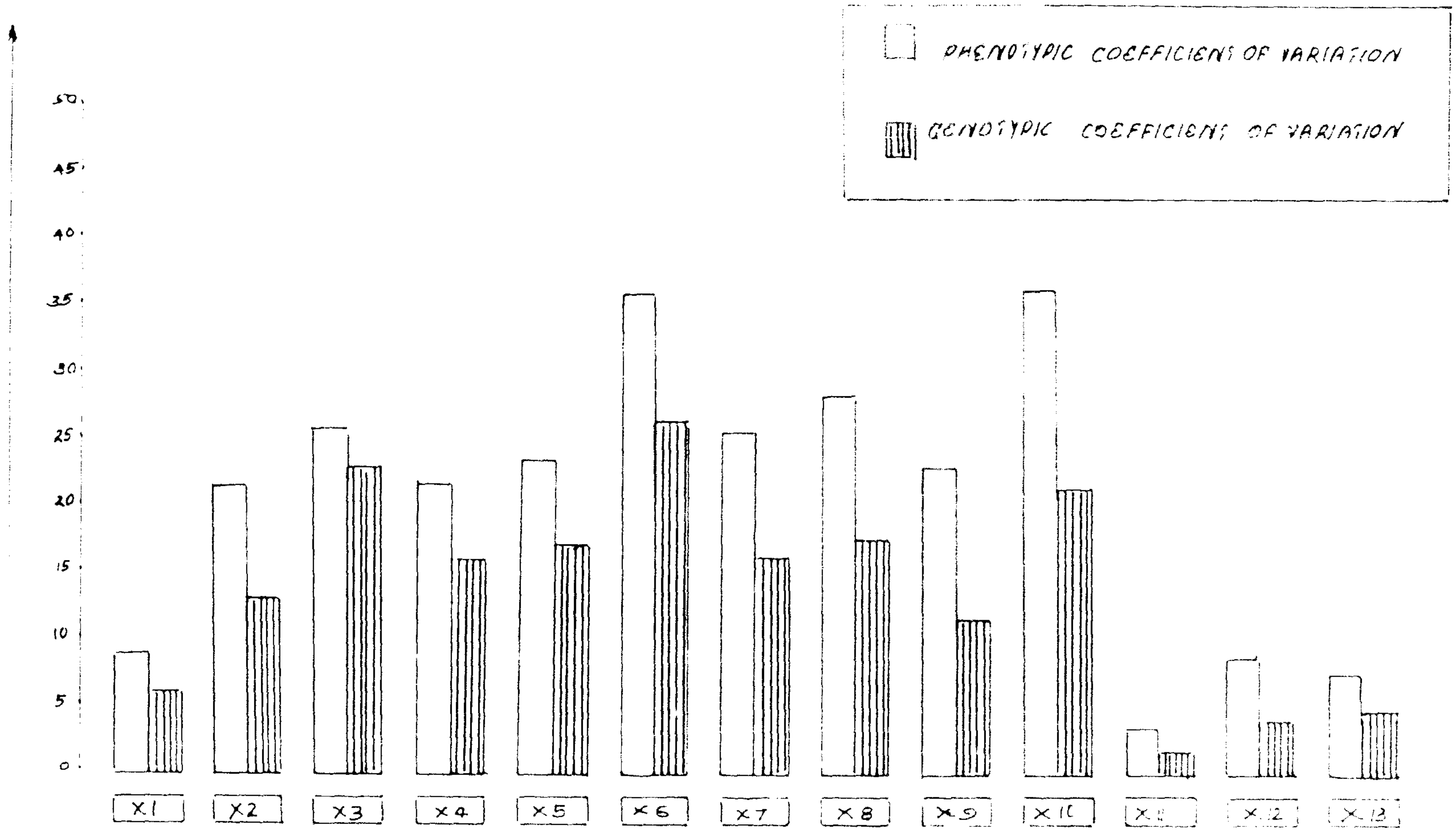
X_{10} - Leaf Area Index

X_{11} - Chlorophyll 'a'

X_{12} - Chlorophyll 'b'

X_{13} - Total pigments

FIG-1- PHENOTYPIC AND GENOTYPIC COEFFICIENT OF VARIATION FOR THIRTEEN CHARACTERS IN GUINEA GRASS



fresh weight basis (16.699 per cent) showed moderately high genotypic coefficient of variation.

4.3. Genetic analysis

Estimates of heritability, genetic advance and genetic gain are furnished in Table 11 and Fig. 2. In general, the heritability estimates were medium to high for most of the characters. The highest heritability estimate was recorded for number of panicles per plot (82.45 per cent) followed by leaf: stem ratio on dry weight basis (66.32 per cent), leaf: stem ratio on fresh weight basis (59.98 per cent) and plant height (54.65 per cent). Green fodder yield per hill and Leaf Area Index recorded moderately high heritability. Low values of heritability were recorded for chlorophyll 'a' (17.47 per cent) and chlorophyll 'b' (17.66 per cent).

Number of panicles per plot recorded the maximum genetic gain (43.92 per cent) followed by green fodder yield per hill (39.55 per cent), leaf: stem ratio on dry weight basis (32.67 per cent) and Leaf Area Index (30.74 per cent). Chlorophyll 'a' recorded the minimum value (1.13 per cent).

Number of panicles per plot recorded high heritability coupled with high genetic gain. Leaf: stem ratio on dry weight basis, leaf: stem ratio on fresh weight basis,

Table 11. Heritability, Genetic Advance and Genetic gain for thirteen characters studied

Sl. No.	Characters	Heritability in % (H^2)	Genetic advance (GA) at 5%	Genetic gain in % (GG)
1.	Plant height	54.65	17.83	9.93
2.	Number of tillers/hill	32.47	1.35	14.27
3.	Number of panicles/plot	82.45	6.76	43.92
4.	Leaf: stem ratio on fresh weight basis	59.98	0.177	26.98
5.	Leaf: stem ratio on dry weight basis	66.32	0.248	32.67
6.	Green fodder yield/hill	53.65	84.59	39.55
7.	Green fodder yield/plot	40.03	7.16	21.05
8.	Dry matter yield/hill	35.93	9.49	21.26
9.	Dry matter yield/plot	23.66	0.836	11.40
10.	Leaf Area Index	42.42	1.734	30.74
11.	Chlorophyll 'a'	17.47	0.252	1.13
12.	Chlorophyll 'b'	17.66	0.869	3.14
13.	Total pigments	28.81	3.36	4.44

