SHADE TOLERANCE OF GUINEA GRASS var. *MACKUENII* UNDER DIFFERENT LEVELS OF POTASSIUM

BY

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DECLARATION

I hereby declare that this thesis entitled "SHADE TOLERANCE OF GUINEA GRASS VAR. MACKUENII UNDER DIFFERENT LEVELS OF POTASSIUM" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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C E R T I F I C A T E

Certified that this thesis entitled "SHADE TOLERANCE OF GUINEA GRASS VAR. MACKUENII UNDER DIFFERENT LEVELS OF POTASSIUM" is a record of research work done independently by Sri. P. Mullakoya, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

India has the largest cattle population in the world accounting for 179 million cattle and 58 million buffaloes. Though we have a huge cattle wealth, the main problem facing animal husbandry in India is the extremely low production of good quality fodder.

The situation in Kerala is still worse. The state is having a cattle population of 3.33 million (1972 census). The requirement of roughages is estimated to be 56.1 lakh tonnes whereas the present production is only 43 lakh tonnes, of which 80 per cent constitutes poor quality Paddy straw (Anon, 1977). Thus there is a deficit of 13 lakh tonnes or 23 per cent of the total requirement. Hence all efforts should be oriented to produce sufficient quantity of nutritive green roughage to meet the requirement of cattle without encroaching the area under other crops.

The area under fodder crops in Kerala is estimated to be 7000 hectares which constitutes only about 0.02 per cent of the gross area sown, while it is 13.03 per cent in Punjab and 11.09 per cent in Rajasthan. Because of the extreme pressure exerted on the cultivated land by other crops, increasing the area for fodder cultivation is a remote possibility. As such a viable alternative is to intensify the production per unit area and utilise the inter spaces of coconut plantations for the cultivation of fodder crops.

There are altogether 7.5 lak hectares of land under coconut in Kerala State and if 1.5 lakh hectares are brought under fodder intercropping, the present deficit of 23 per cent in green fodder can be made up.

Research work on multiple cropping in coconut gardens was taken up only by 1970, though the practice of cultivating crops in the inter spaces of coconut had been a common practice in Kerala. Early studies conducted at the Central Plantation Crops Research Institute, Kasargode, indicated that there is enough scope for intensifying intercropping in coconut garden as the coconut roots actively exploit only about 20 to 25 per cent of land area. However, success of this sort of inter and mixed cropping had been highly variable. The success of crop combination arise mainly out of variation in the competition between crops for the three basic inputs of production viz., light, water and nutrients. The competition of these three factors is reflected both in terms of decrease in yield of the main crop and also in terms of poor performance of associated crops mainly due to competition for light.

Preliminary studies conducted at the Central Plantation Crops Research Institute have indicated that the amount of light that filters through the coconut canopy is markedly affected by the age of coconut palms. It has been estimated that light infiltration can range from as low as 10 per cent to as much as 70 per cent depending upon the age of the palm in a space planted coconut garden. Based on this indication, the general recommendation had been that multiple cropping in coconut garden can be taken up before the 10th year and after 20th year of planting. Even so, the illumination intensity in the inter spaces of coconut palms still shows wide variations from about 20 to 70 per cent. In anticipation of getting reasonable and profitable returns from the associated crop, the general recommendation again can be to grow shade loving and shade tolerant plants in situatinns of higher shade intensity.

Studies conducted under the All India Co-ordinated Project for Research on Forage Crops at Vellayani revealed that many of the tropical grasses are suitable for growing as intercrop in coconut plantations. Guinea grass (Panicum maximum. J) is one among such grass species. It is a native of tropical Africa which was introduced in India in 1870 and is well suited to the Agro-climatic conditions of the state. It is a fairly drought resistent perennial crop suitable for growing under rainfed conditions and very well relished by cattle.

Grassland production consists essentially of the conversion by solar energy of atmospheric CO_2, soil nutrients and water into herbage. The basic climatic factor limiting production is the seasonal input of solar energy, but in practice, the utilization of solar energy may itself be limited by other climatic factors such as low temperature, water stress and shortage of soil nutrients particularly nitrogen. Light provides the energy for photosynthesis and hence for plant growth, but the effect of a particular energy input will be influenced by both its intensity and duration. In general, the longer the period over which a given amount of energy is spread during the 24 hour day, the more efficient is its conversion through photosynthesis. In addition to this the duration can also have important morphogenetic effects. In tropical grasses assimilation and growth continues to increase as light intensity increases to values of 60,000 lux or more.

Grassland farming in Kerala is being done in the existing plantations of varying age groups. The amount of light falling on the ground also varies according to age of the palms. Guinea grass var. Mackuenii is the most popular strain under cultivation in the state. Information on the shade tolorance of this variety and also its ability to utilize potash for herbage production has not been investigated in any of the tropical countries. Hence, the present investigation was taken up with the following objectives.

(1) To assess the fodder production potential of Guinea grass var. Mackuenii under varying intensities of light.

(2) To find out the maximum intensity of light for obtaining optimum fodder yield.

(3) To assess the potassium requirement of guinea grass under different intensities of light.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A. Effect of shade levels

Experimental evidences on the response to varying intensities of light in the case of plants cultivated as intercrops in Kerala are very meagre. The literature available on Panicum maximum are relatively scanty in this aspect. Hence works done under shaded conditions with common agriculturally important tropical crops are reviewed in this chapter. In many experiments the levels of shade or light intensity tried are not clearly available and highly variable, and wherever the shade levels are mentioned these are included in review and in other cases overall effects of shade, irrespective of its intensity are presented.

The review is given classifying the effect of shade on the following characters.

1. Plant height

Results of research in respect of plant height under shaded condition varied from crop to crop. Increase in plant height may be positive as in turmeric, coleus, ginger, tobacco and cowpea or negative as in grain sorghum or positive, negative or neutral as in tomato.

Panicker et al. (1969) noticed an increase of 35.2 per cent in the hight of tobacco plants under shade as compared to unshaded plants. Aclan and Quisumbing (1976) observed that ginger plants grown under full sunlight were shorter than those grown in shade. Tarila et al. (1977) reported that in cowpea, higher light intensity reduced plant height.

The height of grain sorghum plants was found to decrease with increasing levels of shade from 0 - 50 per cent (Palis and Buatrillos, 1976).

Cooper (1969) observed in the case of tomato that shading either decreased or had no effect on mean stem extension rate. It was also noticed that the effect of shade on plant height was either positive, negative or neutral depending on the time of year and age of the plant.

2. Number of tillers

Duggar (1903) elucidated that plants under shaded conditions exhibited reduced number of branches. Under shade the peach plants produced only lesser number of branches which were willowy and slender (Gourley, 1920). Beinhart (1963) observed that increased light intensity resulted in increased branching in white clover. Tarila et al. (1977) reported increased branching in the case of cowpea due to higher light intensity.

Lalithabai (1981) in an experiment with different crops viz., sweet potato, coleus, colecasia, turmeric and ginger observed that the number of branches in all the the crops significantly decreased with increasing levels of shade.

3. Leaf development

Research works in this line have shown positive results in leaf expansion and negative response in leaf thickening. In the case of total leaf area, in apple and tomato, there were increases because of shading.

Rolfs (1903) reported that citrus plants grown under 50 per cent shade developed thinner leaves with a greater leaf area. In many horticultural plants, Clark (1905) observed that for leaf development, low light intensity was most favourable and intense light caused decreased leaf growth resulting in smaller and thicker leaves. Gourley (1920) reported that in apple, shading resulted in the production of loosely packed mesophyll tissues and thinner epidermal cells in leaves and increased leaf area. Increased leaf area consequent to shading had also been reported by Porter (1937) in tomato plants. Hardy (1958) studied the nature of leaves of cocoa seedlings under varying intensities of light and observed that leaves produced under heavy shade were much larger, often attaining a length of 20 to 24 inches and were thinner, heavier and contained larger proportions of water. In general, the leaves of shaded plants were thinner showing development of palisade tissue and spongy mesophyll cells (Boardman, 1977).

Beinhart (1963) claimed that increased light intensity resulted in greater leaf area in clover though the mean number of leaves produced per plant remained non-significant. Panikar et al. (1969) observed that in tobacco length and breadth of leaves were increased by 15.1 and 17.6 per cent respectively under shade as compared to unshaded plants. Schoch (1972) reported that the shade increased leaf surface, cell division and cell expansion in Capsicum annum. Such results were reported by Crist and Stout (1929). It was also observed that shade decreased the number of stomata per mm^2 and percentage of stomata in relation to other cells. Crookston et al. (1975) in an experiment found that shading reduced leaf number, area and thickness in itchgrass (Rottboelia exalata L.F) a noxious weed. Patterson (1979) stated that leaf area production was not severely retarded by shading, the plants grown at 2, 25 and 60 per cent sunlight had respectively 1.7, 42 and 99 per cent of leaf area of the plants grown at full sunlight. In another experiment with three ecotypes of gogon grass (Imperata cylindrica) grown under three light intensities viz., 100, 56 and 11 per cent of full sunlight Patterson (1980) reported that after 89 days, the plants of all ecotypes produced, on an average three times as much leaf area in full sunlight as in 56 per cent full sunlight and 20 times as much as in 11 per cent full sunlight. In a 30 year old trinitario cocoa plantation Boyer (1970) observed that the flushing intensity, leaf number and total foliar surface per tree were greater in unshaded trees than those under light or moderate shade.

Tarila et al. (1977) reported that in cowpea, higher light intensity improved leaf area and plant size. Radha (1979) observed that number of leaves in pineapple was not influenced by shading.

4. Chlorophyll content

Most of the research results have shown that chlorophyll content per unit weight of leaf increases under shaded conditions than in the open as reported in the case of crops like cocoa, tea, strawberry, bean, alfalfa, birdsfoot trefoil etc. But the chloroplast content per unit leaf surface has been found to decrease with shading as in alfalfa, birdsfoot trefoil and some other plants. In crops like cowpea and wheat increasing shade intensities have been found to decrease the chlorophyll content per unit leaf weight. Changes in the position of chloroplast according to the differences in light intensity have also been reported.

Clark (1905) observed that in the case of strawberry direct sunlight of high intensity resulted in the destruction of chlorophyll. Increased chlorophyll content was noticed in the leaves of shaded cocoa plants (Evans and Murray, 1953, Guers, 1971). Similar observations were made by Ramaswami (1960) and Venkitamani (1961) in the case of tea. Khossien (1970) noticed reduction in the leaf pigment at high intensity of light in the case of bean plants. Radha (1979) observed that chlorophyll a, b and total chlorophyll content of leaves were found to increase as the intensity of shade increased in pineapple. Okali and Owusu (1975) noticed that, in cocoa plant, the chlorophyll content for unit leaf (fresh) weight was significantly greater in deep shade. Chlorophyll content per unit weight of leaf was found to increase in the case of plants grown at lower light intensities, but chlorophyll content per unit area of leaf surface was very often lower than the plants grown in open (Bjorkman and Holmgren, 1963). Similar observations were recorded by Cooper and Qualls (1967) in the case of alfalfa and birdsfoot trefoil.

Contrary to the above reports, in the case of cowpea, Higazy et al.(1975) observed that concentration of total chlorophyll as well as its components 'a' and 'b' decreased by increasing shade intensity. Moursi et al. (1976a) observed that all pigments decreased significantly with increasing shade intensities viz., 100, 60, 40 or 20 per cent full sunlight. But the ratio of chlorophyll a:b remained constant at all shade intensities.

Baker et al. (1973) observed that at high light intensities photosynthetic rate per unit chlorophyll in the case of cocoa leaf was found to be highest for leaves in the open which suggested that photosynthetic efficiency was increased by growth in full day light.

Lalitha Bai (1981) observed in the case of five crops viz. coleus, colacasia, turmeric, ginger and sweet potato, that the effect of shade on chlorophyll 'a', 'b' and total chlorophyll in leaves was significant in all crops except sweet potato.

While discussing the biology of living chloroplast, Priestly (1929) stated that the chloroplast in leaves would undergo changes in position according to the differences in light intensity. It was pointed out that in leaves of plants grown under lower light intensities, the plastids were limited in number and they were arranged at right angles to the light rays and were larger in size, thus increasing area for light absorption.

In an experiment conducted by Kopylova (1978) on effect of solar radiation on yield of wheat under different nutritional regimes, has stated that application of nutrients increase absorption of solar radiation and grain yield from 1.67 to 2.76 t ha^{-1}. Applied N increased leaf contents of pigments especially chlorophyll, but had no significant effect on pigment composition.

5. Photosynthesis and Dry matter accumulation

Photosynthesis and dry matter accumulation have been reported to be adversely affected by shading in many of the plants, while in the case of ginger positive influence was reported. The extent of decline in dry matter accumulation was however, varying between plants. In the case of pineapple, there was no appreciable decrease in dry matter accumulation upto 75 per cent shading.

Singh (1967) reported that exposure of ginger to intense light is deterimental to photosynthesis. According to Wilson and Cooper (1969) leaf anatomy studies showed that intensity of light during growth did not effect mesophyll cell size, but that stomatal size was decreased by decrease in light intensity during growth. Pears and Leedr (1969) in an experiment of growing Lucern plants in growth characters under high and low level light intensities (32 - 43 K lux and 13 - 14 K lux) have shown that specific leaf weight and net photosynthesis were greater under high light intensity than under low light intensity.

According to Minoru and Hori (1969) Zingiber mioga, Rose. requires a saturating light intensity of 200 kilo lux. In the trial on potted arabica coffee seedlings shaded to provide 25, 50 or 75 per cent light, Silveira and Maestri (1973) found that the best growth (as measured by the dry matter production) was with 50 per cent light. Radha (1979) noticed comparable dry matter accumulation in the leaves of pineapple both in shade and in the open upto flowering stage. It was also seen that the reduction in total dry matter accumulation was not considerable in spite of shading upto 75 per cent. Wong and Wilson (1980), from studies on the effect of shading to 100, 60 and 40 per cent of full sunlight on the growth of green panic grass and siratro in pure and mixed awards defoliated at 4 weeks, and 8 weeks stage reported that individual leaves of shaded green panic had greater photosynthetic activity than these from full sunlight.

It was reported by Duggar (1903) that shading either partially or completely reduced the carbon dioxide assimilation and thereby the available constructive materials for plants. In tomato plants, Porter (1937) observed that total amount of photosynthates decreased with decrease in light intensity. Benedict (1941) reported that plants of Agropyron cristatum, Agropyron smithi and Boutelova gracilis fgrown in shade had smaller dry weight. Myhr and Saebo (1969) from the trial on the effects of shade on growth, development and chemical composition in some grass species observed that shading greatly reduced dry matter content in Festuca rubra Lolium perenne Phleum pratense, Agrostids tenuism and Poa palustris.

In shade experiment with cogon grass Patterson (1980) observed that after 89 days, the plants of three ecotypes produced on an average three times as much total dry weight in full available sunlight as in 56 per cent full light and 20 times as much in 11 per cent full light. The plants from the shaded and exposed habitats generally did not differ significantly in their responses to shading. Wong and Wilson (1980) reported that leaves of shade grown siratro had a lower photosynthetic potential than in the full sunlight treatment.

6. Growth analysis

Various works done shows that effect of shade on leaf area index (LAI) of plants varied widely. In the case of green panic response was positive, while in siratro, it was negative. In cocoa, net assimilation rate (NAR) was not influenced by shade in one of the experiment whereas in another decrease in NAR with increasing shade was reported. Also a negative response to shade in NAR in wheat had been reported. In cocoa relative growth rate (RGR) has been positively influenced by shading while leaf area ratio (LAR) showed a negative relationship.

Wong and Wilson (1980) observed an increased LAI in shaded green panic awards and a decreased LAI in shaded siratro. When a crop of grain sorghum was subjected to 0, 25 or 50 per cent shade, the LAI was found to decrease with increase in shade (Palis and Bustrillos, 1976).

Wilson and Cooper (1969) conducted a trial with 18 populations of Lolium perenne in glass house at natural winter light intensity and at approximate light saturation. At both light intensities there were significant differences between population in RGR, NAR and LAR. NAR was significantly correlated with shoot/root ratio at low light intensity.

Hardy (1958) observed lowest NAR at highest shade level and vice-versa in cocoa. In the case of cocoa seedlings, Gopinath (1981) observed that NAR was not influenced by increase in shade intensity ranging from 25 to 75 per cent.

Moursi et al. (1976b) found that the NAR of wheat decreased with increased shade intensities from 5.7 to 3.2 and from 11.9 to 0.8 g g^{-1} day^{-1} at 80 to 95 and 95 to 100 days respectively when the light intensity was brought down from 100 to 20 per cent full sunlight.

From the studies on light and fertiliser requirements of cocoa, Evans and Murry (1953) recorded greatest RGR at a light intensity between 30 to 60 per cent of full day light. Okali and Owusu (1975) observed that RGR was maximal for cocoa plants grown under medium shade.

Cooper and Qualls (1967) noticed that the increase in ratio of leaf area to leaf weight which occurs due to shading of legume (alfalfa and birds foot trefoil) was associated with changes in leaf morphology.

7. Yield and yield attributes

Reports of increases in yield consequent to shading were noted in cocoa, tomato and green panic. But at the same time general effect on shade on final yield of crops was that of decrease in the case of apple, peaches, sorghum, soyabean, cowpea and cocoa. In the case of ginger reduction in yield was reported only at very intense shade.

Edmond et al. (1964) conducted shade experiments in tomatoes and maximum yield was obtained from plants receiving only 45 per cent of full sunlight. Schmidt (1967) in an experiment with an artificially induced shade on *Zea mays* found that the yield per hectare were significantly reduced when 75 per cent to 100 per cent of solar energy available to leaves located below the ear was intercepted.

Screening trials conducted by Sahasranaman and Pillai (1976) at Kasaragod showed that the fodder grass Gautemala (*Tripsacum laxum*)hybrid napiar (Pusa Giant and NB-21) and guinea grass (*Panicum maximum*) gave a green fodder yield of 50 - 60 t ha^{-1} under coconut shade.