Fig. 2 Heritability and genetic gain for thirteen characters in guinea grass

X_1 - Plant height

X_2 - Number of tillers/hill

X_3 - Number of panicles/plot

X_4 - Leaf: stem ratio on fresh weight basis

X_5 - Leaf: stem ratio on dry weight basis

X_6 - Green fodder yield/hill

X_7 - Green fodder yield/plot

X_8 - Dry matter yield/hill

X_9 - Dry matter yield/plot

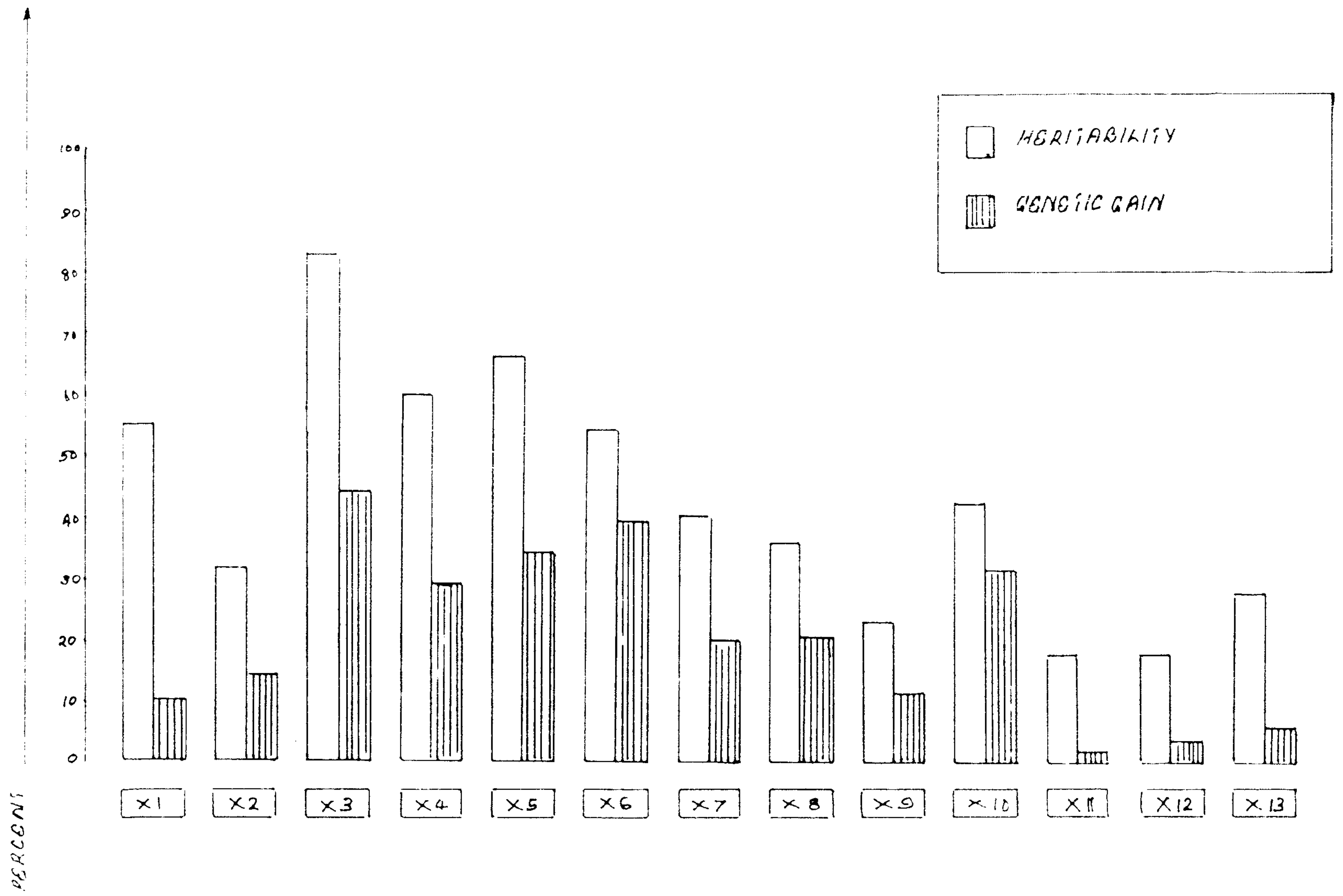
X_{10} - Leaf Area Index

X_{11} - Chlorophyll 'a'

X_{12} - Chlorophyll 'b'

X_{13} - Total pigments

FIG. 2. HERITABILITY AND GENETIC GAIN FOR THIRTEEN CHARACTERS IN GUINEA GRASS



green fodder yield per hill and Leaf Area Index recorded moderately high heritability and genetic gain.

4.4. Correlation analysis

The analysis of covariance was done for all the possible pairs of characters. The genotypic and phenotypic covariance components were computed in a similar manner as for the corresponding variance components. From the covariance and variance values, the genotypic and phenotypic correlation coefficients were estimated and are presented under the following heads.

4.4.1. Correlation between green fodder yield per plot and its components

4.4.2. Correlation among the yield components

4.4.1. Correlation between green fodder yield per plot and its components

The genotypic and phenotypic covariances between green fodder yield per plot and its components are presented in Table 12 and the corresponding correlation coefficients in Table 13. The genotypic correlation coefficients were in general, higher than the phenotypic correlation coefficients.

The genotypic correlation of green fodder yield per plot with all other characters was positive except for plant

Table 12. The genotypic (G) and phenotypic (P) covariances between green fodder yield per plot and other yield component characters in guinea grass

Sl. No.	Characters	Phenotypic covariance (P)	Genotypic covariance (G)
1.	Plant height	11.263	-22.678
2.	Number of tillers/hill	8.959	4.122
3.	Number of panicles/plot	-2.703	-9.295
4.	Leaf: stem ratio on fresh weight basis	0.251	0.433
5.	Leaf: stem ratio on dry weight basis	0.199	0.434
6.	Green fodder yield/hill	424.232	272.591
7.	Dry matter yield/hill	70.246	41.100
8.	Dry matter yield/plot	13.593	4.268
9.	Leaf Area Index	11.629	7.211
10.	Chlorophyll 'a'	-2.965	-1.955
11.	Chlorophyll 'b'	-10.493	-3.496
12.	Total pigments	-27.379	-16.286

Table 13. Phenotypic (r_p) and genotypic (r_G) correlation coefficients between green fodder yield per plot and other yield component characters

Sl. No.	Characters	r_P	r_G
1.	Plant height	0.0819	-0.3526
2.	Number of tillers/hill	0.5097**	0.6504
3.	Number of panicles/plot	-0.0782	-0.4681
4.	Leaf: stem ratio on fresh weight basis	0.2046	0.7191
5.	Leaf: stem ratio on dry weight basis	0.1267	0.5332
6.	Green fodder yield/hill	0.6383**	0.8851
7.	Dry matter yield/hill	0.6311**	0.9737
8.	Dry matter yield/plot	0.9132**	0.9321
9.	Leaf Area Index	0.6747**	1.0152
10.	Chlorophyll 'a'	-0.4873**	-1.2138
11.	Chlorophyll 'b'	-0.5059**	-0.6339
12.	Total pigments	-0.5563**	-0.9744

* Significant at 5 per cent level

** Significant at 1 per cent level

height, number of panicles per plot, content of chlorophyll 'a', chlorophyll 'b' and total pigments. The correlation was the highest with Leaf Area Index (r = 1.0152) followed by dry matter yield per hill (r = 0.9737), dry matter yield per plot (r = 0.9321), green fodder yield per hill (r = 0.8851), leaf: stem ratio on fresh weight basis (r = 0.7191), number of tillers per hill (r = 0.6504) and leaf: stem ratio on dry weight basis (r = 0.5332). The correlation of green fodder yield per plot with plant height (r = -0.3526), number of panicles per plot (r = -0.4681), content of chlorophyll 'a' (r = -1.2138), chlorophyll 'b' (r = -0.6339) and total pigments (r = -0.9744) were negative.

The phenotypic correlation of green fodder yield per plot was positive and significant with dry matter yield per plot (r = 0.9132), Leaf Area Index (r = 0.6747), green fodder yield per hill (r = 0.6383), dry matter yield per hill (r = 0.6311) and number of tillers per hill (r = 0.5097). Its association was positive and non significant with leaf: stem ratio on fresh weight basis (r = 0.2046), leaf: stem ratio on dry weight basis (r = 0.1267) and plant height (r = 0.0819). Its association with number of panicles per plot (r = -0.0782) was negative and non significant. Green fodder yield per plot showed significant negative correlation with the contents of chlorophyll 'a' (r = -0.4873 , chlorophyll 'b' (r = -0.5059) and total pigments (r = -0.5563).

4.4.2. Correlations among the yield components

The genotypic and phenotypic covariance values among the yield components were computed and are presented in Table 14 and corresponding correlation coefficients in Table 15. The genotypic correlations among green fodder yield per plot and 12 yield components are diagramatically presented in Fig. 3.

Plant height showed positive genotypic correlation with the content of chlorophyll 'a' (r = 0.8437), number of panicles per plot (r = 0.7554), total pigments (r = 0.2903) and chlorophyll 'b' content (r = 0.2818). The genotypic correlation of plant height with all other characters viz., leaf: stem ratio on fresh weight basis (r = -0.6535), leaf: stem ratio on dry weight basis (r = -0.6313), Leaf Area Index (r = -0.4585), number of tillers per hill (r = -0.3677), dry matter yield per plot (r = -0.3574), dry matter yield per hill (r = -0.2902) and green fodder yield per hill (r = -0.2630) were negative.

The phenotypic association of this character was positive and significant with number of panicles per plot (r = 0.6394). Dry matter yield per hill (r = 0.2812), green

Table 14. Genotypic and phenotypic covariance among the yield component characters

Characters		Plant height	Number of tillers/ hill	Number of panicles/ plot	Leaf: stem ratio on fresh weight basis	Leaf: stem ratio on dry weight basis	Green fodder yield/ hill	Dry matter yield/hill	Dry matter yield/ plot	Leaf Area Index	Chloro-phyll 'a'	Chloro-phyll 'b'	Total pigments
t height	G	..	-4.967	31.972	-0.851	-1.093	-172.664	-26.109	-3.489	-12.772	2.892	3.318	10.359
	P	..	5.021	40.315	-1.431	-1.790	235.274	57.099	2.460	5.115	2.010	-3.728	2.058
ber of tillers/hill	G	..	..	-0.205	0.070	0.066	25.143	4.682	0.997	1.574	-0.105	0.711	0.115
	P	..	..	1.106	0.018	-0.023	94.401	18.702	1.914	3.352	-0.121	-0.476	-2.106
ber of panicles/plot	G	..	..	..	-0.349	-0.495	-118.463	-14.626	-0.694	-6.080	0.961	1.736	2.926
	P	..	..	..	-0.408	-0.569	-86.626	-7.661	0.689	-3.356	0.711	0.617	1.199
f: stem ratio on sh weight basis	G	..	..	..	..	0.015	3.770	0.581	0.067	0.266	-0.039	-0.072	-0.153
	P	..	..	..	..	0.024	2.195	0.163	0.017	0.129	-0.032	-0.012	-0.042
f: stem ratio on weight basis	G	..	..	..	..	..	4.466	0.674	0.060	0.324	-0.051	-0.112	-0.201
	P	..	..	..	..	..	2.198	0.106	-0.003	0.166	-0.035	-0.015	-0.023
en fodder yield/hill	G	..	..	..	..	..	..	-48.971	33.35	116.486	-8.636	-15.283	-77.900
	P	..	..	..	..	..	..	943.084	54.460	170.251	-11.940	-45.059	-127.594
matter yield/hill	G	..	..	..	..	..	..	..	5.618	16.784	-1.045	-0.342	-9.227
	P	..	..	..	..	..	..	..	10.573	29.059	-2.062	-1.326	-24.079
matter yield/plot	G	..	..	..	..	..	..	..	..	1.044	-0.291	-0.254	-2.209
	P	..	..	..	..	..	..	..	..	1.323	-3.513	-1.911	-5.167
f Area Index	G	..	..	..	..	..	..	..	..	..	-0.859	-1.246	-4.853
	P	..	..	..	..	..	..	..	..	..	-0.684	-2.563	-6.051
orophyll 'a'	G	..	..	..	..	..	..	..	..	..	..	0.262	0.762
	P	..	..	..	..	..	..	..	..	..	..	1.256	3.128
orophyll 'b'	G	..	..	..	..	..	..	..	..	..	..	..	2.645
	P	..	..	..	..	..	..	..	..	..	..	..	12.365
al pigments	G	..	..	..	..	..	..	..	..	..	..	..	..
	P	..	..	..	..	..	..	..	..	..	..	..	..

Table 15. Genotypic (r_G) and Phenotypic (r_P) correlation coefficients among the yield component characters

Characters		Plant height	Number of tillers/ hill	Number of panicles/ plot	Leaf: stem ratio on fresh weight basis	Leaf: stem ratio on dry weight basis	Green fodder yield/ hill	Dry matter yield/ hill	Dry matter yield/ plot	Leaf Area Index	Chlorophyll 'a'	Chlorophyll 'b'	Total pigment
Plant height	G	1.0000	-0.3677	0.7554	-0.6535	-0.6313	-0.2630	-0.2302	-0.3574	-0.4585	0.8437	0.2818	0.2909
	P	1.0000	0.1566	0.6394**	-0.6294**	-0.6225**	0.1941	0.2812	0.0906	0.1147	0.1611	-0.0955	0.0227
Number of tillers/hill	G	..	1.0000	-0.0491	0.5428	0.3868	0.3887	0.5282	1.0364	0.5736	-0.3114	0.6141	0.0327
	P	..	1.0000	0.1372	0.0634	-0.0616	0.6092**	0.7206**	0.5515**	0.5880**	-0.0855	-0.0985	-0.1835
Number of panicles/plot	G	..	..	1.0000	-0.8639	-0.9261	-0.5845	-0.5265	-0.2303	-0.7070	0.9079	0.4784	0.2661
	P	..	..	1.0000	-0.7144**	-0.7875**	-0.2843	-0.1301	0.1010	-0.3021*	0.2547	0.0648	0.0531
Leaf: stem ratio on fresh weight basis	G	..	..	..	1.0000	0.9403	0.6048	0.6801	0.7323	1.0211	-1.1862	-0.6427	-0.4535
	P	..	..	..	1.0000	0.9083**	0.2000	0.0887	0.0706	0.3166*	-0.3187*	-0.0346	-0.0520
Leaf: stem ratio on dry weight basis	G	..	..	..	..	1.0000	0.5386	0.5928	0.4890	0.9193	-1.1891	-0.7519	-0.4470
	P	..	..	..	..	1.0000	0.1580	0.0465	-0.0108	0.3294*	-0.2758	-0.0350	-0.0224
Green fodder yield/hill	G	..	..	..	..	..	1.0000	0.9955	0.7130	0.8733	-0.5261	-0.2715	-0.4566
	P	..	..	..	..	..	1.0000	0.9671**	0.4150**	0.7899**	-0.2227	-0.2464	-0.2941
Dry matter yield/hill	G	..	..	..	..	..	..	1.0000	0.8769	0.9181	-0.4644	-0.0443	-0.3946
	P	..	..	..	..	..	..	1.0000	0.4311**	0.8050**	-0.2296	-0.2719	-0.3313
Dry matter yield/plot	G	..	..	..	..	..	..	..	1.0000	0.9682	-1.1399	-0.3095	-0.8707
	P	..	..	..	..	..	..	..	1.0000	0.5338**	-0.4267**	-0.4666**	-0.5317**
Leaf Area Index	G	..	..	..	..	..	..	..	..	1.0000	-1.2321	-0.5219	-0.6704
	P	..	..	..	..	..	..	..	..	1.0000	-0.3467*	-0.3780*	-0.3791
Chlorophyll 'a'	G	..	..	..	..	..	..	..	..	..	1.0000	0.8399	0.8551
	P	..	..	..	..	..	..	..	..	..	1.0000	0.7564**	0.7873**
Chlorophyll 'b'	G	..	..	..	..	..	..	..	..	..	..	1.0000	0.8660
	P	..	..	..	..	..	..	..	..	..	..	1.0000	0.9137**
Total pigments	G	..	..	..	..	..	..	..	..	..	..	..	1.0000
	P	..	..	..	..	..	..	..	..	..	..	..	1.0000

* Significant at 5 per cent level

** Significant at 1 per cent level

Fig. 3 Correlation diagram

Y - Green fodder yield/plot

X_1 - Plant height

X_2 - Number of tillers/hill

X_3 - Number of panicles/plot

X_4 - Leaf: stem ratio on fresh weight basis

X_5 - Leaf: stem ratio on dry weight basis

X_6 - Green fodder yield/hill

X_7 - Dry matter yield/hill

X_8 - Dry matter yield/plot

X_9 - Leaf Area Index

X_{10} - Chlorophyll 'a'

X_{11} - Chlorophyll 'b'

X_{12} - Total pigments

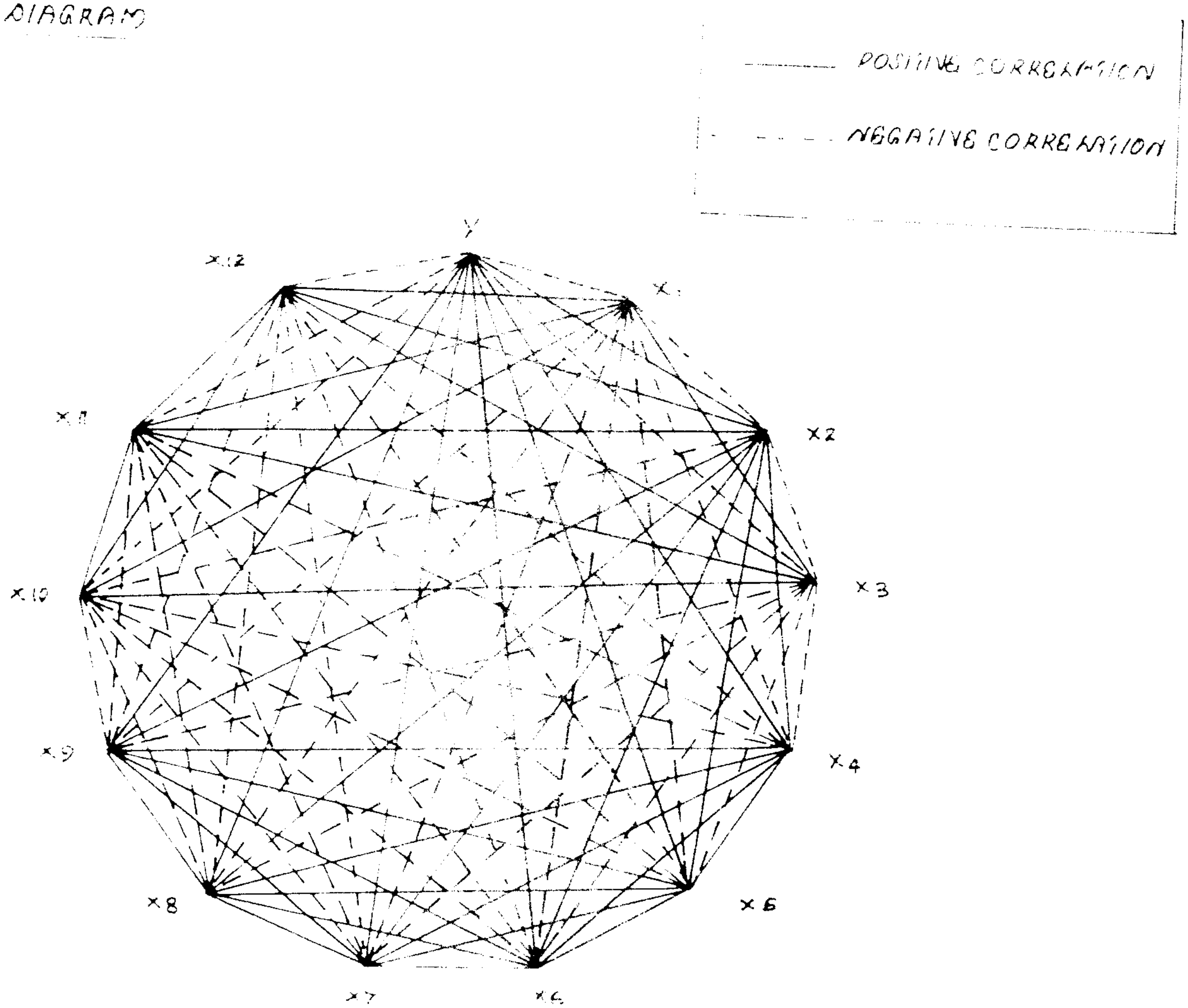
Table 15. Genotypic (r_G) and Phenotypic (r_P) correlation coefficients among the yield component characters