Fisher (1975) in an experiment have shown that crop growth in case of wheat was reduced in direct proportion to the reduction in radiation. Joseph (1979) reported that the tea clones under shade gave much higher yield than in exposed plots. Wong and Wilson (1980) from the studies on the effect of illumination at 100, 60 and 40 per cent of sunlight on the growth of siratro and green panic in pure and 50 : 50 mixture swards, defoliated every 4 (D4) or (D8) weeks, observed that shading to 60 and 40 per cent of full sunlight increased the shoot yield of green panic in pure sward by 30 and 27 per cent respectively in the D8, but reduced it in the D4 treatment by 3 and 14 per cent.

In shading experiments with tomato in which the light intensity was lowered to 50 or 25 per cent of that of the controls Sakiyama (1968) noticed that the greater the shading, the lower was the fruit weight. Boneta Garcia and Bosque Lugo

(1973) observed that more yield was obtained when coffee was grown in full sunlight than when grown in partial shade (40 per cent). Buttrose (1974) observed a decrease in the number of flower and initiated in shaded cocoa compared to unshaded cocoa. Gramen (1974) observed that decreasing the amount of photosynthetically active radiation by 40 - 60 per cent by shading in beans (Vicia faba) plants resulted in decrease with the shading of young pods. Palis and Bustrillos (1976) found that, in sorghum, grain yield and grain straw ratio decreased with increased in shading ranging from 0 to 50 per cent. Huang (1977) in a trial in which rice plants were grown with and without 90 per cent shading observed that shading decreased spikelet number per panicle by 54 per cent giving a higher proportion of degenerated spikelets.

Venkataswarlu and Srinivasan (1978) conducted a trial to study the influence, of low light intensities on rice and observed that yield loss was greatest with continual shading at 40 to 50 per cent of natural light.

Flowering of barley in natural day light was directly related to light intensity.

8. Quality of produce

Quality of crops due to shade effect varies widely. In general protein content increases and carbohydrate content decreases with shading.

Myhr and Saebo (1969) observed that in some grass species, the crude protein and ash contents were approximately doubled by shading from 10 to 15 per cent of intensity of natural light, whereas the sugar contents approximately halved, and serious lodging occurred as a result of reduction in fibre content. Shading was found to increase the concentration of total soluble and protein nitrogen in the grain tissue when 20 to 100 per cent full light was tried on wheat (Moursi et al. 1976c). Palis and Bustrillos (1976) observed in the case of grain sorghum plants subjected to 0, 25 or 50 per cent shade that protein increased while carbohydrate decreased with decrease in light. In an experiment where soyabean plants were shaded at four trifoliate leaf stage to reduce sunlight by 20, 47, 63, 80 and 90 per cent it was seen that shade had little effect on oil and protein content of seed except that protein content was highest and oil content lowest at 90 per cent shade (Wahua and Miller, 1978).

Aono et al. (1976) found that shading tea bushes to about 45 per cent light intensity with cloth screens about 60 cm above the plucking table, improved the green tea quality. It was noticed that the quality was directly related to the shade intensity and this increase in quality was the greatest in the first plucking season.

9. Nutrient content

It has seen that mineral nutrient status of plants are increasing with increase in shade in certain cops like apple, cocoa, spinach and tea. In case of soyabean on the contrary, nitrogen content was found to be positively related to illumination levels. Also adverse affects of shade on nutrient content has been reported in siratro, cocoa and pineapple.

Cunningham and Lamb (1959) in a fertiliser experiment with bermuda grass grown under shade observed that 113 lb N, 120 lb P, 90 lb K_2O and 46 lb MgO per acre were removed and shade produced 88.5 per cent increase compared with 45.5 per cent due to fertiliser treatment.

Root and rhizome development was halved by deep shade and available carbohydrates in the forage were also reduced particularly at the low levels of fertility (Burton, 1959). Nosbergr and Fessler (1968) conducted an experiment with Italian ryegrass. He grew the grass under full day light and 36 per cent day light and applied 0 or 120 Kg N per hectare. Nitrogen increased dry matter production in unshaded plants especially in the later stages. In shaded plants the response to N remained constant. Shading and nitrogen increased LAI and shoot root ratio. Shading decreased NAR. Nitrogen increased and shading decreased the number of tiller per plant.

Myhr and Saebo (1969) found that potassium contents were approximately doubled by shading some grass species from 10 to 15 per cent of the intensity of natural light. Phosphorus, calcium and magnesium contents also increased under shading. Guers (1971) reported that cocoa leaves exposed to direct sunlight contained less moisture and nitrogen than shaded leaves. American Holly plant exhibited higher amounts of potassium and magnesium in leaf tissues when the plants were grown at 92 per cent shade (Fretz and Dunham, 1971). Cantliffe (1972) observed in spinach that the concentration of potassium in the tissue increased with reduction in the light intensity. _Dracaena sanderiana_ plants grown at five shade intensities were analysed for foliar nitrogen, phosphorus, potassium, calcium and magnesium and it was found that different shades had little effect on the leaf nutrient content except that high shade intensity increased potassium and magnesium especially in young leaves (Rodriguez et al., 1973). Radha (1979) observed that the uptake pattern of major nutrients in pineapple was not greatly influenced by shading. It was also noticed that shading increased the magnesium content of leaves, at all stages of growth and nitrogen content at later stages growth.

Oladokun (1980) reported that in the case of coffee, shade significantly influenced plant nitrogen, phosphorus and potassium contents. According to Wong and Wilson (1980) nitrogen accumulation in all the plant components of green panic was markedly improved by shading. Gopinath (1981) in the case of cocoa seedlings noticed higher percentage of nitrogen, phosphorus and potassium in plants grown under direct sunlight than in shaded plants. However, between the plants exposed to different shade intensities the nutrient contents showed no significant differences.

10. General growth of plants

Evans (1951) described a shade experiment in which a cocoa was grown under different artificial shade levels viz., 15, 25, 50, 75 and 100 per cent day light. Results during the first year showed that cocoa made the best growth at 25 to 50 per cent sunlight but plants receiving 50 per cent light were of better shape. As plants became bigger and auto shading developed, the 75 per cent light plot improved its position with increasing light intensity, the need of nitrogen fertiliser became more apparent.

Williams (1970) in an experiment in which Agropyron repens was shaded with fabric screens which transmitted approximately 46 per cent of normal day light for different periods of growing season, have resulted reduced rhizome weight but had a much smaller effect on shoot weight. Fisher (1975) found that shading always reduced growth of wheat plants approximately in direct proportion to the reduction in radiation.

Agboola and Fayemi (1971) observed competition for light between maize and legume. The legume was suppressed by maize shade. Kassan (1976) reported that cowpea, when grown mixed with other crops was adopted more to lower light intensity. Screening trials conducted by Sahasranaman and Pillai (1976) at Kasaragod showed that the fodder grasses gautimala (Tripsacum laxum), hybrid napier (Pusa Giant and NB-21) and guinea grass (Panicum maximum) gave a green fodder yield of 50 - 60 t ha^{-1} under coconut shade.

The growth of alfalfa was affected adverely by shading when it was grown with sorghum (Scott, 1960).

Kadman et al. (1979) have conducted several studies on the effects of modified spectral composition of natural illumination on plant development. Plants were grown under coloured frames in net houses or in the glass houses. Response of barley and wheat (long day species) sorghum, maize, Setaria italica (short day plants) were kept to the spectral composition of main light period and to the end of the day irradiation with (a) red (b) far red light was identical. Flowering and internode elongation were enhanced (c) blue + far red and were retarded in pure (d) blue light. In barley flowering in neutral day light was directly related to light intensity.

B. Potash nutrition

The literature portaining to the role of potash nutrition and crop production is voluminous and most of them relates to cereals and other crops. Works on grasses especially on shaded cultivation are very few. Some of the works under ordinary and shaded conditions are reviewed here.

Research over the years has shown that potash is essential for various metabolic activities of living cells. Potash always accumulates in those parts of the plant in which cell division and growth processes are actively proceeding and in cases of deficiency it is transported from the older leaves to the young, tissues. The main function of potassium is the maintenance of the physiological state of swelling of plasma colloids which is necessary for the normal course of all metabolic process. The absorption and reduction of nitrates, cell division and many other processes are stimulated by an adequate supply of potash. It is recognised that potassium contributes to the hardening of the supporting tissues and subsequent to a stronger structure. Potash also restricts excess respiration of the plants and thus reducing the catabolic process.

Nightingale et al. (1930) and James and Penston (1933) reported that potassium concentrations were associated with actively growing plant tissues.

Watson (1947) found that the surface area of leaves was increased by application of potassium and hence the photosynthesis. Fujiwara and Lida (1955) had shown by experiments that potassium had an effect in increasing the carbohydrate and especially the starch contents of paddy and barley.

Plant stem is also reported to be strengthened by adequate supply of potassium. Shrivastava and Yawalkar (1960) showed that application of potash decreased the length of lower internodes and increased the breaking strength, thus helping the plant against lodging. Walsh (1963) while investigating on potassium in Ireland, observed that the application of potash improved the quality of carbohydrate and protein constituents of the wheat grain to some extent.

Buckman and Brady (1964) had stressed the importance of potassium in the development of chlorophyll although potassium itself was not a constituent of the pigment.

Ramakrishnan Nair (1963) reported a lack of response to phosphorus and potash application in ragi in case of height of plant. Nitrogen had favourably influenced the plant height of finger millet but phosphorus and potash failed to evoke any response (Subramanian, 1969). Subramanian et al. (1971) while studying the effects of N, P and K observed significant increase in plant height by increased doses of nitrogen while P and K failed to influence any response.

Increase in tiller number by potash application has been reported by various workers. Ramakrishnan Nair (1963) observed an increase in tiller production when potash was applied at 20 lb per acre. Usha (1967) observed beneficial influence of potash in paddy by way of promoting growth, tillering and straw yield. Ramankutty (1967) observed that potash had no significant effect on the number of tillers. Application of potash upto 80 Kg ha^{-1} in rice had shown an increasing trend in the number of tillers (Vijayan, 1970).

Raya Chaudhari (1976) had observed, in several experiments that potassium has given moderate to high response in respect of rice, wheat jowar, bajra, maize, potato and sugar cane.

Garg et al. (1978) conducted an experiment on effects of two levels of potassium as soil or foliar application on growth, yield and physiological characters of maize plant. Significant increase in all the growth attributes were noted in case of soil application of K_2O at 90 Kg ha^{-1} + 0.2 ppm Mg. The amount of carbohydrates in shoot and roots and starch content in grain were increased. Gosh and Biswas (1978) have conducted a series of experiments located in various soil climatic regions of the country. Different degrees of response in crop yield to potassic fertilisations were observed on wheat, rice, maize and potato. Under intensive cropping, the influence of K became progressively pronounced in some soils which initially did not show any beneficial effect.

In many experiments mineral nutrient status of plants were found to improve under shading as in the case of apple, cocoa, spinach and tea. In the case of soyabean on the contrary, nitrogen content was found to be positively related to illumination levels. Also adverse effect of shade on nutrient content has been reported in siratro cocoa seedlings and pineapple.

Myhr and Saebo (1969) found that potassium contents were approximately doubled by shading some grass species to 10 to 15 per cent of the intensity of natural light. Phosphorus, calcium and magnesium contents also increased under shading. Guers (1971) reported that cocoa leaves exposed to direct sun light contained less moisture and nitrogen than shaded leaves. American Holly Plant exhibited higher amounts of potassium and magnesium in leaf tissues when the plants were grown at 92 per cent shade (Fretz and Dunham, 1971). Cantliffe (1972) observed in spinach that the concentration of potassium in the tissue increased with reduction in the light intensity. Dracaena sanderiana plants grown at five shade intensities, were analysed for foliar nitrogen, phosphorus, potassium, calcium and magnesium and it was found that the different shades had little effect on leaf nutrient content except that high shade intensity increased potassium and magnesium especially in young leaves (Rodriguez et al. 1973). Radha (1979) observed that the uptake pattern of major nutrients in pneapple was not greatly influenced by shading. Oladokum (1980) reported that in the case of coffee shade significantly effected plant nitrogen, phosphorus and potassium content. In the case of cocoa seedlings, Gopinathan (1981) noticed higher percentage of nitrogen, phosphorus and potassium in plants grown under direct sunlight than in the shaded plants.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present research programme was undertaken with a view to assess the fodder production potential of Guinea grass var. Mackuenii. And also to study the influence of graded doses of potash on fodder production under partially shaded condition.

Experimental site

The experiment was conducted in the Instructional Farm attached to College of Agriculture, Vellayani.

Soil

The soil of experimental site was Red loam. Mechanical composition and chemical properties of the soil are given below.

(a) Mechanical composition

Gravel	3.60 per cent
Coarse sand	40.70 per cent
Fine sand	25.30 per cent
Silt	18.00 per cent
Clay	12.40 per cent

(b) Chemical properties

Total nitrogen	0.133 per cent
Available phosphorus	0.038 per cent
Available potassium	0.092 per cent
pH	5.2

Season and climate

The experiment was started during the last week of June 1981 and concluded by the second week of April 1982. The meteorological data for the above period and also 24 years mean are presented in Fig.1 and Appendix 1 respectively.

Cropping history of the field

The experimental area was cultivated with a bulk crop of fodder grass during the previous year.

MATERIALS

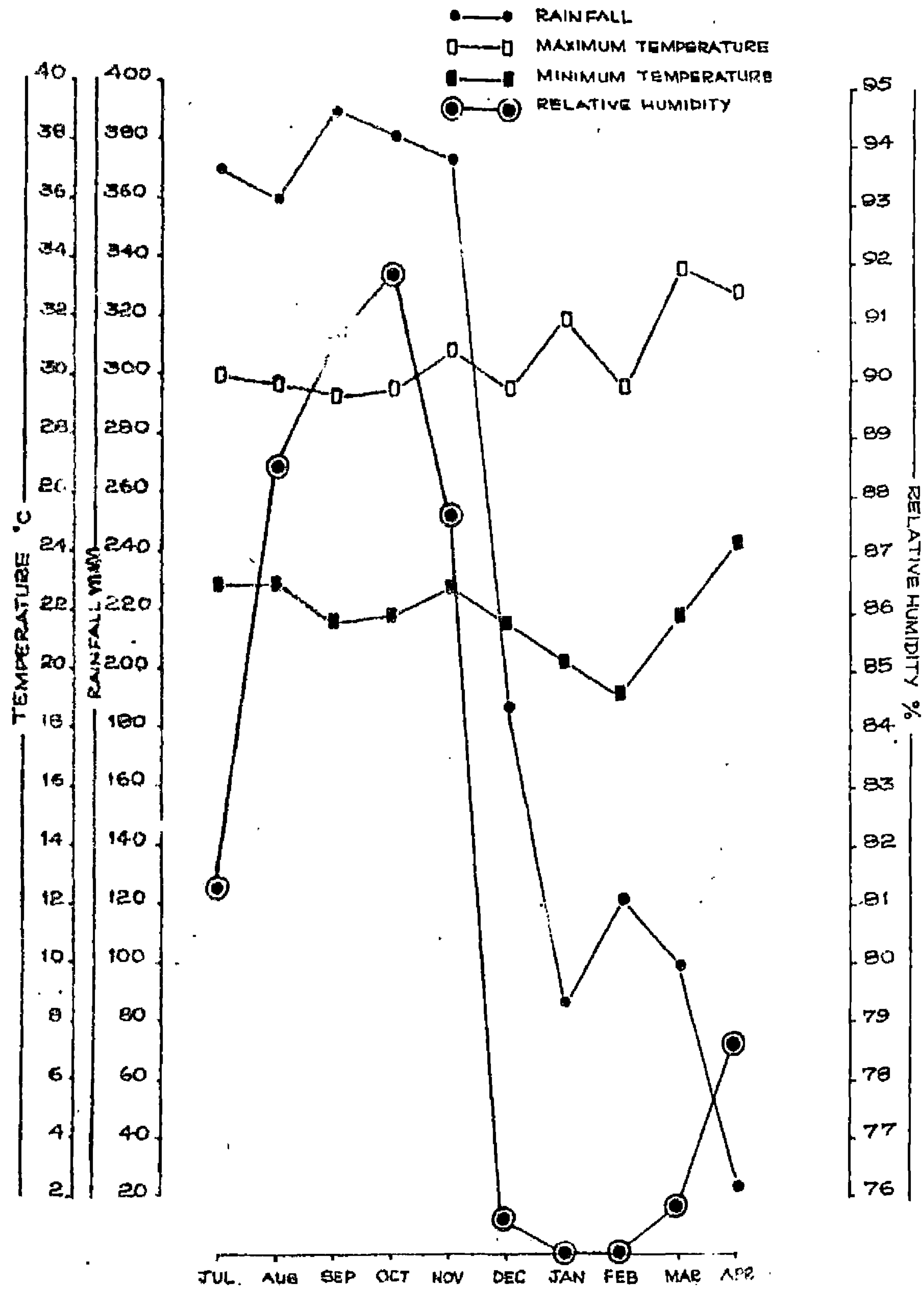
Slips

Vigourous and healthy slips of guinea grass var. Muckuenii were obtained from the germ plasm collections under All India Co-ordinated Project for Research on Forage Crops, College of Agriculture, Vellayani. The var. Mackuenii is becoming prominent and popular strain throughout the state in dairy farmers holdings. It is drought resistant, fertilizer responsive and is relished by all categories of livestock especially milch cows.

Fertilizers

The crop received the cultural and manurial practices as per the package recommendations of the Kerala Agricultural University (KAU 1978) except in the case of potash. Fertilizers containing the following analytical values were used for manuring.

FIG. 1. WEATHER CONDITIONS DURING THE CROPPING SEASON.



1.	Urea	46 per cent nitrogen
2.	Super phosphate	18 per cent P_2O_5
3.	Muriate of potash	60 per cent potash

Shading

Unplaited coconut leaves were used for providing shade to the desired intensities.

METHODS

Layout of the experiment

The experiment was laid out in a factorial 4 x 4 randomised block design with 3 replications. The layout and plan is given in Fig.2.

Treatments

S = Shade levels

S_0 = No shade (Full sunlight)

S_1 = 25 per cent shade (75 per cent sunlight)

S_2 = 50 per cent shade (50 per cent sunlight)

S_3 = 75 per cent shade (25 per cent sunlight)

K = Potash levels

K_0 = 25 Kg K_2O ha^{-1}

K_1 = 50 Kg K_2O ha^{-1}

K_2 = 75 Kg K_2O ha^{-1}

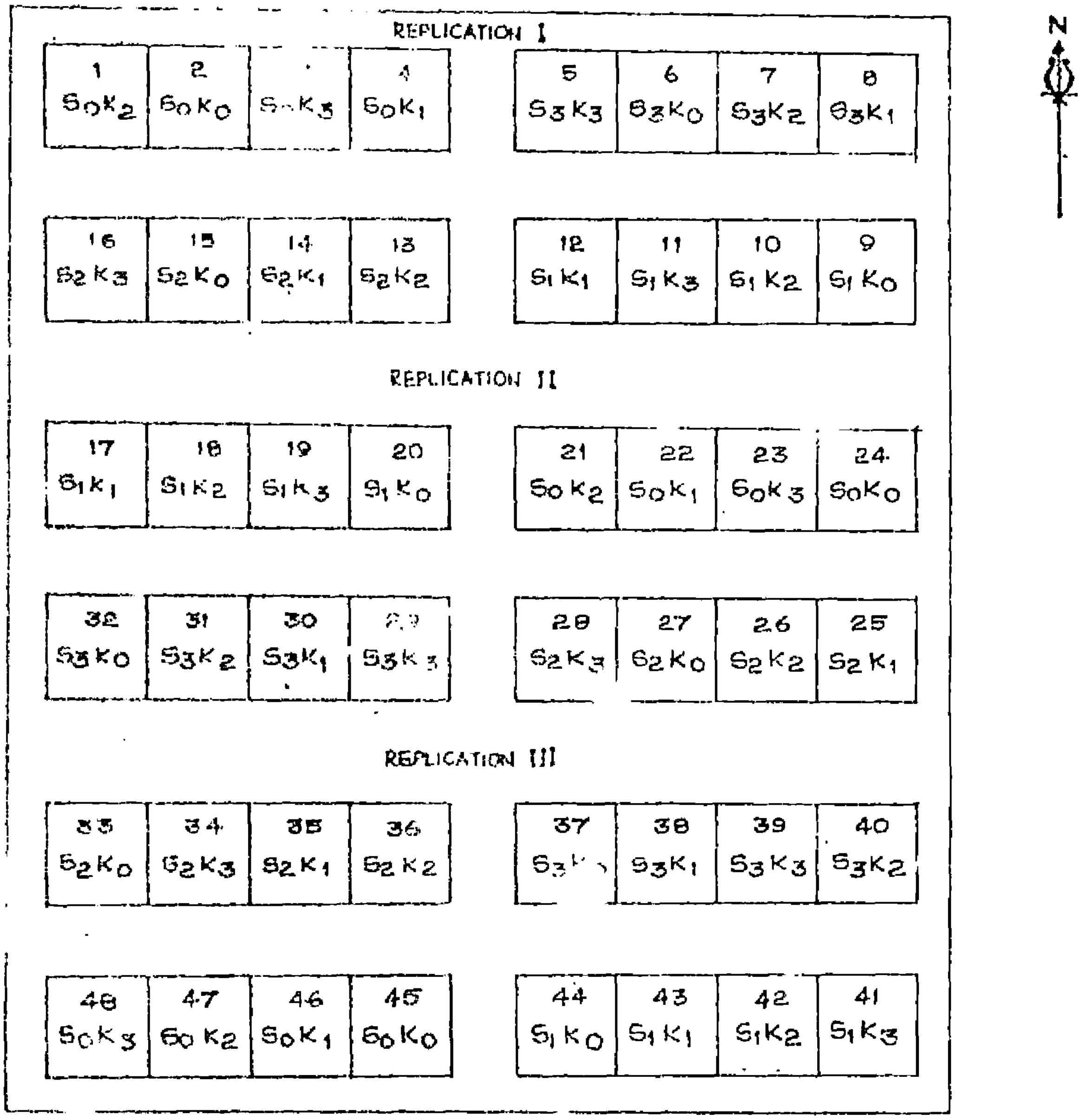
K_3 = 100 Kg K_2O ha^{-1}

Treatment combinations

1.	S0K0	=	Full sunlight + 25 Kg K_2O ha^{-1}
2.	S0K1	=	Full sunlight + 50 Kg K_2O ha^{-1}
3.	S0K2	=	Full sunlight + 75 Kg K_2O ha^{-1}
4.	S0K3	=	Full sunlight + 100 Kg K_2O ha^{-1}
5.	S1K0	=	25 per cent shade + 25 Kg K_2O ha^{-1}
6.	S1K1	=	25 per cent shade + 50 Kg K_2O ha^{-1}
7.	S1K2	=	25 per cent shade + 75 Kg K_2O ha^{-1}
8.	S1K3	=	25 per cent shade + 100 Kg K_2O ha^{-1}
9.	S2K0	=	50 per cent shade + 25 Kg K_2O ha^{-1}
10.	S2K1	=	50 per cent shade + 50 Kg K_2O ha^{-1}
11.	S2K2	=	50 per cent shade + 75 Kg $K2^O$ ha^{-1}
12.	S2K3	=	50 per cent shade + 100 Kg K_2O ha^{-1}
13.	S3K0	=	75 per cent shade + 25 Kg K_2O ha^{-1}
14.	S3K1	=	75 per cent shade + 50 Kg K_2O ha^{-1}
15.	S3K2	=	75 per cent shade + 75 Kg K_2O ha^{-1}
16.	S3K3	=	75 per cent shade + 100 Kg K_2O ha^{-1}

Treatment combinations	-	16
Replications	-	3
Total plots	-	48
Gross plot size	-	4.0 m x 3.0 m.
Net plot size	-	2.4 m x 2.2 m
Spacing	-	40 cm x 20 cm

FIG 2. LAY OUT PLAN 4 x 4 FACTORIAL R.B.D.



S_0	FULL SUNLIGHT	K_0	25 KG. K_2O HA^{-1}
S_1	25 PER CENT SHADE	K_1	50 KG. K_2O HA^{-1}
S_2	50 PER CENT SHADE	K_2	75 KG. K_2O HA^{-1}
S_3	75 PER CENT SHADE	K_3	100 KG. K_2O HA^{-1}

Details of cultivation

The experimental area was dug twice, stubbles were removed, clods broken and the field was laid out into blocks and plots. The individual plots were again dug and levelled.

Fertilizer application

A uniform dose of nitrogen (200 Kg N ha^{-1}) and phosphorus (50 Kg P_2O_5 ha^{-1}) were applied along with muriate of potash so as to supply varying doses of K_2O as per treatment.

Method of planting

Young vigorous and healthy slips were selected and planted at the rate of 3 slips per hill at a spacing of 40 cm x 20 cm. Planting was done on 26-6-1980.

Provision of shade

Artificial shading to the desired level was obtained by placing unplaited coconut leaves on erected pandals. Pandals were individually erected for each shade level by fixing arecnut reapers on Bamboo poles. Sufficient spacing of 2.5 m were given between the treatments so as to avoid mutual shading of pandals. Each pandal was covered from all sides with unplaited coconut leaves upto about half of its hight from top to bottom to avoid the direct entry of slant rays. Raised beds were taken leaving a boarder area of 1 m within the shade levels to avoid the boarder effect.

An'Aplab' luxmeter was used for adjusting the shade intensities. First the intensity of light in the open condition was noted. Other desired levels of light intensity was adjusted on the basis of the intensity in the open condition. Frequent checks were made several times throughout the course of experiment to maintain the shade intensities to the desired levels.

General condition of the crop

The general growth of the crop was satisfactory. Slips which exhibited poor growth were removed and planted with fresh slips after the first and second weeks of planting. Growth and establishment of crop in control plots during severe summer season were comparatively poor.

Interculture and weeding

The soil was slightly dug and weeds were removed one month after planting. A second weeding was also given one month after the first weeding.

Harvest

Grasses were harvested at monthly intervals from 16-8-1981 coinciding with abundant growth or 50 per cent flowering stage. Altogether four harvests were taken during the period and data recorded for analysis.

OBSERVATIONS RECORDED

A. Growth characters

For recording growth characters four hills were selected randomly.

(a) Height of plants

The height of the plant was recorded on the day previous to each cutting. The height was measured from the base of the plant at the ground level to the tip of the tallest leaf.

(b) Tiller count

The number of tillers were counted on the day previous to each harvest and recorded.

(c) Leaf area

Leaf area was calculated by ploting the area in graph paper.

(d) Leaf : Stem ratio

The plant samples collected were separated into leaf and stem portions weighed separately and leaf stem ratios was worked out. The same portions were again put together and dried for estimating the dry fodder production.

(e) Chlorophyll content of leaves

Chlorophyll 'a' , 'b' and total chlorophyll contents were estimated twice, once at the first harvest and second at the second harvest by using Spectro-photometric method as described by Starness and Hadley (1965). Matured leaves were used for estimation.

One gram of the representative green sample, collected from five plants chosen at random was taken in a mortar in the presence of excess aceton. Then it was ground well and filtered through a Buchner funnel. The brei was washed repeatedly with fresh acetone (80 per cent) until the washing was colourless. The extract and washings were then made upto 50 ml. The optical density (A) of an aliquot was measured using a Specto-photometer (Spectronic-20) at wave length of 645 nm and 663 nm. The contents of chlorophyll 'a' , 'b' and total chlorophyll (mg g^{-1} fresh weight) were then estimated using the following relationships.

Chlorophyll 'a'	=	12.72 A 663 - 2.58 A 645
Chlorophyll 'b'	=	22.87 A 645 - 4.67 A 663
Total chlorophyll (Chlorophyll a + b)	=	8.05 A 663 + 20.29 A 645

(f) Green fodder yield

The green matter yields from the net plot area were recorded immediately after harvest.

(g) Dry fodder yield

The samples from each cut were first sun dried and then oven dried to a constant weight at 80°C. The drymatter contents were computed for each treatment and their drymatter yields were worked out.

B. Quality characters

Plant samples

The plant samples were dried in an over at 80°C and ground in a Wiley mill.

(a) Protein content

The total nitrogen content of the samples were determined by modified microkjeldahl method (Jackson, 1967) and crude protein was calculated by multiplying the nitrogen content by the factor 6.25 (Simpson et al., 1965).

(b) Crude fibre content

Crude fibre content was determined by A.O.A.C. method (1975).

(c) Ash content

Ash content was determined by A.O.A.C. method (1975).

(d) Phosphorus, Potassium, Calcium and Magnesium content

One gram of powdered sample was digested with triple acid mixture (HNO_3 + H_2SO_4 + $HClO_4$) (Jackson and Ulrich, 1959), the digest was filtered and made upto 100 ml and used for the estimation of phosphorus, potassium, calcium and magnesium.

Phosphorus was determined by Vanadomolybdate phosphoric yellow colour method (Jackson, 1967).

Potassium was determined by using a flame photometer.

Calcium and magnesium were determined in a suitable aliquot of triple acid digest with EDTA (Cheng and Bray, 1951).

C. Soil analysis

Total nitrogen, available phosphorus and available potassium content of the composite soil sample collected prior to experiment and soil samples collected from individual plots after the experiment were analysed. Total nitrogen was determined by modified micro-kjeldahl method, available phosphorus by Bray's method and available potassium by ammonium acetate method (Jackson, 1967).

D. Statistical analysis

Data relating to different parameters were analysed statistically by applying the technique of analysis of variance for 4 x 4 Randomised Block design factorial experiment and significance was tested by F - test (Snedecor and Cochran, 1967).

RESULTS

RESULTS

An experiment on shade tolerance of Guinea grass variety Mackuenii under different levels of potassium was conducted in the Instructional Farm, College of Agriculture, Vellayani. Levels of shade given were 25 per cent, 50 per cent, 75 per cent and 'no shade' (open). Doses of potash applied were 25 Kg ha^{-1}, 50 Kg ha^{-1}, 75 Kg ha^{-1} and 100 Kg ha^{-1}. Biometric observations and chemical analysis for various nutrient contents were carried out at different stages of crop growth. All the observations were statistically analysed. The results obtained are discussed below separately.

I. Plant Characters

A. Biometric Observations

1. Height of the plants

The mean data are presented in Tables 1 to 5 and analysis of variance in Appendix II.

The effect of shade on the height of Guinea grass was significant in all cuts including combined mean, except the first cut. Maximum height was recorded under 50 per cent shade and minimum in (open field condition) the plot where there was no shade.

Potash levels had significant effect in all cuts and combined mean. Maximum height was recorded under the highest

Height of the plant (m)

Table No.1: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	1.23	1.37	1.33	1.41	1.33
S_1	1.25	1.25	1.50	1.37	1.34
S_2	1.33	1.42	1.32	1.33	1.34
S_3	1.20	1.33	1.35	1.37	1.31
Mean	1.25	1.34	1.37	1.37	

C.D. (0.05) Marginal mean = 0.0879

C.D. (0.05) 2 factor mean = 0.1758

Table No.2: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	1.73	1.84	1.91	2.07	1.89
S_1	1.84	1.87	2.00	1.93	1.90
S_2	1.66	1.82	1.82	1.83	1.79
S_3	1.61	1.45	1.47	1.59	1.53
Mean	1.71	1.74	1.80	1.86	

C.D. (0.05) Marginal mean = 0.0859

C.D. (0.05) 2 factor mean = 0.1718

Height of the plant (m)

Table No.3: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.81	0.93	1.01	1.06	0.95
S_1	1.25	1.28	1.33	1.40	1.32
S_2	1.28	1.38	1.42	1.45	1.38
S_3	1.26	1.25	1.33	1.38	1.30
Mean	1.15	1.21	1.27	1.32	

C.D. (0.05) Marginal mean = 0.0869

C.D. (0.05) 2 factor mean = 0.1739

Table No.4: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.60	0.66	0.71	0.72	0.68
S_1	0.98	1.04	1.00	1.09	1.05
S_2	1.13	1.18	1.25	1.19	1.19
S_3	1.21	1.18	1.31	1.28	1.25
Mean	0.96	1.02	1.09	1.07	

C.D. (0.05) Marginal mean = 0.0650

C.D. (0.05) 2 factor mean = 0.1301

Height of the plant (m)

Table No.5: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	1.10	1.20	1.24	1.32	1.22
S_1	1.33	1.37	1.48	1.45	1.41
S_2	1.35	1.45	1.45	1.45	1.43
S_3	1.32	1.30	1.36	1.41	1.35
Mean	1.28	1.33	1.38	1.41	

C.D. (0.05) Marginal mean = 0.0435

C.D. (0.05) 2 factor mean = 0.0869

level of potash. No significance was noticed due to interaction between shade and potash levels.

2. Leaf area

The mean data are presented in Tables 6 to 10 and the analysis of variance in Appendix III.

Eventhough shade had no significant effect in leaf area in the first cut, in all other cuts the effect of shade was significant. Maximum leaf area was noted under 75 per cent shade but it was on par with 50 per cent shade.

Potash levels showed significance only in the third cut and combined mean. Highest leaf area was recorded under the highest level of potash but it was one par with 75 Kg potash.

3. Tiller Production

The mean data are presented in Tables 11 to 15 and analysis of variance in Appendix IV.

Tiller production has shown significant difference due to shade effect throughout the crop growth. Tiller production was highest under open conditions and least under 75 per cent shade.

Levels of potash showed significant influence only in the third cut and combined mean. Tiller number was maximum due to highest level of potash but the same was on par with all other levels.

Leaf area (cm^2)

Table No.6: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	101.82	99.36	107.07	108.88	104.28
S_1	116.43	111.51	126.61	128.29	120.71
S_2	101.61	123.84	116.74	116.35	114.64
S_3	146.77	104.00	116.39	119.59	121.69
Mean	116.67	109.67	116.70	118.27	

C.D. (0.05) Marginal mean = 22.49

C.D. (0.05) 2 factor mean = 44.98

Table No.7: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	50.88	52.41	72.01	75.25	62.66
S_1	89.86	95.38	91.10	101.46	94.45
S_2	100.77	96.43	103.26	115.10	103.89
S_3	106.21	93.21	95.86	98.68	98.50
Mean	86.93	84.36	90.58	97.63	

C.D. (0.05) Marginal mean = 10.66

C.D. (0.05) 2 factor mean = 21.33

Leaf area (cm^2)

Table No.8: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	62.27	80.46	87.58	92.36	86.67
S_1	112.63	117.12	122.37	133.43	121.39
S_2	139.26	150.09	160.02	158.42	151.95
S_3	138.42	166.38	167.44	180.99	163.31
Mean	113.15	128.52	134.35	141.30	

C.D. (0.05) Marginal mean = 13.00

C.D. (0.05) 2 factor mean = 26.01

Table No.9: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	39.71	46.44	49.71	54.97	47.71
S_1	99.29	100.64	106.47	110.15	104.14
S_2	118.39	137.76	130.69	120.07	126.71
S_3	124.63	137.48	138.57	149.88	137.64
Mean	95.49	105.58	106.36	108.77	

C.D. (0.05) Marginal mean = 11.02

C.D. (0.05) 2 factor mean = 22.04

Leaf area (cm^2)

Table No.10: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	63.67	69.66	79.06	82.87	73.82
S_1	104.53	106.20	111.60	118.36	110.17
S_2	114.96	127.03	127.66	129.10	124.69
S_3	129.03	125.26	129.56	137.30	130.29
Mean	103.05	107.04	111.96	116.90	

C.D. (0.05) Marginal mean = 6.82

C.D. (0.05) 2 factor mean = 13.64

Tiller production (Number/hill)

Table No.11: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	15.33	20.33	19.00	20.33	18.75
S_1	15.33	16.33	20.00	21.00	18.16
S_2	14.67	19.33	13.33	16.33	15.92
S_3	14.33	15.67	16.00	12.33	14.58
Mean	14.92	17.92	17.08	17.50	

C.D. (0.05) Marginal mean = 2.69

C.D. (0.05) 2 factor mean = 5.30

Table No.12: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	19.67	16.00	15.00	20.33	17.75
S_1	10.00	9.00	11.33	11.00	10.33
S_2	7.67	8.33	8.33	9.33	8.42
S_3	4.67	3.67	4.33	5.33	4.50
Mean	10.50	9.25	9.75	11.50	

C.D. (0.05) Marginal mean = 2.69

C.D. (0.05) 2 factor mean = 5.38

Tiller production (Number/hill)

Table No.13: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	11.00	18.00	17.67	10.67	14.33
S_1	12.67	9.67	12.33	11.00	11.42
S_2	11.00	12.33	9.33	11.00	10.92
S_3	7.00	6.00	6.00	6.67	6.42
Mean	10.41	11.50	11.33	9.83	

C.D. (0.05) Marginal mean = 2.62

C.D. (0.05) 2 factor mean = 5.25

Table No.14: Fourth cut

	K_1	K_2	K_3	K_3	Mean
S_0	17.67	22.00	19.67	21.67	20.25
S_1	14.00	18.33	15.33	14.33	15.50
S_2	15.33	14.33	14.33	15.67	14.92
S_3	12.33	10.67	15.00	10.67	12.16
Mean	14.83	16.33	16.08	15.58	

C.D. (0.05) Marginal mean = 3.02

C.D. (0.05) o factor mean = 6.05

Tiller production (Number/hill)

Table No.15: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	15.92	19.08	17.83	19.08	17.98
S_1	13.00	13.33	14.75	14.33	13.85
S_2	12.17	13.58	11.33	13.08	12.54
S_3	9.58	9.00	10.33	9.58	9.63
Mean	12.67	13.75	13.56	14.02	

C.D. (0.05) Marginal mean = 1.82

C.D. (0.05) 2 factor mean = 3.64

4. Leaf : Stem ratio

The mean values are given in Tables 16 to 20 and analysis of variance in Appendix V.