Characters		Plant height	Number of tillers/ hill	Number of panicles/ plot	Leaf: stem ratio on fresh weight basis	Leaf: stem ratio on dry weight basis	Green fodder yield/ hill	Dry matter yield/ hill	Dry matter yield/ plot	Leaf Area Index	Chlorophyll 'a'	Chlorophyll 'b'	Total pigment
Plant height	G	1.0000	-0.3677	0.7554	-0.6535	-0.6313	-0.2630	-0.2902	-0.3574	-0.4585	0.8437	0.2818	0.2908
	P	1.0000	0.1566	0.6394**	-0.6294**	-0.6225**	0.1941	0.2812	0.0906	0.1147	0.1811	-0.0955	0.0229
Number of tillers/hill	G	..	1.0000	-0.0491	0.5428	0.3868	0.3887	0.5282	1.0364	0.5736	-0.3114	0.6141	0.0327
	P	..	1.0000	0.1372	0.0634	-0.0616	0.6092**	0.7206**	0.5515**	0.5880**	-0.0855	-0.0985	-0.1835
Number of panicles/plot	G	..	..	1.0000	-0.8689	-0.9261	-0.5845	-0.5265	-0.2303	-0.7070	0.9079	0.4784	0.2661
	P	..	..	1.0000	-0.7144**	-0.7875**	-0.2843	-0.1501	0.1010	-0.3021*	0.2547	0.0648	0.0531
Leaf: stem ratio on fresh weight basis	G	..	..	..	1.0000	0.9403	0.6048	0.6801	0.7323	1.0211	-1.1862	-0.6427	-0.4535
	P	..	..	..	1.0000	0.9088**	0.2000	0.0887	0.0706	0.3166*	-0.3187*	-0.0346	-0.0520
Leaf: stem ratio on dry weight basis	G	..	..	..	..	1.0000	0.5386	0.5928	0.4890	0.9193	-1.1891	-0.7519	-0.4470
	P	..	..	..	..	1.0000	0.1580	0.0465	-0.0108	0.3294*	-0.2758	-0.0350	-0.0224
Green fodder yield/hill	G	..	..	..	..	..	1.0000	0.9955	0.7130	0.8733	-0.5261	-0.2715	-0.4566
	P	..	..	..	..	..	1.0000	0.9671**	0.4150**	0.7899**	-0.2227	-0.2464	-0.2941
Dry matter yield/hill	G	..	..	..	..	..	..	1.0000	0.8769	0.9181	-0.4644	-0.0443	-0.3946
	P	..	..	..	..	..	..	1.0000	0.4811**	0.8050**	-0.2296	-0.2719	-0.3313*
Dry matter yield/plot	G	..	..	..	..	..	..	..	1.0000	0.9682	-1.1899	-0.3095	-0.8707
	P	..	..	..	..	..	..	..	1.0000	0.5338**	-0.4267**	-0.4666**	-0.5317**
Leaf Area Index	G	..	..	..	..	..	..	..	..	1.0000	-1.2321	-0.5219	-0.6704
	P	..	..	..	..	..	..	..	..	1.0000	-0.3467*	-0.3780*	-0.3791*
Chlorophyll 'a'	G	..	..	..	..	..	..	..	..	..	1.0000	0.8899	0.8551
	P	..	..	..	..	..	..	..	..	..	1.0000	0.7564**	0.7879**
Chlorophyll 'b'	G	..	..	..	..	..	..	..	..	..	..	1.0000	0.8660
	P	..	..	..	..	..	..	..	..	..	..	1.0000	0.9137**
Total pigments	G	..	..	..	..	..	..	..	..	..	..	..	1.0000
	P	..	..	..	..	..	..	..	..	..	..	..	1.0000

* Significant at 5 per cent level

** Significant at 1 per cent level

FIG-3- CORRELATION DIAGRAM



fodder yield per hill (r = 0.1941), the content of chlorophyll 'a' (r = 0.1811), number of tillers per hill (r = 0.1566), Leaf Area Index (r = 0.1147), dry matter yield per plot (r = 0.0906) and total pigments (r = 0.0229) showed positive non significant phenotypic association with plant height. Plant height showed negative significant association with leaf: stem ratio on fresh weight basis (r = -0.6294) and leaf: stem ratio on dry weight basis (r = -0.6225). The phenotypic correlation between plant height and the content of chlorophyll 'b' (r = -0.0955) was negative and negligible.

Number of tillers per hill recorded negative genotypic association with chlorophyll 'a' content (r = -0.3114) and number of panicles per plot (r = -0.0491). For all other characters viz., dry matter yield per plot (r = 1.0364), the content of chlorophyll 'b' (r = 0.6141), Leaf Area Index (r = 0.5736), leaf: stem ratio on fresh weight basis (r = 0.5428), dry matter yield per hill (r = 0.5282), green fodder yield per hill (r = 0.3887), leaf: stem ratio on dry weight basis (r = 0.3868) and total pigments (r = 0.0327), it exhibited positive genotypic correlation.

The phenotypic correlation of number of tillers per hill with dry matter yield per hill (r = 0.7206), green fodder yield per hill (r = 0.6092), Leaf Area Index (r = 0.5880) and dry matter yield per plot (r = 0.5515) were positive and significant. It also exhibited positive non significant phenotypic correlation with number of panicles per plot (r = 0.1372) and leaf: stem ratio on fresh weight basis (r = 0.0634). Negative non significant phenotypic correlation was observed with total pigments (r = -0.1835), the content of chlorophyll 'b' (r = -0.0985), chlorophyll 'a' (r = -0.0855) and leaf: stem ratio on dry weight basis (r = -0.0616).

Number of panicles per plot showed negative genotypic correlation with almost all the characters under study except the content of chlorophyll 'a' (r = 0.9079), chlorophyll 'b' (r = 0.4784) and total pigments (r = 0.2661) where it was positive. It exhibited negative genotypic association with leaf: stem ratio on dry weight basis (r = -0.9261), leaf: stem ratio on fresh weight basis (r = -0.8689), Leaf Area Index (r = -0.7070), green fodder yield per hill (r = -0.5849), dry matter yield per hill (r = -0.5265) and dry matter yield per plot (r = -0.2303).

Significant negative phenotypic correlation was observed between this character and leaf: stem ratio on dry weight basis (r = -0.7875), leaf: stem ratio on fresh weight basis (r = -0.7144) and Leaf Area Index (r = -0.3021). A non significant negative phenotypic correlation was observed with green fodder yield per hill (r = -0.2843) and dry matter yield per hill(r=-0.1501). The phenotypic correlation with chlorophyll 'a' (r = 0.2547), dry matter yield per plot (r = 0.1010), chlorophyll 'b' (r = 0.0648) and total pigments (r = 0.0531) were negligible.

At genotypic level, leaf: stem ratio on fresh weight basis exhibited positive correlations with Leaf Area Index (r = 1.0211), leaf: stem ratio on dry weight basis (r = 0.9403), dry matter yield per plot (r = 0.7323), dry matter yield per hill (r = 0.6801) and green fodder yield per hill (r = 0.6048). Negative genotypic association was seen for this character with the content of chlorophyll 'a' (r = -1.1862), chlorophyll 'b' (r = -0.6427) and total pigments (r = -0.4535).

The phenotypic correlation of this trait was positive and significant with leaf: stem ratio on dry weight basis (r = 0.9088) and Leaf Area Index (r = 0.3166). Positive non significant correlation was observed with green fodder yield per hill (r = 0.2000), dry matter yield per hill (r = 0.0887) and dry matter yield per plot (r = 0.0706). The phenotypic correlation was negative and significant with chlorophyll 'a' (r = -0.3187) while it was negative and non significant with total pigments (r = -0.0346).

The genotypic correlation of leaf: stem ratio on dry weight basis was positive with other characters like Leaf Area Index (r = 0.9193), dry matter yield per hill (r = 0.5923), green fodder yield per hill (r = 0.5336) and dry matter yield per plot (r = 0.4890). This character exhibited negative genotypic association with chlorophyll 'a' (r = -1.1891), chlorophyll 'b' (r = -0.7519) and total pigments (r = -0.4479). The phenotypic correlation was significant and positive with Leaf Area Index (r = 0.3294). Non significant positive correlation was observed with green fodder yield per hill (r = 0.1580) and dry matter yield per hill (r = 0.0465). The phenotypic correlations with the content of chlorophyll 'a' (r = -0.2763), chlorophyll 'b' (r = -0.0350), total pigments (r = -0.0224) and dry matter yield per plot (r = -0.0108) were negative and non significant.

Green fodder yield per hill showed the highest genotypic correlation with dry matter yield per hill (r = 0.9955) followed by Leaf Area Index (r = 0.8733) and dry matter yield per plot (r = 0.7130). The correlation with chlorophyll 'a' (r = -0.5261), total pigments (r = -0.4566) and chlorophyll 'b' (r = -0.2715) were negative.

As in the case of genotypic correlation, the phenotypic correlation of green fodder yield per hill with dry matter yield per hill (r = 0.9671), Leaf Area Index (r = 0.7399) and dry matter yield per plot (r = 0.4150) were positive and significant. This trait showed negative non significant phenotypic correlation with total pigments (r = -0.2941), the content of chlorophyll 'b' (r = -0.2464) and chlorophyll 'a' (r = -0.2227).

Dry matter yield per hill exhibited positive genotypic correlation with Leaf Area Index (r = 0.9181) and dry matter yield per plot (r = 0.8769). It had negative correlation with the content of chlorophyll 'a' (r = -0.4644), total pigments (r = -0.3946) and chlorophyll 'b' (r = -0.0443). This character had significant positive phenotypic correlation with Leaf Area Index (r = 0.8050) and dry matter yield per plot (r = 0.4811). The phenotypic correlation was negatively significant with total pigments (-0.3313) and non significant with chlorophyll 'b' (-0.2719) and chlorophyll 'a' (-0.2296).

The maximum positive correlation for dry matter yield per plot at genotypic level was observed with Leaf Area Index (r = 0.9682). With the content of chlorophyll 'a' (r = -1.1899), total pigments (r = -0.8707) and chlorophyll 'b' (r = -0.3095) the genotypic correlation coefficients were negative. This character also recorded significant positive phenotypic correlation with Leaf Area Index (r = 0.5338). The phenotypic correlation with the content of total pigments (r = -0.5317), chlorophyll 'b' (r = -0.4665) and chlorophyll 'a' (r = -0.4267) were negatively significant.

At genotypic level, Leaf Area Index showed negative correlation with the content of chlorophyll 'a' (r = -1.2321), total pigments (r = -0.6704), and chlorophyll 'b' (r = -0.5219). Negatively significant phenotypic correlation was observed with the content of total pigments (r = -0.3791), chlorophyll 'b' (r = -0.3780) and chlorophyll 'a' (r = -0.3467).

Chlorophyll 'a' content showed positive correlation at the genotypic level with chlorophyll 'b' (r = 0.8899) and total pigments (r = 0.8551). The phenotypic correlation of this character with the content of total pigments (r = 0.7878) and chlorophyll 'b' (r = 0.7564) were positive and significant.

Chlorophyll 'b' content exhibited positive genotypic correlation with total pigments (r = 0.8660). This correlation was significant and positive at the phenotypic level (r = 0.9131).

4.3. <u>Path analysis</u>

Five morphological characters which showed high genotypic correlation with green fodder yield per plot viz., plant height, number of tillers per hill, leaf: stem ratio on fresh weight basis, green fodder yield per hill and Leaf Area Index were considered for path coefficient analysis in order to partition the total correlation of the characters with green fodder yield per plot, into direct and indirect effects. Path coefficients were worked out and the results obtained are presented in Table 16 and Fig. 4.

4.5.1. Direct effects

The maximum contribution to green fodder yield per plot was through green fodder yield per hill, since it recorded maximum positive direct effect (0.83424), followed by leaf: stem ratio on fresh weight basis (0.66609), number of tillers per hill (0.31413) and plant height (0.19572). Leaf Area Index showed negative direct effect (-0.48394).

4.5.2. Indirect effects

a. Plant height

Plant height showed positive indirect effect only through Leaf Area Index (0.22189). All other indirect effects were negative. Maximum negative indirect effect was through leaf: stem ratio or fresh weight basis (-0.43529), followed by green fodder yield per hill (-0.21941) and number of tillers per hill (-0.11550).

Table 16. Path coefficient values - Direct and indirect genotypic effects on green fodder yield per plot through various yield components

Sl. No.	Characters	Direct effect	Indirect effects via					Total corre- lation
			Plant height	Number of tillers/ hill	Leaf: stem ratio on fresh weight basis	Green fodder yield/ hill	Leaf Area Index	
1.	Plant height	0.19572	..	-0.11550	-0.43529	-0.21941	0.22189	-0.3526
2.	Number of tillers/hill	0.31413	-0.07196	..	0.36155	0.32427	-0.27759	0.6504
3.	Leaf: stem ratio on fresh weight basis	0.66609	-0.12790	0.17051	..	0.50455	-0.49415	0.7191
4.	Green fodder yield/hill	0.83424	-0.05147	0.12210	0.40285	..	-0.42263	0.8851
5.	Leaf Area Index	-0.48394	-0.08974	0.18018	0.68015	0.72855	..	1.0152

Residual effect = 0.3723

Fig. 4 Path diagram showing direct effects and genotypic correlations in guinea grass

Y - Green fodder yield/plot

X_1 - Height of the plant

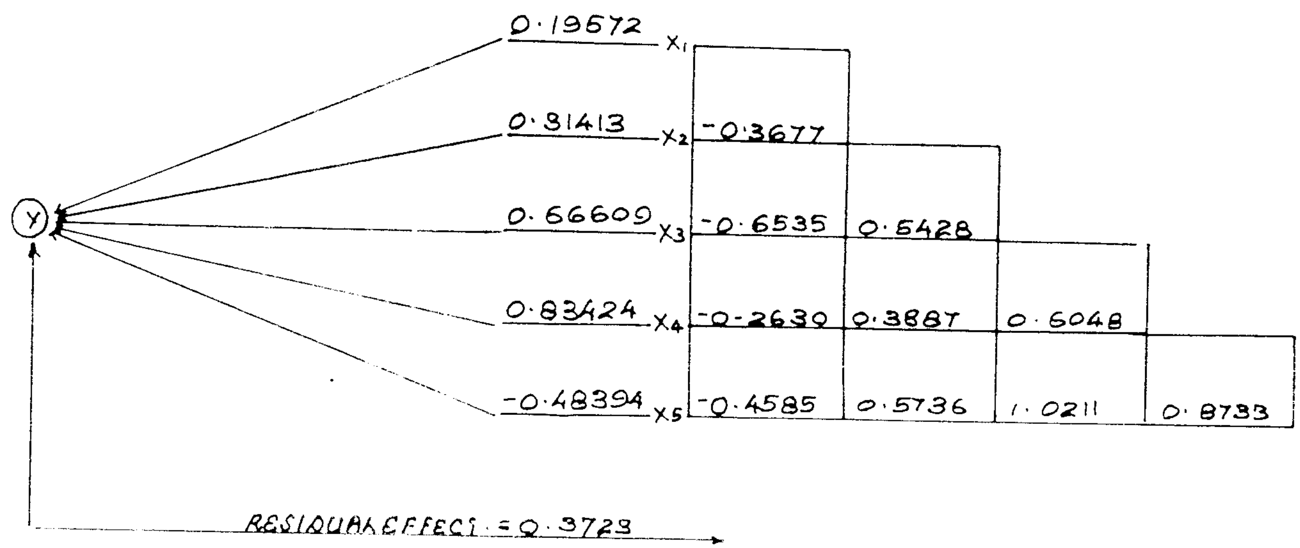
X_2 - Number of tillers/hill

X_3 - Leaf: stem ratio on fresh weight basis

X_4 - Green fodder yield/hill

X_5 - Leaf Area Index

FIG-4- PATH DIAGRAM SHOWING DIRECT EFFECTS AND GENOTYPIC CORRELATIONS IN GUINEAGRASS



b. Number of tillers per hill

Number of tillers per hill had positive indirect effect through leaf: stem ratio on fresh weight basis (0.36155) and green fodder yield per hill (0.32427) and negative indirect effect through Leaf Area Index (-0.27759) and plant height (-0.07196).

c. Leaf: stem ratio on fresh weight basis

This character showed positive indirect effect on yield through green fodder yield per hill (0.50455) and number of tillers per hill (0.17051). It had negative indirect effects on yield through Leaf Area Index (-0.49415) and plant height (-0.12790).

d. Green fodder yield per hill

The positive indirect effect of green fodder yield per hill on green fodder yield per plot was maximum through leaf: stem ratio on fresh weight basis (0.40285), followed by number of tillers per hill (0.12210). It had negative indirect effects through Leaf Area Index (-0.42263) and plant height (-0.05147).

e. Leaf Area Index

This character exhibited maximum positive indirect effects through green fodder yield per hill (0.72855), followed by leaf: stem ratio on fresh weight basis (0.68015) and number of tillers per hill (0.18018). It had negative indirect effect only through plant height (-0.08974). About 63 per cent of the variation in green fodder yield is explained by the direct and indirect effects of the above morphological characters.