Effect of shade was significant only in the third cut. Levels of potash showed no significant influence in the leaf : stem ratio of Guinea grass. The interaction effect was also not significant.

5. Green fodder yield

The mean values are given in Tables 21 to 25 and analysis of variance in Appendix VI.

Significant differences were noticed in green fodder yield due to shade levels. In the first and second cuts highest yield was found in the treatment under 'full sunlight' followed by 25 per cent shade, 50 per cent shade and 75 per cent shade. But in the third and fourth cuts and the combined total, 50 per cent shade levels have given higher yields followed by 25 per cent shade level.

There was significant difference in green fodder yield due to potash levels in the first cut and combined total only. Highest yield was recorded for the highest level (100 Kg ha^{-1}) potash level and the yield decreased with decrease in potash doses.

The interaction effect was not significant.

Leaf stem ratio

Table No.16: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	2.19	1.96	2.21	1.51	1.97
S_1	2.14	2.13	1.97	2.08	2.08
S_2	2.02	2.28	1.93	1.96	2.05
S_3	2.00	1.88	2.11	1.65	1.91
Mean	2.00	2.07	2.06	1.80	

C.D. (0.05) Marginal mean = 0.316

C.D. (0.05) 2 factor mean = 0.633

Table No.17: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	2.05	1.33	1.77	1.16	1.58
S_1	1.71	1.90	1.72	1.69	1.76
S_2	1.73	1.81	1.60	1.64	1.70
S_3	2.48	1.64	1.92	1.87	1.98
Mean	1.99	1.67	1.75	1.59	

C.D. (0.05) Marginal mean = 0.391

C.D. (0.05) 2 factor mean = 0. 782

Leaf stem ratio

Table No.18: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	2.06	3.07	2.79	2.81	2.69
S_1	2.68	2.90	2.77	3.13	2.87
S_2	2.97	2.77	2.80	3.00	2.88
S_3	2.42	2.13	2.35	2.53	2.36
Mean	2.53	2.72	2.68	2.87	

C.D. (0.05) Marginal mean = 0.290

C.D. (0.05) 2 factor mean = 0.580

Table No.19: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	2.12	2.49	2.13	2.31	2.26
S_1	2.69	2.44	2.42	2.34	2.47
S_2	2.36	2.21	2.18	2.43	2.30
S_3	2.18	2.23	2.50	2.34	2.32
Mean	2.34	2.34	2.31	2.36	

C.D. (0.05) Marginal mean = 0.398

C.D. (0.05) 2 factor mean = 0.796

Leaf stem ratio

Table No.20: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	2.19	2.46	1.89	2.03	2.14
S_1	2.30	2.34	2.22	2.31	2.29
S_2	2.27	2.26	2.13	2.26	2.23
S_3	2.27	1.97	2.22	2.18	2.16
Mean	2.26	2.26	2.11	2.20	

C.D. (0.05) Marginal mean = 0.230

C.D. (0.05) 2 factor mean = 0.460

Green fodder yield (T ha^{-1})

Table No.21: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	27.73	39.07	39.67	39.73	36.55
S_1	27.73	34.03	40.93	39.06	35.44
S_2	28.33	36.53	31.50	40.33	34.18
S_3	21.43	25.20	21.50	29.63	26.94
Mean	26.30	33.71	35.90	37.19	

C.D. (0.05) Marginal mean = 5.31

C.D. (0.05) 2 factor mean = 10.63

Table No.22: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	30.23	37.80	44.13	45.36	39.38
S_1	31.50	34.03	35.26	32.76	33.39
S_2	30.86	30.23	30.28	29.63	30.24
S_3	16.36	11.96	11.96	14.46	13.69
Mean	27.24	28.50	30.40	30.65	

C.D. (0.05) Marginal mean = 3.80

C.D. (0.05) 2 factor mean = 7.61

Green fodder yield ($T\ ha^{-1}$)

Table No.23: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	17.63	23.98	21.43	26.46	22.36
S_1	29.60	34.03	28.96	34.03	31.65
S_2	34.00	33.36	36.53	36.53	35.10
S_3	23.93	15.73	18.90	23.93	20.62
Mean	26.29	26.76	26.45	30.24	

C.D. (0.05) Marginal mean = 5.03

C.D. (0.05) 2 factor mean = 10.06

Table No.24: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	8.20	11.30	11.33	14.50	11.33
S_1	18.26	21.43	17.00	15.10	17.95
S_2	27.06	22.70	22.70	24.56	24.25
S_3	25.20	17.00	18.90	21.43	20.63
Mean	19.68	18.10	17.48	18.90	

C.D. (0.05) Marginal mean = 3.98

C.D. (0.05) 2 factor mean = 7.97

Green fodder yield (T ha^{-1})

Table No. 25: Combined total

	K_0	K_1	K_2	K_3	Mean
S_0	83.80	112.10	116.56	126.03	109.63
S_1	107.10	123.63	122.17	120.97	118.44
S_2	120.26	122.83	120.96	131.06	123.78
S_3	86.93	70.60	81.26	106.13	86.28
Mean	99.53	107.32	110.24	121.05	

C.D. (0.05) Marginal mean = 12.49

C.D. (0.05) 2 factor mean = 24.98

Response curve

The response of shade on fodder yield is found to be quadratic (Fig.5) and is given by the equation

$$Y = 107.6584 + 1.1308\ S - 0.0185\ S^2$$

where Y is the fodder yield (tonnes ha^{-1}) and S is the degree of shade (percentage).

The response of potash on fodder yield is found to be linear (Fig.6) and is given by the equation

$$Y = 92.66 + 0.27\ K$$

where Y is the fodder yield (tonnes ha^{-1}) and K is the level of potash (Kg ha^{-1}).

6. Dry fodder yield

Mean values are given in Tables 25 to 30 and analysis of variance in Appendix VII.

Dry fodder yield varied significantly due to shade. In the first and second cut higher yields were recorded in the open condition and thereafter yield decreased with increase in shade intensity. In the third cut highest yield was recorded under 25 per cent shade and in the fourth cut under 50 per cent shade. In the case of combined total highest yield wa s obtained in full sunlight which was on par with 25 and 50 per cent shade levels. In all the cuts as well as in the combined total the lowest yield was recorded in 75 per cent shade level.

Dry fodder yield (T ha^{-1})

Table No.26: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	7.71	9.01	9.39	8.46	8.64
S_1	8.14	6.75	8.10	7.43	7.60
S_2	6.97	7.23	8.58	6.53	7.33
S_3	5.21	4.94	7.38	5.99	5.88
Mean	7.01	6.99	8.36	7.10	

C.D. (0.05) Marginal mean = 1.39

C.D. (0.05) 2 factor mean = 2.98

Table No.27: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	6.82	8.92	9.26	14.03	9.76
S_1	7.18	7.93	6.37	8.28	7.44
S_2	5.82	5.65	6.43	6.17	6.02
S_3	4.02	6.09	3.65	3.17	4.24
Mean	5.96	7.15	6.43	7.91	

C.D. (0.05) Marginal mean = 2.25

C.D. (0.05) 2 factor mean = 4.50

Dry fodder yield (T ha^{-1})

Table No.28: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	7.31	7.38	7.62	9.17	7.87
S_1	8.13	9.04	7.52	8.19	8.21
S_2	8.07	7.35	8.45	8.22	8.02
S_3	6.29	4.74	5.28	6.03	5.58
Mean	7.44	7.12	7.21	7.90	

C.D. (0.05) Marginal mean = 1.00

C.D. (0.05) 2 factor mean = 2.00

Table No.29: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	4.31	4.53	5.66	7.24	5.43
S_1	7.49	7.97	7.26	5.50	7.05
S_2	9.34	7.39	7.56	8.99	8.32
S_3	7.84	5.34	5.47	6.41	6.26
Mean	7.24	6.31	6.49	7.03	

C.D. (0.05) Marginal mean = 1.68

C.D. (0.05) 2 factor mean = 3.36

Dry fodder yield (T ha^{-1})

Table No.30: Combined total

	K_0	K_1	K_2	K_3	Mean
S_0	28.16	31.51	32.48	38.41	32.14
S_1	32.21	31.69	29.25	19.39	28.13
S_2	30.19	27.62	31.03	29.91	29.69
S_3	23.36	21.12	21.80	21.60	21.97
Mean	27.98	27.99	28.64	27.33	

C.D. (0.05) Marginal mean = 5.16

C.D. (0.05) 2 factor mean = 10.32

There was no significant effect in the application of different doses of potash in dry fodder yield.

The interaction between shade and potash levels were not significant.

7. Crude protein content

Mean data are given in Tables 31 to 35 and analysis of variance in Appendix VIII.

The crude protein content of fodder varied significantly in the second and third cut and combined mean. Maximum crude protein content was recorded under 75 per cent shade levels in all these cuts. In general crude protein recorded in full sunlight was the minimum.

Levels of potash had no significant influence in crude protein content of Guinea grass. The interaction was also not significant.

8. Crude fibre

Mean values are given in Tables 36 to 40 and analysis of variance in Appendix IX.

Significant effects were noticed in second and third cut and also in combined mean. Maximum value for crude fibre content was noted under full sunlight and it decreased with increase in shade intensity.

No significant response was noticed in the case of potash levels.

Crude protein (per cent)

Table No.31: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	7.52	7.44	7.67	8.23	7.72
S_1	7.39	8.33	8.33	8.02	8.02
S_2	8.22	8.12	8.33	7.92	8.14
S_3	8.66	8.12	8.31	8.21	8.33
Mean	7.96	8.00	8.16	8.09	

C.D. (0.05) Marginal mean = 1.26

C.D. (0.05) 2 factor mean = 2.52

Table No.32: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	7.16	7.32	7.16	7.05	7.18
S_1	7.42	8.00	7.65	7.82	7.72
S_2	7.88	7.94	7.45	8.28	7.89
S_3	8.38	8.16	8.50	8.37	8.35
Mean	7.71	7.85	7.69	7.88	

C.D. (0.05) Marginal mean = 0.56

C.D. (0.05) 2 factor mean = 1.13

Crude protein (per cent)

Table No.33: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	7.18	7.43	7.29	7.18	7.27
S_1	7.60	7.81	7.63	7.70	7.68
S_2	7.78	7.75	7.66	8.08	7.82
S_3	8.11	8.03	8.16	8.42	8.18
Mean	7.67	7.75	7.68	7.84	

C.D. (0.05) Marginal mean = 0.32

C.D. (0.05) 2 factor mean = 0.65

Table No.34: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	5.86	5.83	6.16	6.23	6.02
S_1	7.06	7.07	6.51	6.53	6.79
S_2	6.50	6.75	6.50	6.64	6.61
S_3	6.52	6.53	6.77	6.85	6.68
Mean	6.49	6.54	6.49	6.56	

C.D. (0.05) Marginal mean = 0.97

C.D. (0.05) 2 factor mean = 1.94

Crude protein (per cent)

Table No.39: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	6.94	7.03	5.07	7.18	6.56
S_1	7.37	7.80	7.53	7.51	7.56
S_2	7.59	7.64	7.50	7.73	7.62
S_3	7.93	7.71	7.94	7.96	7.88
Mean	7.46	7.55	7.58	7.60	

C.D. (0.05) Marginal mean = 0.87

C.D. (0.05) 2 factor mean = 1.73

Crude fibre (per cent)

Table No.36: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	34.44	34.42	34.67	34.04	34.40
S_1	35.09	34.03	34.37	33.94	34.35
S_2	33.91	33.82	34.28	34.30	34.08
S_3	33.48	33.70	33.33	33.96	33.61
Mean	34.24	33.99	34.16	34.06	

C.D. (0.05) Marginal mean = 1.18

C.D. (0.05) 2 factor mean = 2.36

Table No.37: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	34.83	34.96	34.97	34.78	34.88
S_1	34.57	34.32	33.99	34.21	34.27
S_2	33.64	34.31	34.53	33.94	34.11
S_3	33.36	33.86	33.06	33.37	33.41
Mean	34.10	34.36	34.14	34.07	

C.D. (0.05) Marginal mean = 0.74

C.D. (0.05) 2 factor mean = 1.48

Crude fibre (per cent)

Table No.38: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	33.93	33.42	33.90	33.92	33.79
S_1	33.49	32.59	33.06	33.70	33.21
S_2	33.03	33.47	32.99	32.81	32.83
S_3	32.87	33.41	32.77	33.39	33.11
Mean	33.33	32.97	33.18	33.46	

C.D. (0.05) Marginal mean = 0.52

C.D. (0.05) 2 factor mean = 1.05

Table No.39: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	34.24	33.83	33.54	33.73	33.83
S_1	32.99	32.70	33.51	33.19	33.09
S_2	33.85	32.97	32.87	33.18	32.97
S_3	33.25	32.89	33.10	33.01	33.06
Mean	33.33	33.10	33.26	33.28	

C.D. (0.05) Marginal mean = 0.98

C.D. (0.05) 2 factor mean = 1.97

Crude fibre (per cent)

Table No.40: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	34.38	34.16	34.27	34.12	34.23
S_1	34.04	33.41	33.73	33.76	33.73
S_2	33.36	33.39	33.67	33.56	33.50
S_3	33.24	33.11	33.43	33.43	33.30
Mean	33.75	33.52	33.78	33.72	

C.D. (0.05) Marginal mean = 0.48

C.D. (0.05) 2 factor mean = 0.97

The interaction effect was also not significant.

9. Ash content

Mean values are given in Tables 41 to 45 and analysis of variance in Appendix X.

Ash content did not show any significant difference with different values of shade and different doses of potash. The interaction effect was also not significant.

10. Chlorophyll content

Mean values are given in Tables 46 to 51 and analysis of variance in Appendix XI.

Significant differences were noticed for chlorophyll 'a' in the first and second cuts. Chlorophyll 'a' content increased with increase in shade intensity. Maximum content was noted under 75 per cent shade level and minimum values were noticed under full sunlight. In the case of chlorophyll 'b' significant response was noticed only in second observation. Here also higher chlorophyll content was noticed with higher levels of shade. Significant differences in total chlorophyll content were seen due to shade levels in both observations. Here also chlorophyll content increased with increase in shade intensity.

The effect due to potash levels was not significant in the case of chlorophyll a, b or total chlorophyll.