DISCUSSION

DISCUSSION

In any crop improvement programme it is highly essential to combine high yielding potential with other agronomic and quality characters. For achieving this goal, the plant breeder needs basic information on genetic variability for different attributes, nature of association between characters and adaptability to diverse environmental conditions. The production of guinea grass can be substantially increased through the development of types suited to the diverse conditions such as drought, shade and other environmental stresses.

In the present study, 15 clones of guinea grass were evaluated under partial shade of coconut garden. Genetic variability and correlation were estimated and path analysis done using the data collected on green and dry fodder yield and other morphological and physiological characters. The results obtained are discussed in the following pages.

5.1. Variability

Guinea grass is a facultative apomictic crop which exhibits limited variability under open pollinated seed propagation system of cultivation. But wide variability exists among different varieties in many of the morphological characters and yielding abilities. Although the experiment was conducted in shade, the effect of shade on the growth rate of clones were different. This differential growth response is attributed to the varied genetic constitution of the clones tried. In the present study differences in the mean values for most of the characters were significant. Similar differences among guinea grass clones were reported by Pillai et al. (1974) and Usberti and Jain (1978). Goud and Lakshmi (1977) also reported wide range of phenotypic variation in yield components in finger millet. The existence of such varietal diversity offers much scope for formulating effective breeding programmes.

The variability available in a population can be partitioned into heritable and non heritable components with the aid of genetic parameters like genotypic coefficient of variation, heritability, genetic advance and genetic gain. The genotypic coefficient of variation provides a valid basis for comparing and assessing the range of genetic diversity for quantitative characters. Phenotypic coefficient of variation measures the extent of total variability. In the present study, the phenotypic coefficients of variation were higher than the respective genotypic coefficients of variation for all the 13 characters studied indicating higher influence of environment over the expression of these characters.

Large values of genotypic coefficient of variation were observed for green fodder yield per hill, number of panicles per plot, Leaf Area Index and leaf: stem ratio. This indicates that variation in genotype contributed markedly to the total variability for the above characters. The high genotypic coefficient of variation for these characters in the present study suggest that they can be given priority for selection programmes in guinea grass. Such high genotypic coefficient of variation for fodder yield was reported by Phul et al. (1972) in fodder oats, Sangha and Singh (1973) in bajra, Rana et al. (1976) in forage sorghum, Dhanakodi (1980) in ragi and Sreenivasan (1983) in guinea grass. Substantially high genotypic coefficient of variation for Leaf Area Index and leaf: stem ratio were reported by Sreenivasan (1983) in guinea grass and for panicle number by Subramaniam (1979) in little millet (*Panicum miliare*).

5.2. Heritability and genetic advance

With the help of genotypic coefficient of variation alone, it is not possible to estimate the amount of heritable variation. Burton (1952) suggested that genotypic coefficient of variation along with heritability would provide a better understanding of the amount of advancement to be expected by phenotypic selection.

In the present study, majority of characters had medium to high heritability, suggesting less influence by the environment. The highest value of heritability was recorded by number of panicles per plot. Moderately high heritability was shown by leaf: stem ratio on fresh weight and dry weight bases, green fodder yield per hill, Leaf Area Index and plant height. The influence of environment was minimum on these characters. Similar reports of high heritability for number of panicles was made by Shankar (1986) in finger millet. Moderate to high heritability for fodder yield was reported by Phul et al. (1972) in fodder oats, Sangha and Singh (1973) in pearl millet, Yadav et al. (1976) in *Dichanthium annulatum*, Jhorar and Paroda (1976) in forage sorghum, Tyagi et al. (1977) in fodder oats, Sethi and Singh (1978) in barley and Tyagi et al. (1980) in pearl millet. High heritability value for fodder yield was reported by Gupta and Gupta (1971) in pearl millet and Rana et al. (1976) in forage sorghum. High heritability value for leaf: stem ratio was reported by Tyagi et al. (1977) in fodder oats. High heritability value for plant height was reported by Sethi and Singh (1978) in barley, Salak-Warzecha and Goral (1979) in timothy, Tyagi et al. (1980) in pearl millet and Shankar (1986) in finger millet. High heritability for polygenically controlled characters is useful to plant breeders for making effective selection.

Johnson et al. (1955) suggested that heritability in conjunction with genetic advance is more effective and reliable in predicting the resultant effect of selection than heritability alone. Panse (1957) has suggested that high values of heritability and genetic advance together indicated the additive gene action for the character. In the present study, number of panicles per plot recorded high genetic gain. Leaf: stem ratio on fresh and dry weight bases, green fodder yield per hill and Leaf Area Index recorded moderately high genetic gain. Moderately high heritability and genetic gain for the above mentioned characters indicate that these traits are predominantly governed by additive gene effects and selection would be most effective for genetic improvement of these traits in guinea grass. Moderately high genetic gain for green fodder yield per hill suggests the evolution of high fodder yielding genotypes through mass selection for this character. High values of genetic gain for fodder yield were reported by Phul et al. (1972) in fodder oats, Sangha and Singh (1973) in pearl millet, Yadav et al. (1976) in *Dichanthium annulatum*, Jhorar and Paroda (1976) in forage sorghum, Tyagi et al. (1977) in fodder oats and Tyagi et al. (1980) in pearl millet. Tyagi et al. (1977) reported reasonably high genetic gain for leaf: stem ratio in fodder oats. Sethi and Singh (1978) recorded high genetic gain for leaf area in barley.

High values of genotypic coefficient of variation, heritability and genetic gain were obtained for the yield components such as green fodder yield per hill, Leaf Area Index, number of panicles per plot and leaf: stem ratio. Selection for these characters will therefore be effective for improvement of this crop. In the present study, the heritability estimate for plant height was comparatively high but the genetic gain for this character was low. The estimate of high heritability does not always signify an increased genetic advance (Johnson et al., 1955). High heritability values associated with low genetic gain is attributed to the presence of non-additive gene effects which include epistasis, dominance and genotype x environment interaction as well (Panse, 1957).

5.3. Correlation

Yield is a complex character since it is the combined expression of many other associated characters. It is an example of integration in which the components of yield are partially independent in their development. Therefore, an estimation of the inter-relationship between yield and yield contributing characters is vital. This would facilitate effective selection for simultaneous improvement of one or more yield contributing components. Moreover, indirect selection for one or more components of yield is more effective than direct selection for yield itself.

The intensity and direction of association between characters can be measured by genotypic and phenotypic correlation coefficients (Mode and Robinson, 1959). A knowledge of phenotypic correlation of metric characters with each other and especially with yield is useful in designing effective breeding programmes. Genotypic correlation provides a reliable measure of genetic association between the characters and help to differentiate the vital associations useful in breeding from the non-vital ones (Falconer, 1981). A knowledge of genotypic correlation between characters is also of theoretical interest, because it may arise from genetic linkage, pleiotropy or from developmentally induced relationships between components that are indirect consequences of gene action (Stebbins, 1950).

In the present study, genotypic correlation coefficients were slightly higher than the respective phenotypic correlation coefficients. This indicates the masking effect of the environment to the total expression of the genotype. These results are in agreement with the reports of Dhanakodi (1980) in ragi.

5.3.1. Correlation between green fodder yield per plot and its components

In the present study green fodder yield per plot was found to be positively correlated with all characters except plant height, number of panicles per plot, content of chlorophyll 'a' and 'b' and total pigments. This indicated that majority of the yield components chosen for the study may probably be directly associated with fodder yield. Improvement in any one of these characters will lead to an increase in fodder yield per plot.

Leaf Area Index had high positive correlation with green fodder yield, which underlines the paramount role of longer and broader leaves in augmenting the fodder yield. Similar correlation had been reported in guinea grass by Sreenivasan (1983) and in several other crops like sorghum (Wakankar et al., 1970; Patel et al., 1973; Singhania et al., 1977 and Vaithialingam, 1979), fodder oats (Mehra, 1971 and Nair and Gupta, 1977), rye grass (Rhodes, 1972), and in pearl millet (Tyagi et al., 1980). The strong and positive correlation between green fodder yield and Leaf Area Index may be explained on the basis of the 'source-sink' relationships. The leaf area provides the photosynthesising surface which serves as the 'source' for assimilates. This assimilates get accumulated in the vegetative plant parts and also contribute to the production of more 'source' viz., leaf area. As leaf area increases, the biomass accumulation also get increased in a linear order which may lead to higher production.