Ash (per cent)

Table No.41: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	9.31	9.48	9.45	9.75	9.49
S_1	9.56	9.85	9.77	9.49	9.67
S_2	9.49	9.42	9.80	9.38	9.52
S_3	8.83	9.36	9.38	9.05	9.15
Mean	9.30	9.52	9.60	9.41	

C.D. (0.05) Marginal mean = 0.67

C.D. (0.05) 2 factor mean = 1.24

Table No.42: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	9.35	9.35	9.13	9.50	9.33
S_1	9.39	9.84	9.62	9.45	9.57
S_2	9.27	9.42	9.52	9.08	9.32
S_3	9.10	9.17	9.38	9.20	9.21
Mean	9.27	9.44	9.41	9.30	

C.D. (0.05) Marginal mean = 0.38

C.D. (0.05) 2 factor mean = 0.77

Ash (per cent)

Table No.43: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	9.18	9.16	9.06	9.00	9.09
S_1	8.90	9.07	9.05	8.95	8.90
S_2	9.03	8.92	9.08	8.88	8.98
S_3	9.06	8.68	8.67	8.80	8.80
Mean	9.05	8.96	8.97	8.91	

C.D. (0.05) Marginal mean = 0.41

C.D. (0.05) 2 factor mean = 0.81

Table No.44: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	8.73	8.82	8.93	8.71	8.80
S_1	9.02	8.82	8.68	8.67	8.80
S_2	8.63	8.56	8.88	9.01	8.76
S_3	9.00	8.82	8.87	8.71	8.85
Mean	8.84	8.74	8.84	8.77	

C.D. (0.05) Marginal mean = 0.41

C.D. (0.05) 2 factor mean = 0.83

Ash (per cent)

Table No.45: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	9.14	9.20	9.15	9.24	9.18
S_1	9.22	9.39	9.28	9.14	9.26
S_2	9.11	9.07	9.32	9.09	9.15
S_3	9.00	9.01	9.08	8.94	9.00
Mean	9.12	9.17	9.21	9.10	

C.D. (0.05) Marginal mean = 0.27

C.D. (0.05) 2 factor mean = 0.55

Chlorophyll 'a'

Table No.46: First observation

	K_0	K_1	K_2	K_3	Mean
S_0	1.59	1.29	1.48	1.65	1.49
S_1	2.79	2.80	2.88	2.87	2.83
S_2	4.40	2.73	3.33	3.46	3.48
S_3	3.31	3.62	3.71	3.35	3.50
Mean	3.03	2.61	2.83	2.83	

C.D. (0.05) Marginal mean = 0.37

C.D. (0.05) 2 factor mean = 0.74

Table No.47: Second observation

	K_0	K_1	K_2	K_3	Mean
S_0	1.02	1.26	1.37	1.05	1.17
S_1	2.22	2.58	1.95	2.96	2.18
S_2	2.50	2.48	2.56	2.37	2.48
S_3	3.10	3.11	2.83	2.94	3.00
Mean	2.21	2.36	2.18	2.08	

C.D. (0.05) Marginal mean = 0.30

C.D. (0.05) 2 factor mean = 0.60

Chlorophyll 'b'

Table No.48: First observation

	K_0	K_1	K_2	K_3	Mean
S_0	3.07	2.83	3.00	3.20	3.03
S_1	3.27	3.47	3.42	3.49	3.40
S_2	3.46	2.55	3.13	4.05	3.29
S_3	3.43	3.71	3.77	3.50	3.60
Mean	3.31	3.14	3.34	3.56	

C.D. (0.05) Marginal mean = 0.85

C.D. (0.05) 2 factor mean = 1.72

Table No.49: Second observation

	K_0	K_1	K_2	K_3	Mean
S_0	1.59	1.78	1.60	1.63	1.65
S_1	2.76	2.55	2.54	2.54	2.60
S_2	3.56	3.22	3.12	3.00	3.22
S_3	3.57	4.37	3.88	3.83	3.91
Mean	2.87	2.98	2.78	2.75	

C.D. (0.05) Marginal mean = 0.67

C.D. (0.05) 2 factor mean = 1.30

Total chlorophyll

Table No.50: First observation

	K_0	K_1	K_2	K_3	Mean
S_0	4.67	3.80	4.46	4.53	4.36
S_1	6.07	6.28	6.31	6.37	6.25
S_2	7.87	5.26	6.45	7.19	6.69
S_3	6.75	7.33	7.49	6.86	7.11
Mean	6.34	5.67	6.17	6.24	

C.D. (0.05) Marginal mean = 1.02

C.D. (0.05) 2 factor mean = 2.04

Table No.51: Second observation

	K_0	K_1	K_2	K_3	Mean
S_0	2.61	3.05	2.97	2.75	2.84
S_1	4.99	5.13	4.49	4.50	4.78
S_2	6.06	5.71	5.38	5.61	5.69
S_3	6.67	6.82	6.76	6.77	6.76
Mean	5.08	5.18	4.90	4.91	

C.D. (0.05) Marginal mean = 0.67

C.D. (0.05) 2 factor mean = 1.35

11. Calcium content

Mean values are given in Tables 52 to 56 and analysis of variance in Appendix XII.

Significant differences due to shade levels were noticed in second, third, and fourth cuts. Maximum calcium content was noticed in 75 per cent shade. Increase in calcium content was observed with increase in shade levels.

Calcium content did not show significant difference due to varying levels of potash.

The interaction effect of shade x potash was also not significant.

12. Magnesium content

Mean values are given in Tables 57 to 61 and analysis of variance in Apppendix XIII.

Different levels of shade showed significant influence in magnesium content of grasses in all cuts and in combined mean. Increasing levels of shade were found to increase the magnesium content of fodder.

Application of different levels of potash showed significant difference only in the second cut and combined mean. Maximum value for magnesium content was noticed with the highest level of potash but the same was on par with the next two lower levels.

Calcium (per cent)

Table No.52: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.46	0.46	0.50	0.47	0.47
S_1	0.47	0.46	0.43	0.44	0.46
S_2	0.50	0.44	0.49	0.47	0.47
S_3	0.48	0.46	0.48	0.51	0.48
Mean	0.48	0.45	0.47	0.47	

C.D. (0.05) Marginal mean = 0.05

C.D. (0.05) 2 factor mean = 0.09

Table No.53: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.47	0.42	0.47	0.45	0.45
S_1	0.46	0.49	0.50	0.48	0.48
S_2	0.51	0.50	0.49	0.50	0.50
S_3	0.51	0.52	0.54	0.54	0.52
Mean	0.48	0.48	0.50	0.50	

C.D. (0.05) Marginal mean = 0.02

C.D. (0.05) 2 factor mean = 0.04

Calcium (per cent)

Table No.54: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.39	0.41	0.41	0.45	0.41
S_1	0.43	0.43	0.45	0.42	0.43
S_2	0.46	0.47	0.47	0.48	0.47
S_3	0.46	0.49	0.51	0.49	0.49
Mean	0.44	0.45	0.46	0.46	

C.D. (0.05) Marginal mean = 0.02

C.D. (0.05) 2 factor mean = 0.04

Table No.55: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.41	0.40	0.41	0.42	0.41
S_1	0.45	0.45	0.47	0.46	0.46
S_2	0.47	0.45	0.48	0.48	0.47
S_3	0.46	0.49	0.50	0.50	0.49
Mean	0.45	0.45	0.47	0.46	

C.D. (0.05) Marginal mean = 0.02

C.D. (0.05) 2 factor mean = 0.04

Calcium (per cent)

Table No.56: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	0.43	0.42	0.45	0.45	0.44
S_1	0.45	0.46	0.46	0.45	0.45
S_2	0.49	0.46	0.48	0.49	0.48
S_3	0.48	0.49	0.50	0.51	0.49
Mean	0.46	0.46	0.49	0.48	

C.D. (0.05) Marginal mean = 0.02

C.D. (0.05) 2 factor mean = 0.03

Magnesium (per cent)

Table No.57: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.52	0.55	0.53	0.54	0.54
S_1	0.61	0.59	0.60	0.56	0.59
S_2	0.60	0.62	0.61	0.61	0.61
S_3	0.59	0.62	0.61	0.62	0.61
Mean	0.58	0.59	0.58	0.59	

C.D. (0.05) Marginal mean = 0.03

C.D. (0.05) 2 factor mean = 0.05

Table No.58: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.52	0.56	0.55	0.56	0.55
S_1	0.58	0.58	0.59	0.58	0.58
S_2	0.56	0.60	0.58	0.61	0.59
S_3	0.61	0.62	0.63	0.63	0.63
Mean	0.57	0.59	0.50	0.60	

C.D. (0.05) Marginal mean = 0.02

C.D. (0.05) 2 factor mean = 0.04

Magnesium (per cent)

Table No.59: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.52	0.53	0.53	0.54	0.53
S_1	0.54	0.56	0.56	0.55	0.55
S_2	0.56	0.57	0.55	0.57	0.56
S_3	0.56	0.58	0.59	0.60	0.58
Mean	0.54	0.56	0.56	0.56	

C.D. (0.05) Marginal mean = 0.02

C.D. (0.05) 2 factor mean = 0.04

Table No.60: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.54	0.53	0.52	0.51	0.53
S_1	0.54	0.56	0.56	0.58	0.56
S_2	0.56	0.59	0.57	0.57	0.57
S_3	0.59	0.60	0.61	0.61	0.60
Mean	0.56	0.57	0.57	0.57	

C.D. (0.05) Marginal mean = 0.02

C.D. (0.05) 2 factor mean = 0.04

Magnesium (per cent)

Table No.61: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	0.52	0.55	0.53	0.54	0.54
S_1	0.57	0.57	0.58	0.57	0.57
S_2	0.57	0.60	0.58	0.59	0.59
S_3	0.59	0.61	0.61	0.62	0.61
Mean	0.56	0.58	0.58	0.58	

C.D. (0.05) Marginal mean = 0.01

C.D. (0.05) 2 factor mean = 0.02

13. Potash content

Mean values are given in Tables 62 to 66 and analysis of variance in Appendix XIV.

Significant differences were noticed in the potash content of fodder due to varying intensities of shades in all stages of observation. Maximum value for potash content was recorded under 75 per cent shade and the potash content decreased with increasing light intensity.

The effect of application of potash fertilizers showed significant influence only in the first cut and in the combined mean. Maximum potash content in the fodder was recorded with the highest dose of fertilizer potash and it decreased with decreasing doses of applied potash.

The interaction effect was not significant.

14. K: (Ca + Mg) ratio

Mean values are given in Tables 67 to 71 and analysis of variance in Appendix XV.

Significant differences were seen in the case of K: (Ca + Mg) ratio with varying levels of shade in all cuts and in combined mean. Highest ratio was noted under 75 per cent shade and it reduce with increasing light intensity.

The effect due to potash levels was significant only in the first cut, where higher ratio was obtained with the highest dose of potash and it decreased with decreasing

Potassium (per cent)

Table No.62: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.55	0.74	0.81	1.27	0.84
S_1	0.85	0.97	0.98	1.37	1.04
S_2	0.68	1.16	1.26	1.27	1.09
S_3	1.05	1.53	1.66	1.82	1.52
Mean	0.78	1.10	1.18	1.43	

C.D. (0.05) Marginal mean = 0.18

C.D. (0.05) 2 factor mean = 0.36

Table No.63: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.58	0.40	0.71	0.55	0.56
S_1	1.00	0.87	1.10	1.20	1.04
S_2	0.79	0.98	1.14	1.19	1.02
S_3	1.18	1.39	1.19	1.44	1.30
Mean	0.89	0.91	1.03	1.09	

C.D. (0.05) Marginal mean = 0.17

C.D. (0.05) 2 factor mean = 0.34

Potassium (per cent)

Table No.64: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.19	0.24	0.18	0.21	0.20
S_1	0.42	0.46	0.41	0.64	0.48
S_2	0.62	0.72	0.81	0.73	0.72
S_3	1.00	1.12	1.14	1.07	1.08
Mean	0.56	0.63	0.63	0.66	

C.D. (0.05) Marginal mean = 0.10

C.D. (0.05) 2 factor mean = 0.20

Table No.65: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.15	0.16	0.17	0.14	0.15
S_1	0.24	0.18	0.19	0.32	0.23
S_2	0.20	0.37	0.29	0.25	0.27
S_3	0.45	0.50	0.48	0.52	0.49
Mean	0.26	0.30	0.28	0.30	

C.D. (0.05) Marginal mean = 0.08

C.D. (0.05) 2 factor mean = 0.16

Potassium (per cent)

Table No.66: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	0.37	0.39	0.47	0.54	0.44
S_1	0.62	0.62	0.67	0.88	0.70
S_2	0.57	0.81	0.89	0.85	0.78
S_3	0.92	1.14	1.12	1.21	1.10
Mean	0.62	0.74	0.79	0.87	

C.D. (0.05) Marginal mean = 0.08

C.D. (0.05) 2 factor mean = 0.17

K : (Ca + Mg) ratio

Table No.67: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.56	0.73	0.79	1.26	0.84
S_1	0.79	0.92	0.96	1.35	1.01
S_2	0.61	1.07	1.15	1.18	1.00
S_3	0.98	1.41	1.51	1.62	1.38
Mean	0.73	1.03	1.10	1.35	

C.D. (0.05) Marginal mean = 0.18

C.D. (0.05) 2 factor mean = 0.35

Table No.68: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.60	0.42	0.70	0.55	0.56
S_1	0.97	0.87	1.07	0.97	0.98
S_2	0.75	0.96	1.02	1.05	0.95
S_3	1.06	1.22	1.01	1.22	1.13
Mean	0.85	0.87	0.96	0.95	

C.D. (0.05) Marginal mean = 0.18

C.D. (0.05) 2 factor mean = 0.86

K : (Ca + Mg) ratio

Table No.69: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.21	0.25	0.19	0.21	0.22
S_1	0.45	0.46	0.41	0.66	0.49
S_2	0.61	0.68	0.80	0.69	0.69
S_3	0.97	1.04	1.04	0.98	1.01
Mean	0.56	0.61	0.61	0.64	

C.D. (0.05) Marginal mean = 0.10

C.D. (0.05) 2 factor mean = 0.20

Table No.70: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.15	0.17	0.18	0.16	0.16
S_1	0.23	0.19	0.19	0.30	0.22
S_2	0.19	0.36	0.31	0.21	0.26
S_3	0.42	0.45	0.43	0.47	0.44
Mean	0.25	0.29	0.28	0.28	

C.D. (0.05) Marginal mean = 0.08

C.D. (0.05) 2 factor mean = 0.15

K : (Ca + Mg) ratio

Table No.71: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	0.38	0.39	0.47	0.54	0.45
S_1	0.61	0.61	0.66	0.49	0.59
S_2	0.54	0.82	0.81	0.78	0.74
S_3	0.86	1.03	1.06	1.16	1.03
Mean	0.59	0.71	0.75	0.75	

C.D. (0.05) Marginal mean = 0.13

C.D. (0.05) 2 factor mean = 0.26

potash doses. Interaction effect was also not significant.

15. Phosphorus content

Mean values are given in Tables 72 to 76 and analysis of variance in Appendix XVI.

Shade intensities, potash levels and their interactions did not show any significant influence on the phosphorus content of the grass.

B. Soil characters.

1. Total nitrogen (per cent)

Mean values are given in Table 77 and analysis of variance in Appendix XVII.

No significant difference was noticed due to shade levels, potash levels or their interactions in the case of nitrogen content of soil analysed after the experiment. Nitrogen content varied from 0.064 to 0.139 per cent. Maximum value were noticed in 75 per cent shade and minimum value in 50 per cent shade.

In response to potash levels, maximum percentage was noticed at 25 kg potash level and minimum 100 kg potash level.

2. Available phosphorus (Kg ha^{-1})

The mean date are given in Table 78 and analysis of variance in Appendix XVII.

Phosphorus (per cent)

Table No.72: First cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.18	0.29	0.19	0.23	0.22
S_1	0.22	0.31	0.23	0.23	0.25
S_2	0.26	0.17	0.24	0.24	0.23
S_3	0.20	0.24	0.21	0.27	0.23
Mean	0.21	0.25	0.21	0.24	

C.D. (0.05) Marginal mean = 0.05

C.D. (0.05) 2 factor mean = 0.09

Table No.73: Second cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.24	0.16	0.20	0.16	0.19
S_1	0.25	0.27	0.21	0.24	0.24
S_2	0.21	0.28	0.26	0.24	0.25
S_3	0.21	0.24	0.27	0.23	0.24
Mean	0.23	0.24	0.24	0.22	

C.D. (0.05) Marginal mean = 0.05

C.D. (0.05) 2 factor mean = 0.10

Phosphorus (per cent)

Table No.74: Third cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.24	0.25	0.19	0.25	0.23
S_1	0.25	0.24	0.28	0.21	0.24
S_2	0.27	0.18	0.20	0.14	0.19
S_3	0.20	0.21	0.28	0.15	0.21
Mean	0.24	0.21	0.23	0.19	

C.D. (0.05) Marginal mean = 0.06

C.D. (0.05) 2 factor mean = 0.12

Table No.75: Fourth cut

	K_0	K_1	K_2	K_3	Mean
S_0	0.14	0.07	0.08	0.13	0.10
S_1	0.12	0.20	0.12	0.08	0.14
S_2	0.17	0.15	0.04	0.06	0.10
S_3	0.11	0.06	0.06	0.06	0.07
Mean	0.14	0.12	0.07	0.08	

C.D. (0.05) Marginal mean = 0.07

C.D. (0.05) 2 factor mean = 0.15

Phosphorus (per cent)

Table No.76: Combined mean

	K_0	K_1	K_2	K_3	Mean
S_0	0.21	0.19	0.17	0.19	0.19
S_1	0.22	0.26	0.22	0.19	0.22
S_2	0.23	0.18	0.20	0.17	0.20
S_3	0.19	0.19	0.21	0.18	0.19
Mean	0.21	0.21	0.19	0.18	

C.D. (0.05) Marginal mean = 0.03

C.D. (0.05) 2 factor mean = 0.05

There were significant differences in the soil phosphorus content due to different intensities of light and potash levels. Interaction effect was also significant. Maximum value for soil phosphorus was noticed under 75 per cent shade which was on par with 50 per cent and 25 per cent shade. Soil phosphorus content under full sunlight was minimum.

Maximum values for potash content was noticed when the applied potash was 50 Kg K_2O ha^{-1} and it was on par with 25 Kg K_2O ha^{-1}.

3. Available potash

Mean data are given in Table 79 and analysis of variance in Appendix XVII.

The effect of shade in available K content of soil was not significant, while it was significantly influenced by different doses of applied potash. Highest value for available K was noticed under 100 Kg ha^{-1} while it was on par with 25 Kg ha^{-1} and 50 Kg K_2O ha^{-1}.

Total Nitrogen (per cent)

Table No. 77:

	K_0	K_1	K_2	K_3	Mean
S_0	0.075	0.082	0.117	0.091	0.091
S_1	0.067	0.072	0.067	0.065	0.068
S_2	0.072	0.074	0.060	0.052	0.064
S_3	0.324	0.084	0.072	0.077	0.139
Mean	0.135	0.078	0.079	0.071	

C.D. (0.05) Marginal mean = 0.11

C.D. (0.05) 2 factor mean = 0.21

Available phosphorus (Kg ha^{-1})

Table No.78:

	K_0	K_1	K_2	K_3	Mean
S_0	48.67	46.00	38.67	34.33	41.92
S_1	39.00	57.66	59.33	51.66	51.92
S_2	69.00	49.00	39.33	29.00	46.58
S_3	49.00	58.66	49.33	51.33	52.08
Mean	51.42	52.83	46.66	41.58	

C.D. (0.05) Marginal mean = 6.30

C.D. (0.05) 2 factor mean = 12.60

Available potassium (Kg ha^{-1})

Table No.79

	K_0	K_1	K_2	K_3	Mean
S_0	46.66	74.65	48.00	61.33	57.67
S_1	41.33	50.66	54.00	68.00	53.50
S_2	42.66	66.66	54.66	57.33	53.83
S_3	54.66	64.00	63.33	93.33	68.83
Mean	46.33	64.00	55.00	68.00	

C.D. (0.05) Marginal mean = 13.91

C.D. (0.05) 2 factor mean = 27.85

DISCUSSION

DISCUSSION

An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani, during the period 1981-82 to study the shade tolerance of Guinea grass Var. Mackuenii under different doses of potash. Results obtained on various characters of the grass are discussed below.

A. Growth Characters

1. Height

Results presented in Tables 1 to 5 showed the variation in height of the grass due to different intensities of shade. Excepting the first cut the shade effects were significantly effective in the height of the plant in all stages of observation. Maximum height was recorded under 50 per cent shade and the minimum under full sunlight, and the increase being 14 per cent over unshaded plants. It is a well known fact that plants grown in shade are always taller than those grown in full sunlight. This might be because plants growing in shade have a higher availability of gibberelic acid due to the reduced rate of its disintegration. Panicker et al. (1969) noticed that in the case of tobacco plant height increased under shade as compared to unshaded plants.

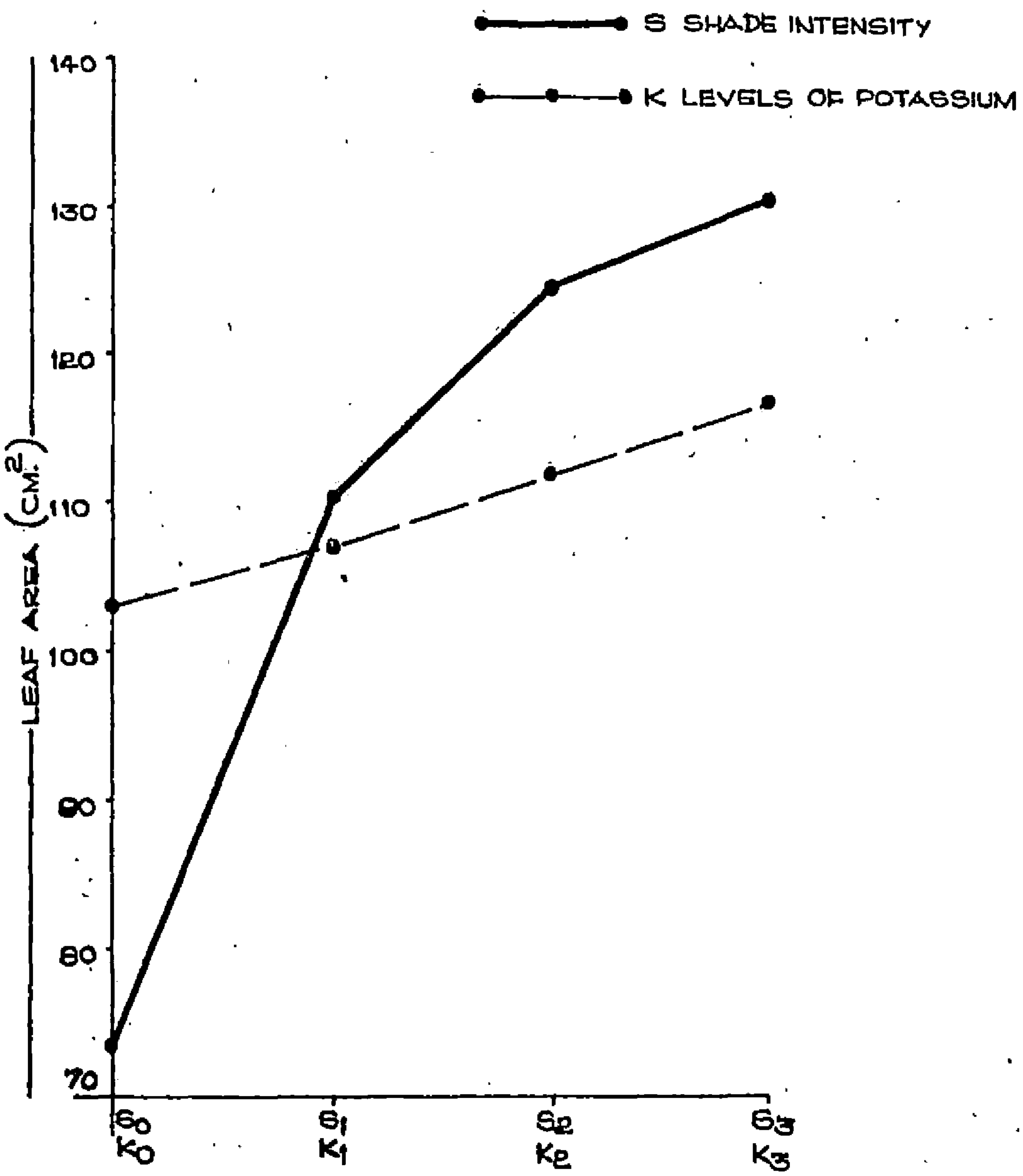
Application of potash had shown linear increase in the height of the plant with increasing levels. Potash is essential for various metabolic activities of living cells. This function of potash in the plant might have stimulated grasses to grow taller under higher doses of potash application.

2. Leaf area

The results presented in Tables 6 to 10 in general showed significant differences in leaf area. Maximum leaf area was noted under highest shade intensity. Results clearly indicated the positive effect of shade in increasing the leaf area. Leaf area decreased with increasing light intensities, thus minimum leaf area was recorded in 75 per cent shade level. Experiments conducted earlier with different crops have shown higher leaf area with increasing shade intensity. This may be due to shade effect which causes production of loosely packed mesophyll tissues and thinner epidermal cells in leaves causing increase in leaf area (Gourley, 1920). And also it is reported that thinness of leaf and increase in leaf area occur due to development of palisade tissue and spongy mesophyll (Boardman, 1977). Shade helps to increase leaf surface, cell division and cell expansion as in Capsicum annum (Schoch, 1972). Crist and Stout (1929) also reported that light promoted the leaf expansion. Gourley (1920), Porter (1938) and Hardy (1958) have reported increase in leaf area with increasing shade intensity in apple, tomato and cocoa respectively.

The potash levels had shown significant effects only in third cut and in combined mean. Maximum leaf area was noticed

FIG. 4 EFFECT OF INTENSITIES OF SHADE AND LEVELS OF POTASSIUM ON LEAF AREA



with 100 Kg hg^{-1} and minimum with 25 Kg ha^{-1} levels. Cell division and associated metabolic processes were stimulated by an adequate supply of potash. This might have resulted in greater vigour of the plant and increased growth rate. Thish resulted in the production of more number of leaves and hence increase in leaf area. Watson (1974) also reported increase in surface area of leaves by application of potash.

3. Tiller production

Results presented in Table 11 to 15 clearly indicated significent negative response of shade in tiller production. Maximum number of tillers were recorded in full sunlight (no shade) and minimum with maximum (75 per cent) shade level. It is a common finding in most crops that tiller production are maximum with greater amounts of solar radiation. This was due to increased vigour and growth of plants under full sunlight. Beinhart (1963) observed that increased light intensity resulted in increased branching in white clover. Tarila et al. (1977) also reported that in cowpea, higher light intensity increased branching of the plants.

Significant response by potash application was recorded only in third cut and combined mean. Maximum tiller production was noted with 100 Kg potash ha^{-1} and minimum with 25 Kg potash ha^{-1}. Ramakrishnan Nair (1963) observed an increase in tiller production when potash was applied at 20 lb ac^{-1}. Usha (1966) observed beneficial influence of

ABSTRACT

An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani, during the year 1981-'82 with the objective to assess the fodder production potential and potassium requirement of guinea grass var. Mackuenii under varying intensities of shade. The experiment was laid out in 4 x 4 factorial randomised block design with 3 replications.

Results revealed that different shade intensities and potash levels had increase the height of the grass. Tiller production was noted highest under full sunlight. Potash levels also had favourable influence in tiller production and maximum number was noted under the highest level of applied potash. The leaf:stem ratio of the grass was not affected from shade as well as potash levels. Altogether four harvests were considered for the analysis of the research problem. In the initial two cuts, green fodder yield was highest from the treatment "full sunlight", but in the later two cuts fodder yields were higher in plots under 50 per cent shade intensity. Dry fodder yield also followed the same trend. Shade intensity increased the crude protein content in fodder registering highest value under 75 per cent shade intensity. Fodder obtained from "full sunlight" treatments recorded highest crude fibre percentage, and decreasing values were noted with increase in shade intensity.

Chlorophyll content in fodder increased with increase in shade intensity. Chlorophyll contents were highest at 75 per cent shade level. Potash application did not show any positive response with regard to chlorophyll content.

Calcium, magnesium and potassium contents in fodder were increased with increasing intensities of shade. While application of potash had no effect on the calcium content in fodder, the magnesium and potassium contents were increased with increase in potash doses. The K:(Ca+Mg) ratio increased with shade intensities and highest value was noted under 75 per cent, but the increase did not affect the quality of the fodder. Similarly, the ratio increased with higher doses of potash, but it never exceeded the safer level of 2.2.

ABSTRACT

An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani, during the year 1981-'82 with the objective to assess the fodder production potential and potassium requirement of guinea grass var. Mackuenii under varying intensities of shade. The experiment was laid out in 4 x 4 factorial randomised block design with 3 replications.

Results revealed that different shade intensities and potash levels had increase the height of the grass. Tiller production was noted highest under full sunlight. Potash levels also had favourable influence in tiller production and maximum number was noted under the highest level of applied potash. The leaf:stem ratio of the grass was not affected from shade as well as potash levels. Altogether four harvests were considered for the analysis of the research problem. In the initial two cuts, green fodder yield was highest from the treatment "full sunlight", but in the later two cuts fodder yields were higher in plots under 50 per cent shade intensity. Dry fodder yield also followed the same trend. Shade intensity increased the crude protein content in fodder registering highest value under 75 per cent shade intensity. Fodder obtained from "full sunlight" treatments recorded highest crude fibre percentage, and decreasing values were noted with increase in shade intensity.

Chlorophyll content in fodder increased with increase in shade intensity. Chlorophyll contents were highest at 75 per cent shade level. Potash application did not show any positive response with regard to chlorophyll content.

Calcium, magnesium and potassium contents in fodder were increased with increasing intensities of shade. While application of potash had no effect on the calcium content in fodder, the magnesium and potassium contents were increased with increase in potash doses. The K:(Ca+Mg) ratio increased with shade intensities and highest value was noted under 75 per cent, but the increase did not affect the quality of the fodder. Similarly, the ratio increased with higher doses of potash, but it never exceeded the safer level of 2.2.

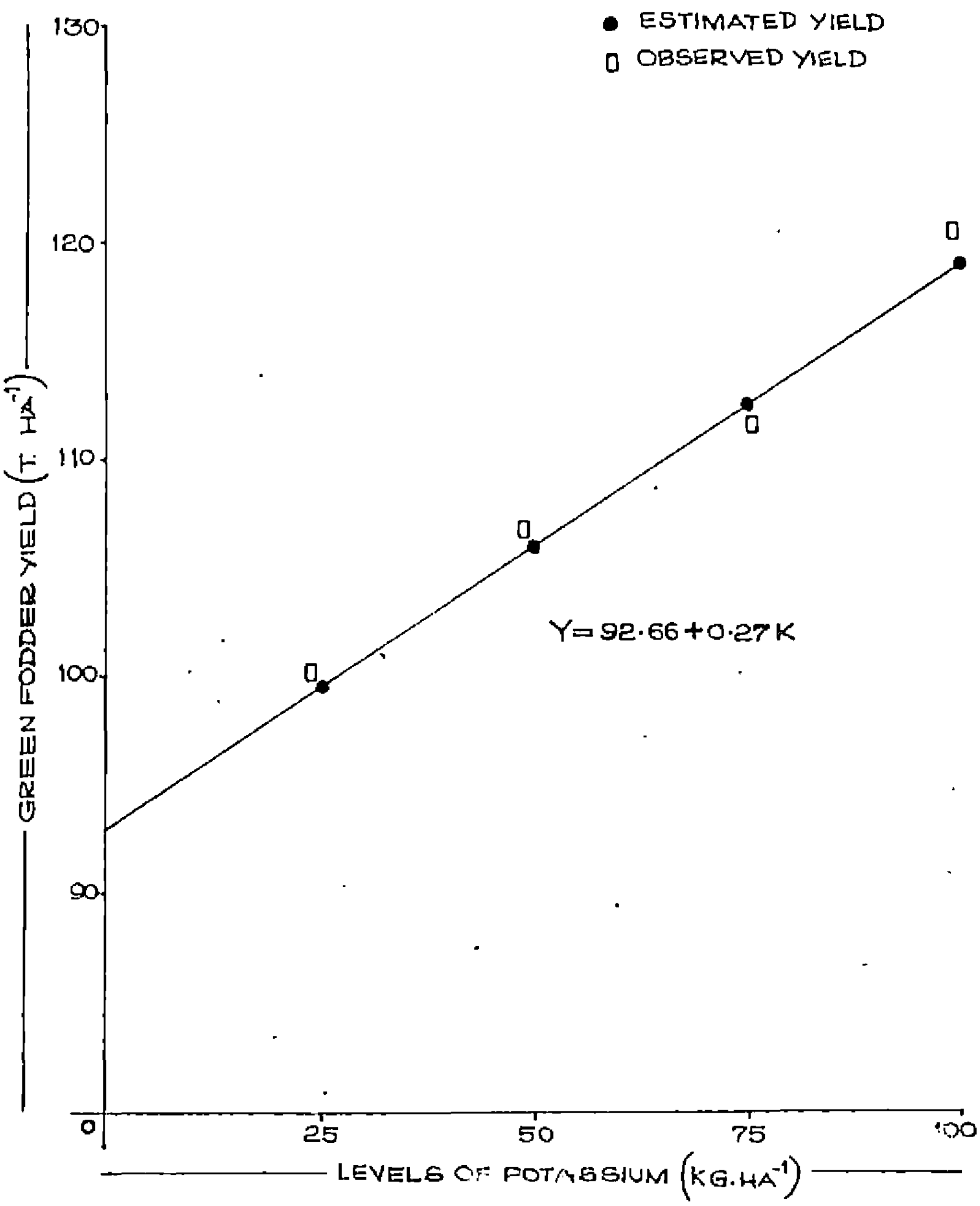
Response curve fitted was found to be quadratic in nature (Fig.5) as given by the equation $Y = 107.6584 + 1.1308\ S - 0.0185\ S^2$ where Y is the fodder yield and S is the degree of shade. From the curve the optimum shade level was found to be 30.5per cent for maximum yield beyond which green fodder yield declined as per estimated yield.

Significant effect in respect of potash levels were recorded in the first cut and combined total. Maximum yield was noted for the highest level of potash. The response to potash levels was linear and the fodder yield increased with increasing levels (Fig.6). From the response curve, yield can be derived from the equation $Y = 92.66 + 0.27\ K$ where Y is the yield and K is the level of potash. This may be due to the fact that potash is frequently required to favour the development of thick cell walls and stiff straw which resulted in a higher production of green fodder by this grass. This result is in agreement with those of Kresge and Younts (1963).

6. Dry fodder yield

Results recorded in Tables 26 to 30 showed significant differences due to shade levels in the case of dry fodder yield. The dry fodder yield recorded showed wide variation at different harvests. In the initial stages of crop growth, as seen in the first and second cuts dry fodder yield recorded under full sunlight were higher when compared to those of

FIG.6 GREEN FODDER YIELD RESPONSE TO DIFFERENT LEVELS OF POTASSIUM.



different shade intensities. This trend was seen gradually altered in the later cuts (third and fourth), wherein with increasing shade intensity the dry fodder yield was also increased upto moderate shade. In the combined total of all the cuts the treatments full sunlight, 25 per cent shade and 50 per cent shade levels were on par. Eventhough the maximum green fodder yield was noted in 50 per cent shade, the dry fodder yield was found to be on par with that of full sunlight. This may be due to more water content present in the fodder obtained from shades which after drying was not able to show significant increase in dry fodder yield. In shade, spongy tissues are developed in plants which may be responsible for lesser dry matter accumulation. This may be due to the partial reduction or absence of carbondioxide assimilation and reduced availability of constructive materials of plants as reported by Duggar (1903).

Benedict (1941) also reported that plants of Agropyron cristatum, Agropyron smithi and Boetelone gracilis grown in shade had lesser dry weight. Myhr and Saebo (1969) from the trials on the effect of shade, observed that shading greatly reduced dry matter yields in Festuca rubra, Lolium perene and Phleum pratense. The results of the present investigation indicated that shade had no positive influence in increasing the dry matter accumulation of guinea grass and agree with previous works reviewed.

No significant effect had been recorded in dry matter accumulation due to different doses of potash. Though maximum yield was obtained under 75 Kg ha^{-1} of potash in combined total, it was on par with other levels. So it can be persumed that potash levels did not have any significant influence in improving dry matter yield of guinea grass.

7. Crude protein

Results obtained are given in Tables 31 to 35. Crude protein content of fodder varied significantly in second and third cuts and in combined mean. In general increase in crude protein content was recorded with increasing levels of shade. Thus maximum content was noted at 75 per cent shade level and minimum at full sunlight. This might be due to the higher concentration of total soluble and protein nitrogen in green tissues as evidenced by higher green fodder yield recorded under shade. Moursi et al. (1976a) also observed similar results in wheat from trials under 20 to 100 per cent full sunlight. Myhr and Saebo (1969) observed that in some grass species crude protein contents were approximately doubled by shading. Pelis and Bustrillos (1976) also observed in the case of grain sorghum plants subjected to 0, 25 or 50 per cent shade that the protein content was increased. Thus from the results of the present investigation it was evidenced that the quality of guinea grass, the most important aspect of which is related to its crude protein content can be increased by shading

Potash levels had no positive influence in improving the crude protein content of guinea grass.

8. Crude fibre

Results shown in Tables 36 to 40 recorded significant differences due to shade levels in crude fibre content of fodder in the second, third and combined mean. Lowest crude fibre content was noted with highest intensity of light. This might be due to the increased utilisation of assimilates for improvement of the quality thereby reducing the fibre content of grasses. The drymatter yield recorded under full sunlight was the highest when compared to other shade levels which also showed a general reduction with increase in shade intensity, probably because the fibre content and drymatter yields are complementary characters.