Dry matter yield had high positive association with green fodder yield. This suggested true genetic relationship between these traits. Similar significant associations in biomass accumulation were reported by Sotomayor Rios et al. (1971) in *Digitaria*, Jhorar and Paroda (1976) and Vaithialingam (1979) in sorghum, Fujimoth and Susuki (1976) in Italian rye grass, Murtaza et al. (1979) in oats, Tyagi et al. (1980) in pearl millet, Sreenivasan (1983) in guinea grass and Bainiwal et al. (1983) in barley. This correlation suggests that succulence and water content are similar in the different varieties tried.

Leaf: stem ratio exhibited positive association with green fodder yield per plot. Vasudeva Rao and Ahluwalia (1977) observed similar correlations in sorghum. This indicates that leafy varieties contribute to high fodder yield and hence this character has to be given priority in selection.

Positive correlation was also reported between tiller number per hill and green fodder yield per plot. This indicates that the tiller number fully contributes to fodder yield. Many previous workers have reported similar results in other cereal fodders like fodder bajra (Gupta and Nanda, 1971; Saxena et al., 1978 and Tyagi et al., 1980), sorghum (Jhorar and Paroda, 1976), barley (Sethi and Singh, 1978), fodder oats (Nair and Gupta, 1977; Dhumale and Mishra, 1978; Murtaza et al., 1979 and Singh et al., 1980) and also in grass fodders like sorghum-sudan grass hybrid forage (Hussain and Khan, 1973), blue panic grass (Vaidyanathan, 1973), genus Cenchrus (Ramaswamy, 1974 and Jatasra and Thakral, 1986), Dichanthium annulatum (Yadav et al., 1976), Italian rye grass (Fujimoth and Susuki, 1976), Festuca pratensis (Titov et al., 1978), smooth brome grass (Tan et al., 1979), timothy (Salak-Warzecha and Goral, 1979) and Pennisetum pedicellatum (Singh and Prasad, 1976). Contrary to these, a negative correlation between these two characters was reported by Sreenivasan (1983) in guinea grass.

Positive correlation exists between green fodder yield per hill and green fodder yield per plot. Fodder yield per plot can be enhanced by having better hills with high green fodder yield. This suggests the possibility of simultaneous improvement of these two characters.

Plant height, number of panicles per plot, chlorophyll 'a' and 'b' and total pigments had negative correlations with green fodder yield per plot. The negative correlation of plant height and green fodder yield per plot may be explained as the logical results of negative correlation between plant height and number of tillers per hill. Taller varieties have lesser number of tillers and thus low fodder yield per plot. Similar correlation was reported by Sood (1975) in forage sorghum. But contrary to this, many previous workers reported a strong positive correlation between these two traits in other cereal fodders like sorghum, bajra, barley, oats and in some other grass fodders. Number of panicles per plot also showed negative correlation with green fodder yield per plot. Varieties that have lesser number of panicles per plot at the time of harvest possess a longer vegetative phase thereby helping to accumulate more assimilate, which finally contributed to increased fodder yields. These results indicate that medium tall, non flowering or shy flowering types will give higher green fodder yield per plot.

Chlorophyll 'a' and 'b' and total pigments showed negative correlation with green fodder yield. Ostgard (1971) observed in Phleum pratense, Festuca pratense, Dactylis glomerata and Poa pratensis that chlorophyll content per unit leaf area was least in varieties with the highest growth rate. The shady environment under which the experiment was grown might also have contributed to such anomalous correlations.

5.3.2. Correlation among the yield components

Data on inter-relationships among the yield components revealed more reliable information over a mere knowledge of association between yield and its components. The yield components exhibited varying trends of association among themselves. In the present study, the inter-relationships among dry weight, green fodder yield, tiller number per hill, leaf: stem ratio and leaf area index were high and positive at genotypic level. This suggests the possibility of simultaneous improvement of these characters from a selection programme involving any one of these traits.

Negative correlation was observed between plant height and number of tillers per hill. This indicates that taller varieties have lesser number of tillers. Similar results had been reported by Patnaik (1968) and Goud and Lakshmi (1977) in finger millet, Gill and Randhawa (1975) in fox-tail millet, Jhorar and Paroda (1976) in forage sorghum, Salak-Warzecha and Goral (1979) in timothy, Murtaza et al. (1979) in oats, Subramaniam (1979) in little millet and Bainiwal et al. (1983) in barley.

Plant height showed negative correlation with leaf: stem ratio. This may be attributed to the fact that as height increases the weight of stem also increases. Similar correlation had been reported in ragi by Dhanakodi (1980), in sorghum by Vaidyanathan (1982) and in <u>Cenchrus ciliaris</u> by Jatasra and Thakral (1986). Plant height also showed negative correlation with dry matter yield. This finding was in accordance with the results obtained by Subramaniam (1979) in little millet. Plant height showed negative correlation with Leaf Area Index. But many previous workers reported positive association between these characters. It may be the shady environment that contributed to this anomalous correlation.

Number of tillers per hill recorded negative association with number of panicles per plot at the genotypic level, but these two characters showed positive association at the phenotypic level. Positive association of number of tillers and panicle number at the phenotypic level was recorded by Dhanakodi (1980) in ragi.

Positive correlation was observed between number of tillers per hill and leaf: stem ratio. This finding was in confirmity with the results obtained by Dhanakodi (1980) in ragi. Number of tillers also showed positive association with Leaf Area Index. Positive association of tiller number and leaf area was reported by Mehra et al. (1971) in oats. When the number of tillers increases, the number of leaves also increases and thus there is a higher leaf: stem ratio and high value for Leaf Area Index.

Number of tillers per hill and dry matter yield showed positive correlation. Similar results had been reported by Sethi and Singh (1978) in barley, Salak-Warzecha and Goral (1979) in timothy, Murtaza et al. (1979) in oats, Subramaniam (1979) in little millet and Jatarra and Thakral (1986) in *Cenchrus ciliaris*.

In the present study, Leaf Area Index showed high positive correlation with dry matter yield. Similar findings have been reported in winter wheat (Aase, 1978), oats (Rao et al., 1978) and in guinea grass by Sreenivasan (1983). Yoshida (1972) suggested that greater dry matter production could be expected in erect genotypes provided Leaf Area Index is large.

Leaf: stem ratio also showed positive association with dry matter yield. This was in agreement with the findings of Sreenivasan (1983) in guinea grass itself. In the present study, Leaf Area Index and leaf: stem ratio are correlated to each other. Sreenivasan (1983) also obtained similar results in guinea grass.

The content of chlorophyll 'a' and 'b' are inter-correlated. Both showed positive correlation with the content of total pigments. Significant correlation between chlorophyll 'a' and 'b' had been reported in pearl millet by Phul et al. (1974). Since number of tillers per hill, leaf: stem ratio, Leaf Area Index, green fodder yield per hill and dry matter yield showed high magnitude of correlation with green fodder yield per plot and among themselves, selection can be based on these characters for improving fodder yield in guinea grass.

5.4. Path analysis

Coefficients of correlation indicate the intensity and direction of character associations in a crop. The inter-relationships of component characters of yield provide information about the likely consequences of selection for simultaneous improvement of these characters. This situation is further explicable by path analysis proposed by Wright (1921) and illustrated by Dewey and Lu (1959). It is an efficient biometric tool throwing light on the contribution (direct effect) of a character to the yield and also its influence (indirect effect) through other characters.

Many workers have utilised path analysis to measure the degree of influence of the component characters on fodder yield of several fodder crops. In the present study, the relative contribution of different characters towards fodder yield and the co-ordinated relationship existing among these traits were determined by taking the fodder yield and five of its component characters in guinea grass and subjecting them to path analysis. Out of these five component characters, four characters (green fodder yield per hill, leaf: stem ratio on fresh weight basis, tiller number per hill and plant height) exhibited positive direct effect on green fodder yield per plot. Leaf Area Index showed negative direct effect.

The maximum direct contribution to green fodder yield per plot is through green fodder yield per hill. This was followed by leaf: stem ratio on fresh weight basis, number of tillers per hill and plant height. The correlation of green fodder yield per hill and green fodder yield per plot was high and positive. This is due to the total effect of its direct contribution and its indirect effect through leaf: stem ratio on fresh weight basis.