Myhr and Saebo (1969) also observed reduction in fibre content in some grass species due to shading from 10 to 15 per cent of natural light.

9. Ash

Results given in Tables 41 to 45 did not show any significant difference due to different levels of shades and potash. This indicated that the shade levels, potash application as well as their interaction had no effect in ash content of guinea grass.

10. Chlorophyll

Chlorophyll 'a', 'b' and total chlorophyll were estimated and results presented in Tables 46 to 51. The chlorphyll contents were estimated at the first and second cuts only. In case of chlorophyll 'a' significant difference was noticed due to shade levels in both observations, but for chlorophyll 'b' significant difference was noted only in second observation. Significant effects were noticed due to shade levels in the case of total chlorophyll also.

In both the observations chlorophyll 'a' content increased with increased in shade intensity and maximum value was recorded under 75 per cent shade level. More or less the same trend was noticed in the case of chlorophyll 'b' and total chlorophyll contents. The result obtained in the present study could be explained in the light of the research findings given below.

While discussing the biology of living chloroplasts in leaves Priestly (1929) reported that it would undergo changes in position according to differences in light intensity. In leaves of plants grown under lower light intensities, the plastids were limited in number and they were arranged at right angles to the light rays and were larger in and size thus increasing the area for light absorption. This might be the reason for higher contents of chlorophyll in shade than in full sunlight observed in the present investigation. Increased chlorophyll content was noticed in the leaves of shaded cocoa plants by Evans and Murray (1953), Guers (1951). Similar observations were made by Ramaswami (1960) and Venkitamani (1961) in the case of tea. Radha (1979) observed that chlorophyll 'a' , 'b' and total chlorophyll contents of leaves were found to increase as the intensity of shade increased in pineapple. Okali and Owusu (1975) noticed in cocoa plants, the chlorophyll content per unit leaf fresh weight was significantly greater in deep shade.

The application of different doses of potash had not shown any significant influence in improving chlorphyll 'a' 'b' and total chlorophyll contents of guinea grass.

11. Calcium

Results given in Tables 52 to 56 showed significant effects due to shade levels in respect of calcium content of guinea grass. The increase in calcium content might be due to higher rate of calcium uptake in shade as compared to full sunlight. Myhr and Saebo (1969) found that in tropical grasses calcium contents were increased due to shading. Potash application did not influence calcium contents of guinea grass.

12. Magnesium

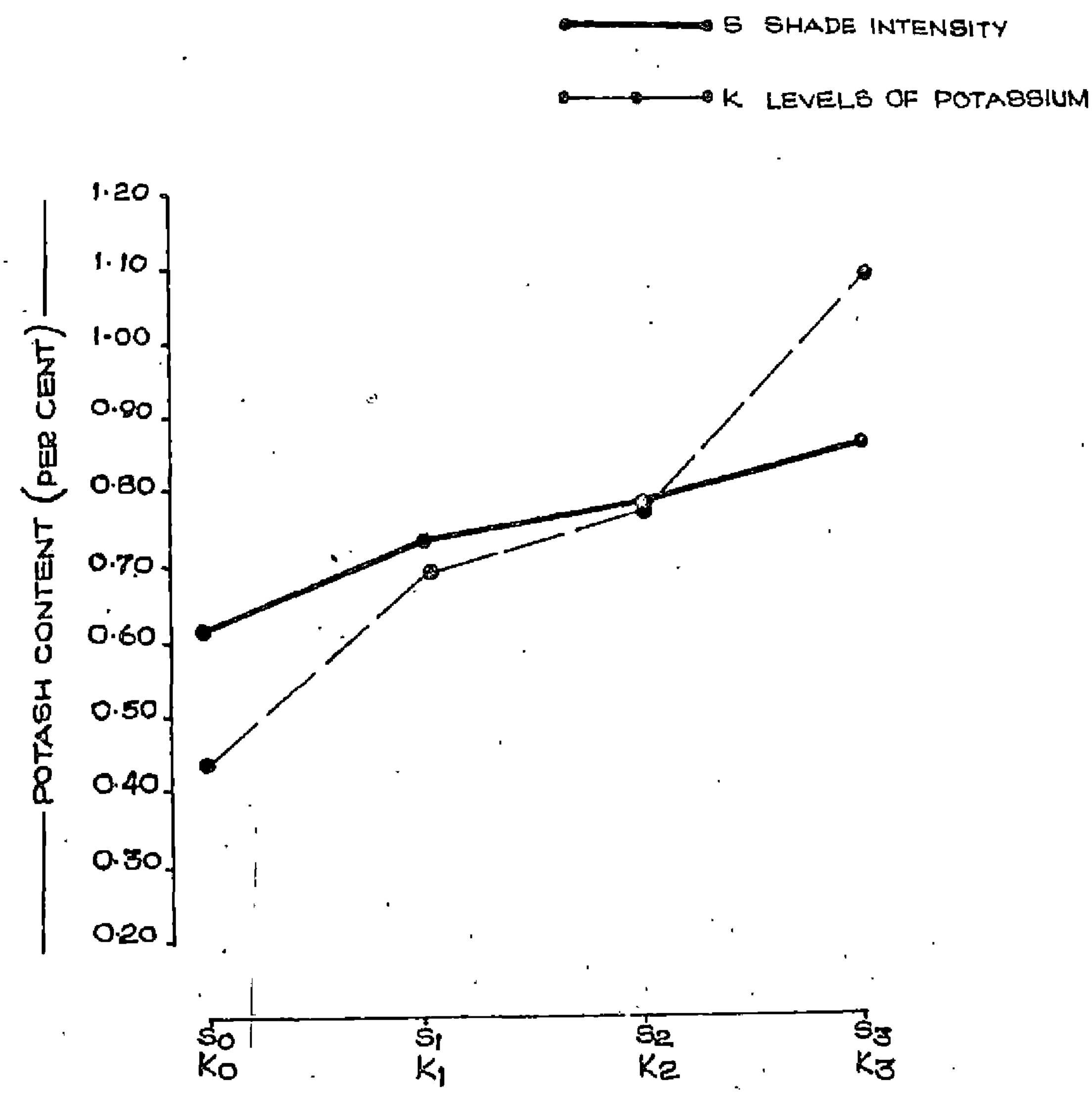
Results on magnesium content are given in Tables 57 to 61 which showed significant differences between shade intensities in respect of magnesium content of guinea grass. Magnesium content increased with increase in shade intensity and maximum value was noted under 75 per cent shade. Myhr and Saebo (1969) also got similar results in tropical grass species. American holly plant had exhibited higher amounts of magnesium in leaf tissues of plants grown at 92 per cent shade (Fretz and Dunham, 1971).

Potash levels have shown significant difference in second cut and combined mean. Highest level of magnesium content was noted at 100 Kg potash ha^{-1} which was on per with the other two levels. This may be attributed to the stimulating effect of potassium for increased uptake of magnesium by grasses. Bedi and Sekhon (1977) also showed influence of potash in improving magnesium content, in maize.

13. Potassium

Results given in Tables 62 to 66 indicated positive increase in potash content of fodder due to different levels of shade intensities throughout the growth period. The fodder potassium content increased with shade intensity and the maximum value was noted under 75 per cent shade level. Increase in potassium content due to shading has been reported earlier also. This might be due to the increase in concentration of potassium in leaf tissues grown in shade which otherwise would be reduced due to sunlight. Cunningham and Lamb (1959) in Bermuda grass under shaded condition found

FIG. 7 RESPONSE OF SHADE INTENSITY AND LEVELS OF POTASSIUM ON POTASH CONTENT OF GUINEA GRASS.



out 88.5 per cent increase when compared to 45.5 per cent under unshaded condition. Myhr and Saebo (1969) found that potassium contents were approximately doubled by shading in some grass species from 10 to 15 per cent of natural light. American holly plant exhibited higher amounts of potassium in leaf tissues when the plants were grown at 92 per cent shade (Fretz and Dunham, 1971). It was found that in Dracaena sandariana plants different shades had little effect on the leaf nutrient content except that high shade intensity increased potassium and magnesium especially in young leaves. From the results of present investigation it became clear that shade levels had positive influence in improving the potash nutrition of guinea grass and that too in early stages of growth. Maximum potash content was recorded in the first cut and minimum in the fourth cut. This again proved that early cut forages were more nutritive than later cut ones.

Potash levels have shown significant effects in second cut and combined mean. There was significant differences in potassium content due to varying doses of potash nutrition. The potassium content in fodder increased with increase in applied potash which may be due to higher rate of absorption (Table 66).

14. K: (Ca + Mg) ratio

Results recorded in Tables 67 to 71 showed significant influences in respect of K: (Ca + Mg) ratio throughout growth period of guinea grass. Highest ratio was noted under highest shade intensity (75 per cent) and it was found decreasing with decreasing shade intensity. It may be seen that potash content of fodder increased with increasing shade intensity (Tables 62 to 66). But such increase was not seen in respect of calcium. Like potassium, magnesium content also increased due to shade intensity. This increase in the potassium and magnesium contents of fodder kept the K: (Ca + Mg) ratio below the critical level of 2.2. This also showed that intercropping fodder in partially shaded coconut garden may not affect the quality of fodder. Early cut forages showed maximum ratio than late cut (fourth cut) fodder.

Application of potash showed significant effect only in the first cut. Thereafter potash levels showed no significant influence either in increasing or decreasing the ratio. This may be due to increased uptake of magnesium to counteract the absorption of potassium, which helped to maintain the K: (Ca + Mg) ratio more or less steadly throughout the growth period. This showed that quality of fodder obtained from partial shade may not be adversely affected by higher doses of potash application.

15. Phosphorus

Results given in Tables 72 to 76 showed no significant influence in improving the phosphorus uptake due to varying intensities of shade, different doses of potash applied or their interactions. Since phosphorus was not included under the treatments, its content in fodder was not affected in this investigation.

B. Soil characters

1. Total nitrogen

The data presented in Table 77 showed that none of the treatment effects or their interactions were able to bring any appreciable change inthe nitrogen content of soil.

2. Available phosphorus

The data presented in Table 78 showed that different intensities of shade were able to bring considerable change in the soil phosphorus content. Maximum value for soil phosphorus content was noted under 75 per cent shade intensity and minimum value for full sunlight. Evidently, as is deduced from the dry fodder yield response (Table 30), the total uptake of phosphorus increased with decreasing shade intensity and resulted in low residual available phosphorus in full sunlight.

3. Available potash

The data presented in Table 75 showed that shade had no significant influence in the available soil potash content. But as expected increase in soil potash was noticed with every incremental dose of applied potash.

SUMMARY

SUMMARY

An investigation was carried out in the Instructional Farm attached to the College of Agriculture, Vellayani, during 1981-'82 with the objective to assess the production potential of guinea grass var. Mackuenii under varying intensities of shade. It was also aimed to assess the potassium requirement of guinea grass under different intensities of shade. The experiment was laid out in a 4 x 4 factorial randomised block design with 3 replications. The results of the study are summarised below:

1. Height of grass was positively influenced by both shade intensities and potash levels.
2. Leaf area of grass was increased with increase in shade intensities and potash levels.
3. Tiller production was adversely affected by shade, while potash application increased tiller numbers of grasses.
4. In the initial stages of the growth of the grasses, highest green fodder yields were noted under full sunlight. But in later stages the green fodder yield increased with increasing shade intensity upto 50 per cent shade. Thus when the total yield for the observation period was considered, highest green fodder yield was noted under 50 per cent shade intensity. Highest green fodder yield was recorded with 100 kg K_2O ha^{-1}.

5. As in the case of green fodder yield in the early stages of the crop growth, highest dry fodder yield was noted under full sunlight. But in the later stages, dry fodder yield increased with increasing shade intensities. In general, maximum dry fodder yield was noted under full sunlight.

6. Highest crude protein content was noted under 75 per cent shade intensity.

7. Crude fibre content was highest under full sunlight. Potash showed no influence in the fibre content.

8. Chlorophyll contents increased with increasing shade intensity. Potash levels did not show any effect in improving the chlorophyll content.

9. Calcium and magnesium contents were increased with increasing shade intensities. Potash application showed significant influence in increasing the magnesium content.

10. Shade levels increased the potassium content of the grass. Potassium content of fodder also increased with increasing levels of applied potassium.

11. Shade intensities as well as potash levels did not adversely affect the K: (Ca + Mg) ratio of guinea grass. Thus the quality of grass was not affected by these treatments.

REFERENCES

REFERENCES

Aclan, F. and Quisumbing, E.C. (1976). Fertiliser requirement, mulch and light attenuation on the yield and quality of ginger. Philippine Agriculturist 60 (5/6): 183 - 191.

Agboola, A.A. and Fayemi, A.A. (1971). Preliminary trials on the inter cropping of maize with different tropical legumes in Western Nigeria. J. Agric. Sci. Camb. 77: 219 - 225.

Anonymous, (1977). Status paper on fodder development, Directorate of Agriculture, Govt. of Kerala, Trivandrum.

A.O.A.C. (1975). Official methods of Analysis of the Association of Official Analytical Chemists. 12th Ed. Benjamin Franklin Station, Washington, D.C. pp 130 - 137

*Aono, H Yanase, Y. Tanaka, S. and Sugu, S. (1976). Use of chemical fibre clothes as artificial shading materials in tea cultivation. Bull. Nat. Res. Inst. Tea No.12, 1 - 123.

Asomaning, E.J.A. and Kwakwa, R.S. (1965). Effects of graded degrees of shading on the growth of healthy and swollen shoot virus infected cocoa seedlings. Conf. Int. Res. Agron. Cocoa Abidjan. 254 - 261.

Baker, N.R. and Hardwick, K. (1973). Bio-chemical and physiological aspects of leaf development in cocoa. 1. Development of chlorophyll and photosynthetic activity. New phytol. 72: 1315 - 1324.

Bedi, A.S. and Sekhon, G.S. (1977). Effect of potassium and magnesium application to soils on the dry matter yield and cation composition of maize. J. Agric. Sci. Camb. 88: 753 - 758.

Beinhart, G. (1963). Effect of environment on meristemetic development, leaf area and growth of white clover. Crop Sci. 3 (3): 209.

Benedict, H.M. (1941). Growth of some range grasses in reduced light intensities. Bot. Gaz. 102: 582 - 589.

Björkman, O. and Holmgren, P. (1963). Adaptability of the photosynthetic apparatus to light intensity in ecotypes from exposed and shaded habitats. Physiol. Plantarum. 16: 889 - 914.

Boardman, N.K. (1977). Comparative photosynthesis of sun and shade plants. Annu. Rev. Plant Physiol. 28: 355 - 377.

*Boneta Garcia, E.G. and Bosque Lugo, R. (1973). Effects on coffee of two levels of fertilizer and frequency of their application. J. Agric. Univ. Puerto Rico. 57 (2): 89 - 95.

*Boyer, J. (1970). The influence of climatic, moisture, radiation and heat on the growth and flowering of cocoa in cameron. Cafe' Cacao. The' 14: 189 - 201.

Buckman, H.O. and Brady, N.C. (1964). Nature and properties of soil. Eurasia Publishing House (Pvt.) Ltd., Ram Nagar, New Delhi.

Burton, G.W., (1959). The influence of light reduction upon the production, persistence and chemical composition of coastal Bermuda grass. Agron. J. 51 (9): 537 - 542.

*Buttrose, M.S. (1974). Climatic factors and fruitlessness in grapevines. A review with reference to some other perennial horticultural plants (HCA 1974. 44 (6): 3448).

Cantliffe, D.J. (1972). Nitrate accumulation in spinach grown under different light intensities. J. Amer. Soc. hort. Sci. 97 (2): 152 - 154.

Clark, V.A. (1905). Light as a factor in plant culture. The problem stated and its method of solution. Proc. Soc. hort. Sci. 24 - 32.

Cooper, A.J. (1969). Effects of shading on tomato stem extension. J. hort. Sci. 44: 75 - 79.

Cooper, C.S. and Qualls, M. (1967). Morphology and chlorophyll content of shade and sun leaves of two legumes. Crop Sci. 7: 672 - 673.

Crist, J.W. and Stout, G.W. (1929). Relation between top and root size in herbaceous plant. Plant Physiol. 4: 63 - 65.

Crookston, R.K, Treharne, K.J. Lawford, P. and Ozbur, J.L. (1975). Response of beans to shading. Crop Sci. 15(3): 412 - 415.

Cunningham, R.K. and Lamb, J. (1959). A cocoa shade and manurial experiment at the West African Cocoa Research Gchana. J. Hort. Sci. 34: 14 - 22.

Cunningham, R.K. and Burridge, J.C. (1960). The growth of cocoa with and without shade. Ann. Bot. N.S. 24: 458 - 462.

Deb, D.L., Das, S.K., Paunilla Chabra, and Sanyal, S.K. (1977). Potassium application for increased phosphorus and zinc availability for crop production. Bull. Indian Soc. Soil. Sci. 10: 205 - 212.

*Dugger, B.M. (1903). The physiological effects of shading plants. Proc. Soc. hort. Sci. 15 - 17.

Edmond, J.B., Senn, T.L. and Andrews, F.S. (1964). Fundamentals of Horticulture. Tata McGraw Hill Publishing Co. Ltd., Bombay. pp 90 - 103.

Evans, H. (1951). Some problems in the physiology of cocoa. J. Agric. Soc. Triv. Tob. 51: 277 - 292.

Evans, H. and Murray, D.B. (1953). A shade and fertiliser experiment on young cocoa. Rep. Cacoa Res. Imp. Coll. Trop. Agric. 1945 - 1951, 10: 67 - 76.

Fisher, R.A. (1975). Yield potential in a dwarf spring wheat and the effects of shading. Crops Sci. 15 (5): 607 - 609.

Fretz, T.A. and Dunham, C.W. (1971). Influence of three levels of light intensity on leaf structure, area and colour difference of American Holly, Ilex opaca cv. Miss Helen. Phyton. 30 (1/2) 135 - 139 (HcA) 44(6): 4162).