The positive correlation between green fodder yield per plot and leaf: stem ratio on fresh weight basis may be due to the direct effect of this character on green fodder yield per plot and also due to the indirect effect through green fodder yield per hill. The direct effect of tiller number on green fodder yield per plot and indirect effect through leaf: stem ratio on fresh weight basis contributed to the higher correlation of green fodder yield per plot and number of tillers per hill. The positive direct effect of tiller number and fodder yield was in confirmity with the findings of Ramaswamy (1974) in _Cenchrus ciliaris_ and _Cenchrus setegerus_, Tan et al. (1979) in smooth brome grass, Murtaza et al. (1979) in fodder oats, Tyagi et al. (1980) in pearl millet, Dhanakodi (1980) in ragi and by Sreenivasan (1983) in guinea grass.

Positive direct effect of plant height on fodder yield was in confirmity with the findings by Patel et al. (1973) and Pokle et al. (1973) in sorghum, Singh and Prasad (1976) in _Pennisetum_ _pedicellatum_, Dhumale and Mishra (1978) in forage oats and by Sreenivasan (1983) in guinea grass.

The correlation of plant height on green fodder yield per plot was negative, though its direct effect is positive. This negative correlation may be due to the negative indirect effects through number of tillers per hill, leaf: stem ratio on fresh weight basis and green fodder yield per hill. Plant height and number of tillers were negatively associated which was evident from the fact that the taller varieties produced lesser number of tillers.

Leaf Area Index had positive correlation with green fodder yield per plot. But, its direct effect on green fodder yield per plot is negative. It has got high positive indirect effects on green fodder yield per plot through green fodder yield per hill and leaf: stem ratio on fresh weight basis.

From the above findings, it can be concluded that, green fodder yield per hill contributed maximum to green fodder yield per plot. Leaf: stem ratio on fresh weight basis directly contributed to green fodder yield per plot. Leaf Area Index had positive indirect effect on green fodder yield per plot through leaf: stem ratio on fresh weight basis and green fodder yield per hill.

In the present study comparatively high values of genotypic coefficient of variation, heritability and genetic gain and also positive correlation with green fodder yield per plot and positive direct and indirect effect on green fodder yield per plot were recorded by three characters viz., green fodder yield per hill, leaf: stem ratio on fresh weight basis and Leaf Area Index. As such in the genetic improvement programme aiming higher productivity, these three characters should be given prime importance.

SUMMARY

SUMMARY

The present investigation was undertaken at the Department of Plant Breeding, College of Agriculture, Vellayani during June to December, 1987. Fifteen types of guinea grass were evaluated under partial shade conditions in coconut gardens. Observations were made on plant height, number of tillers per hill, number of panicles per plot, leaf: stem ratio on fresh weight and dry weight bases, green fodder yield per hill and per plot, dry matter yield and photosynthetic efficiency, Leaf Area Index, chlorophyll 'a' and 'b' and total pigments from each of the fifteen types under study. Variability, correlation and path analysis were studied.

The varieties selected for the investigation exhibited significant differences for all the characters studied except for dry matter yield per plot, chlorophyll 'a' and 'b' and total pigments. This indicated that considerable amount of variability existed among them. The mean values for almost all the important yield contributing characters were more for the variety MC-14 and thus found to express the maximum production potential under partial shade in Coconut gardens.

Green fodder yield per hill and Leaf Area Index were found to exhibit considerable variability both at phenotypic and genotypic levels indicating that these characters are

potentially variable. Analysis of variance also revealed that the expression of almost all the character is affected by environment. Large values of genotypic coefficient of variation were recorded by green fodder yield per hill, number of panicles per plot, Leaf Area Index and leaf: stem ratio on dry weight and fresh weight bases. The lowest genotypic coefficient of variation was observed for chlorophyll 'a' content.

Genotypic coefficient of variation along with heritability would give a better understanding of the amount of advance expected by phenotypic selection. In general, the heritability estimates were medium to high for most of the characters. Very high value of heritability was recorded for number of panicles per plot followed by leaf: stem ratio and plant height. Green fodder yield per hill and Leaf Area Index also recorded moderately high heritability. The high heritability values for the above characters indicate the minimum influence of environment on these characters.

Heritability in conjunction with genetic advance is more effective and reliable in predicting the resultant effect of selection than heritability alone. High values of heritability and genetic advance together indicate additive gene action for the character. Number of panicles per plot recorded high heritability coupled with high genetic gain. Leaf: stem ratio on dry weight basis, leaf: stem ratio on fresh weight basis, green fodder yield per hill and Leaf Area Index recorded moderately high heritability and genetic gain.

Comparatively high values of genotypic coefficient of variation, heritability and genetic gain were recorded for the yield components such as green fodder yield per hill, leaf: stem ratio and Leaf Area Index. Therefore selection for these characters will be effective. Eventhough plant height had high heritability, the expected genetic gain was low. This may be due to the non-additive gene effect and genotype x environment interaction.

An estimate of inter-relationships between green fodder yield per plot and yield contributing characters is vital because this would facilitate effective selection, for simultaneous improvement of one or more of the yield components. The intensity and direction of association were measured by genotypic and phenotypic correlation coefficients.

The genotypic correlation coefficients were slightly higher than the phenotypic correlation coefficients which indicated the masking effect of the environment in the total expression of the genotypes. There was positive genotypic correlation of green fodder yield per plot with tiller number per hill, green fodder yield per hill, dry matter yield, leaf: stem ratio and Leaf Area Index. Plant height, number of panicles per plot, chlorophyll 'a' and 'b' and total pigments exhibited negative genotypic correlation with green fodder yield per plot. Hence simultaneous improvement of these characters and green fodder yield per plot is rather difficult through simple selections. The yield components also exhibit varying degrees of association among themselves.

Path analysis revealed that the maximum direct effect on green fodder yield per plot was exerted through green fodder yield per hill. Leaf: stem ratio on fresh weight basis, number of tillers per hill and plant height also exhibited positive direct effect on fodder yield. Leaf Area Index exhibited negative direct effect and positive indirect effects through green fodder yield per hill and leaf: stem ratio on fresh weight basis on green fodder yield per plot. So green fodder yield per hill, leaf: stem ratio on fresh weight basis and Leaf Area Index are to be given importance in selection programmes.

In the present study high values of genotypic coefficient of variation, heritability, genetic gain and positive correlation with green fodder yield per plot and positive direct and indirect effect on green fodder yield per plot were recorded by characters such as green fodder yield per hill, leaf: stem ratio on fresh weight basis and Leaf Area Index. Hence these characters are to be given prime importance in breeding programmes.

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PRODUCTION POTENTIAL OF GUINEA GRASS CLONES UNDER PARTIAL SHADE IN COCONUT GARDENS

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ABSTRACT OF A THESIS
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ABSTRACT

A research programme was carried out at the Department of Plant Breeding, College of Agriculture, Vellayani, during June to December, 1987 with the objective of evaluating the expression of production potential of guinea grass clones under partially shaded conditions in coconut plantations through estimation of genetic variability, correlation of green fodder yield and other components and the direct and indirect effects of different components on green fodder yield. Fifteen varieties of guinea grass were evaluated under partially shaded conditions in the inter spaces of coconut plantation, adopting a randomised block design replicated thrice. Data on thirteen characters were recorded and subjected to analysis of variance and covariance. The genotypic and phenotypic coefficient of variation, heritability in the broad sense, genetic advance and genotypic and phenotypic correlations were estimated. Path analysis was conducted using green fodder yield per plot as the effect and five component characters as the cause.

Analysis of variance revealed significant differences among the varieties for plant height, number of tillers per hill, number of panicles per plot, leaf: stem ratio on fresh weight and dry weight bases, green fodder yield per hill and

per plot, dry matter yield per hill and Leaf Area Index. Analysis of variance for chlorophyll pigment contents (chlorophyll 'a', 'b' and total pigments) and dry matter yield per plot revealed that there was no significant difference among the varieties. High genotypic coefficients of variation, moderate to high heritability and genetic gain were recorded for the yield components viz., green fodder yield per hill, leaf: stem ratio and Leaf Area Index suggesting the reliability of these characters during selection programmes for the improvement of this crop. Green fodder yield per plot recorded high positive genotypic correlation with tiller number per hill, green fodder yield per hill, dry matter yield, leaf: stem ratio and Leaf Area Index.

Path analysis revealed that green fodder yield per hill had the maximum direct contribution for green fodder yield per plot, followed by leaf: stem ratio on fresh weight basis, number of tillers per hill and plant height. Leaf Area Index exhibited negative direct effect and positive indirect effect through green fodder yield per hill and leaf: stem ratio on fresh weight basis on green fodder yield per plot. It can be suggested that an ideal plant type of guinea grass for cultivation under partially shaded conditions should have high Leaf Area Index with more number of leaves resulting in high green fodder yield per hill. Thus green fodder yield per hill, leaf: stem ratio on fresh weight basis and Leaf Area Index may be considered in breeding programmes for developing high fodder yielding guinea grass varieties suited to partially shaded conditions of coconut plantations.