Fujiwara, A. and Lida, S. (1955). Biochemical and nutritional studies on potassium. II Potassium in relation to carbohydrate metabolisom of higher plants. Tohoku J. Agro. Res. 61: 67 - 74.

Gark, O.K., Ram, R.S. and Sinha, N.C. (1978). Response of maize to application of magnesium and potash. Indian Potash. J. 3 (3): 19 - 29.

Goodall, D.W. (1955). Growth of cocoa seedlings as effected by illumination. XIV Hort. Congr. 1501 - 1510.

Gopinathan, R. (1981). Effect of shade and moisture regimes on the growth of cocoa seedlings. M.Sc. (Ag.) Thesis, Kerala Agricultural University. pp 48 - 80.

Gosh, A.B. and Biswas, C.R. (1978). Potassium responses and changes in soil potassium status with time. Proc. Int. Potassium symp. Potash res. Instt. of India, New Delhi, 379 - 390.

Gourley, J.H. (1920). The effect of shading on some horticultural plants. Proc. Amer. Soc. hort. Sci. 17: 256 - 260.

*Gramen, J. (1974). The influence of some environmental factors on the formation and shedding of reproductive organs in horse bean. 2. Influence of shading and decreased day length. Biologicka. 12 (2): 1 - 15.

Guers, J. (1971). Effect of light on the morphology and physiology of cocoa leaves. Cafe' Cacao The' 15 (3): 191 - 201.

Gupta, R.A., Dubey, P.D. and Thripathi, U.S. (1977). Response of potash in wheat. Indian Potash. J. 2(2): 2 - 5.

Hardy, F. (1958). The light relation of cocoa. Cocoa Manual. Inter. Amer. Inst. Agric. Sci. Turrialba Costa Rica. 85 - 91.

Higazy, M.A., Kheir, N.F., El-Habbasha, K.M. and Bakry, M.O. (1975). Nitrogen, pigment and sugar contents of pea plant (Pisum sativum L.) as effected by light intensity and exposure to different low temperatures Egyptian J. Bot. 18 (1/2): 53 - 57.

Holmgren, P. (1968). Leaf factors affecting light saturated photosynthesis in ecotypes of Solidago virgaurea from exposed and shaded habitats. Physiol. plantarum. 21: 676 - 698.

*Huang, C.S. (1977). Causes of low yields of the second crop rice. J. agric. Ass. China. No. 100: 22 - 33.

Hurd, R.G. and Cunninghem, R.K. (1961). A cocoa shade and manurial experiment at the West African Cocoa Research Institute, Ghana. III. Physiological results. J. hort. Sci. 36 (2): 126 - 137.

Jackson, M.L. (1970). Soil chemical analysis. Prentice-Hall Inc. Engle wood Cliffs N.J., U.S.A. pp 498.

Jackson, M.L. and Ulrich, A (1959). Analytical methods for use of plant analysis. Calif. Agric. Expt. Sta. Bull. No. 766, 26 - 76.

James, W.O. and Penston, N.L. (1933). Ann. Botany (London) 47: 279 - 293.

Joseph, C.P.D. (1979). Interaction of shaden-bulletin - UPASI Tea Scientific Dept. (India). Proc. 2nd Joint Area Scientific Symp. April 1979, No. 36: 5 - 8.

Kadman, Z.A. and Ephrat, E. (1979). Development of plants in filtered sunlight (1) Spectral composition, light intensity, day length and red and far red radiation on long and short day grasses. Israel. J. Bot. 25 (1/2) 11 - 23.

Kassam, A.H. (1976). Crops of the West African semi arid tropics. ICRISAT Annual Report, Hyderabad. pp 37 - 40.

Kerala Agricultural University (1978). Package of Practices recommendations. pp 164 - 165.

*Khossien, M.M. (1970). The effect of light intensity, quality and photo period on the photosynthetic productivity of bean plants. Nauchnye Turdy Ukrain skoi Sel skokhozyai Strennoi Akadieonii No. 31: 96 - 102 (HCA 42 (2): 3800).

*Kopylova, A.A. (1978). Effect of solar radiation on yield of wheat under different nutritional regimes. Irkutsk - USSR 44 - 45.

Lalitha Bai, E.K. (1981). Shade response of common rainfed inter crops of coconut. M.Sc. (Ag.) Thesis submitted to Kerala Agricultural University - pp 159.

*Minoru, T. and Hori, Y. (1969). Studies on the photosynthesis of vegetable crops. 1. Photosynthesis of growing plant of vegetables in relation to light intensity. Bulletin Series A. (Hiratsuka) No. 8 Hort. Res. Sta. Ministry of Agriculture and forestry, Japan, pp 139 - 140.

Moursi, M.A., El-Gawad, A.A.A., El-Din, N.A.N., Ashour, N.I. and Yakout, G.M. (1976a). Effect of shading and nitrogen fertiliser on photosynthetic pigments and nitrogen contents of wheat blades. Egyptian J. Agron. 1 (2): 171 - 178.

Moursi, M.A., El-Gawad, A.A.A., El-Din, N.A.N., Ashour, N.I. and Yakout, G.M. (1976b). Net assimilation rate and efficiency of solar energy conversion of wheat plants as effected by nitrogen fertiliser and shading. Egyptian J. Agron. 1(2): 163 - 169.

Moursi, M.A., El-Gawad, A.A.A., Ashour N.I., El-Din, N.AaN and Yakout, G.M. (1976c). Response of wheat yield to shading and nitrogen fertiliser. Egyptian J. Agron. 1 (2): 179 - 186.

*Murray, D.B. (1953). A shade and fertiliser experiment with cocoa. Rep. Cacao Res. Imp. Coll. Trop. Agric. 1952: 11 - 21.

*Myhr, K. and Saebo, S. (1969). The effect of shade on growth, development and chemical composition in some grass species. Forsk, Fors, Landbr. 20: 297 - 315

Nightingale, G.T., Schermerhom, L.G. and Robbins, W.K. (1930). New Jersey Agric. Expt. Sta Bull. 449.

Nosbergr, J. and Fessler, R. (1968). The effect of light intensity and nitrogen on dry matter production and nitrate content of Italian rye grass. Schweiz land Forsch. 7 (3, 4): 310 - 324.

Okali, D.U.U. and Owusu, J.K. (1975). Growth analysis and photosynthetic rates of cocoa (Theobroma cacao L.) Seedlings in relation to varying shade and nutrient regimes. Ghana J. agric. Sci. 8 (1): 51 -67.

Oladokun, M.A.O. (1980). Legume cover crops, organic mulch and associated soil conditions and plant nutrient content for establishing Quillos coffee. Hort. Sci. 15 (3): 305 - 306.

Palis, R.K. and Bustrillos, A.R. (1976). The effect of limited light on the carbohydrate and protein content of grain sorghum. Philippine J. Crop Sci. 1 (3): 161 - 166.

Panikar, S.N., Sajnani, B.T. and Walunjkar, W.G. (1969). Comparative performance of two varieties of cigar wrapper tobacco, grown at varying nitrogen and spacing levels under shade and in the open. Indian J. agric. Sci. 39: 333 - 340.

Patterson, D.T. (1979). The effects of shading on the growth and photosynthetic capacity of Itchgrass. (Rottboellia exaltata). Weed Sci. 27 (5): 549.

Patterson, D.T. (1980). Shading effects on growth and partitioning of plant biomass in cogon grass (Imperata cylindrica) from shaded and exposed habitats. Weed Sci. 28 (6): 735.

Pears, R.B. and Leedr. (1969). Photosynthetic and morphological adaptation of alfalfa leaves to light intensity at different stages of maturity. Crop Sci. 9 (6): 791 - 794.

*Porter, A.M. (1937). Effect of light intensity on the photosynthetic efficiency of tomato plants. Plant Physiol. 12: 25 - 52. bibl. 24.

*Priestly, J.H. (1929). The biology of the living chloroplast. New phytol. 28: 197 - 217.

Radha, T. (1979). Effect of shade on growth and fruiting in pineapple. M.Sc (Hort.) Thesis, 1979. Kerala Agricultural University, pp 68 -77.

Ramakrishnan Nair, K. (1963). Response of Co-7 Ragi to phosphate and potash. M.Sc. (Ag.) dissertation submitted and accepted by University of Madras.

Ramankutty, N.N. (1967). Studies on the effect of potassium on the growth, yield and nutrient uptake of two newly introduced rice variety (Tainan - 3 and T.N - 1). Thesis submitted to University of Kerala for M.Sc (Ag.) degree.

*Ramaswami, M.S. (1960). Report on Biochemistry for 1959. A.E. Tea Res. Inst. Ceylon for 1959. pp 49.

Rayachaudheri, S.P. (1976). Potassium fertilisers for increasing crop production. Bull. Indian Soci. Soil Sci. 10: 306 - 316.

*Rodriguez, S.J., Rivera-Lopez, C. and Santiago, A. (1973). Variation in chemical composition of Dracaena sanderiana leaves as influenced by leaf maturity and shade intensity. J. agric. Univ. Puerto Rico. 57 (2): 136 - 148.

Rolfs, P.H. (1903). Effect of shading on pineapples and citrus fruits. Proc. Soc. hort. Sci. 1903. 26 - 34.

Roy, R.N., Seetha Raman, S. and Singh, R.N. (1978). Soil and fertilizer potassium in crop nutrition. Fert. News. 23 (6): 31 - 36.

Sahasranaman, K.N. and Pillai, N.G. (1976). Mixed farming in coconut garden. Intensive Agric. 14 (9): 6 - 10.

Sakiyama, R. (1968). Effect of irrigation, temperature and shading on the acidity of tomato fruits. J. Jap. Soc. hort. Sci. 37: 67 - 72.

Schmidt, W.H. and Colville, W.L. (1967). Yield and yield components of Zea mays L. as influenced by artificially induced shade. Crop. Sci. 7 (1): 137 - 139.

Schoch, P.G. (1972). Effects of shading on structural characteristics of the leaf and yield of fruit in Capsicum annum. J. Amer. Soci. Hort. Sci. 97 (4): 461 - 464.

Scott, W.O.D. (1960). Some effect of competition between Alfalfa and sorghum or corn for light moisture, and nutrients. Soils Fert. Abstr. 23: 1488.

Shrivastava, M.M.P. and Yawalkar, K.S. (1960). Effects of nitrogen, phosphate and potash on lodging of wheat. Ind. Jour. Agron. 4: 246 - 257.

*Silveira, A.J., Da and Maestri, M. (1973). The growth of arabica coffee seedlings cv. Bourbon under four light levels. Revista Ceris 20 (111): 354 - 369.

Simpson, J.E., Adair, C.R., Kohler, G.O., Dawson, E.H., Debald, H.A., Kester, E.B. and Klick, J.T. (1965). Quality evaluation studies of foreign and domestic races. Tech. Bull. No. 1331. Service. USDA. 1 - 180.

Singh, A. (1967). Plant physiology. Asia Publishing House, India, pp 614.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. Oxford and IBH Publishing Co., Calcutta, Bombay, New Delhi, pp 593.

Subramanian, S. (1969). Sources and levels of nitrogen with phosphorus and potassium as factors influencing the yield of Ragi, Co - 7. M.Sc. (Ag.) dissertation submitted to and accepted by University of Madras.

Subramanian, S., Morachan, Y.B. and Kalaippa, R. (1971). Sources and levels of nitrogen with phosphorus and potash as factors influencing the yield of Ragi(Eleusine coracana Gaestu). Madras Agric. J. 58 (4): 291 - 296.

Tarila, A.G.I., Ormrod, D.P. and Adedipe, N.O. (1977). Effects of phosphorus nutrition and light intensity on growth and development of the cowpea (Vigna unguiculata L.). Ann. Bot. 41 (11): 75 - 83.

Usha, C. (1967). Potash utilisation of rice with regard to the effect of calcium, magnesium and silicon. Thesis submitted to and accepted by the University of Kerala for M.Sc. (Ag.) degree.

Venkitamani, K.S. (1961). Shade for tea in relation to environment. UPASI Tea Sci. Dept. Bull. 20: 6 - 21.

Venkateswarlu, B. and Srinivasan, T.E. (1978). Influence of low light intensity on growth and productivity in relation to population pressure and varietal reaction in irrigated rice (Oryza sativa L.), Indian J. Plant Physiol. 21 (2): 162 - 170.

Vijayan, C. (1970). Studies on the effect of graded doses and time of application of potash on the yield of rice (Oryza sativa L.) variety I.R. 8. M.Sc. (Ag.) Thesis submitted to and accepted by the University of Kerala.

Wahua, T.A.T. and Miller, D.A. (1978). Effects of shading on the N_2 fixation, yield and plant composition of fieldgrown soyabeans. Agron. J. 70(3): 387 - 392.

Walsh, T. (1963). Some investigations on potassium in Agriculture in Ireland Potash Review, 16: 1 - 11.

*Watson, J.D. (1947). Ann. Botany (London) 11: 375 - 407.

Williams, E.D. (1968). The effects of decreasing light intensity on the growth of Agropyron repense (L.) Weed Res. 10 (4): 360 - 366.

Wilson, D. and Cooper, J.P. (1969). Effect of light intensity during growth on leaf anatomy and subsequent light saturated photosynthesis amongst contrasting lolium genotypes. New Phytol. 68 (4): 1125 - 1135.

Wong, O.C. and Wilson, J.R. (1980). Effects of shading on the growth and nitrogen content of green panic and siratro in pure and mixed swards defoliated at two frequencies. Aust. J. Agric. Res. 31: 269 - 285.

* Originals not referred

APPENDICES

APPENDIX I

Weather Data: Average values for past 24 years (1956 - 1980).

	Rain fall (mm)	Temperature °C		Humidity (per cent)
		Max:	Min:	
January	34.62	30.93	22.46	79.88
February	36.00	31.34	22.87	82.05
March	35.06	32.17	24.00	81.36
April	89.16	32.27	25.02	83.29
May	197.70	31.75	24.92	85.07
June	292.20	30.42	23.95	85.13
July	220.90	29.72	23.46	87.18
August	138.63	29.77	23.22	86.02
September	150.28	30.12	23.36	85.77
October	264.14	29.70	23.76	87.41
November	208.05	29.91	23.81	86.97
December	71.85	30.66	23.26	84.78

APPENDIX II

Analysis of Variance: Height of the plants

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.0816**	0.0753**	0.0281	0.0160	0.0075
Shade	3	0.0033	0.3584**	0.4516**	0.7932**	0.1104**
Potash	3	0.0376*	0.0529**	0.0652**	0.0284**	0.0419**
S x K	9	0.0158	0.0228	0.0031	0.0016	0.0041
Error	30	0.0112	0.0106	0.0108	0.0060	0.0027

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX III

Analysis of Variance: Leaf area

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	1147.64	270.05	1691.51**	202.70	138.91
Shade	3	767.90	4129.35**	16386.34**	19265.59**	7745.65**
Potash	3	177.14	398.75	1724.20**	413.25	433.05**
S x K	9	437.81	153.59	89.79	119.64	39.16
Error	30	727.89	163.66	243.39	174.76	66.93

** Significant at 1 per cent level

APPENDIX IV

Analysis of Variance: Tiller production

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	6.08	125.44**	8.89	36.58	23.95**
Shade	3	45.40*	370.72**	128.35**	135.36**	144.48**
Potash	3	21.40	11.50	7.41**	5.25	4.13**
S x K	9	15.50	5.22	17.53	10.82	2.83
Error	30	10.46	10.41	9.91	13.18	4.76

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX V

Analysis of Variance: Leaf : Stem ratio

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.3039	1.3260**	0.3605	0.7079	0.0265
Shade	3	0.0707	0.3401	0.7190**	0.1003	0.0553
Potash	3	0.2213	0.3643	0.2297	0.0050	0.0572
S x K	9	0.0998	0.1889	0.1893	0.0826	0.0660
Error	30	0.1445	0.2202	0.1235	0.2280	0.0746

** Significant at 1 per cent level

APPENDIX VI

Analysis of Variance: Green fodder yield

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined total
Block	2	376.64**	212.53**	24.00	15.18	35.53
Shade	3	225.36**	1451.44**	595.12**	357.46**	3291.97**
Potash	3	283.81**	30.38	42.34	10.95	952.86*
S x K	9	23.65	45.52	26.63	26.89	315.33
Error	30	40.66	20.84	36.43	22.89	224.49

* Significance at 5 per cent level

** Significant at 1 per cent level

APPENDIX VII

Analysis of Variance: Dry fodder yield

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined total
Block	2	7.91	0.88	1.68	4.14	24.38
Shade	3	15.60**	65.28**	18.27**	18.05*	225.51**
Potash	3	5.36	8.73	1.43	2.33	3.43
S x K	9	1.16	8.85	1.40	4.47	62.75
Error	30	2.79	7.25	1.44	4.06	38.32

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX VIII

Analysis of Variance: Crude protein

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.4341	0.6562	0.6724*	2.8942	0.6626
Shade	3	0.8042	2.8435**	1.6907**	1.4084	4.0658*
Potash	3	0.1025	0.1136	0.0763	0.0161	0.8681
S x K	9	0.3789	0.1705	0.0581	0.1763	0.7584
Error	30	2.2845	0.4670	0.1534	1.3664	1.0790

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX IX

Analysis of Variance: Crude fibre

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.7722	0.6413	0.7320	2.7188	0.0900
Shade	3	1.5970	4.3924**	1.9958**	1.9256	1.9387**
Potash	3	0.1447	6.2087	0.5129	0.1229	0.1660
S x K	9	0.4290	0.2637	0.3111	0.2101	0.0703
Error	30	2.0050	0.7835	0.3985	1.3991	0.3366

** Significant at 1 per cent level

APPENDIX X

Analysis of Variance: Ash content

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.4144	0.2196	0.7980*	0.2806	0.0838
Shade	3	0.5681	0.2756	0.1790	0.0156	0.1311
Potash	3	0.2162	0.0767	0.0384	0.0295	0.0277
S x K	9	0.1009	0.0877	0.0434	0.0929	0.0216
Error	30	0.5493	0.2118	2.3775	0.2462	0.1075

* Significant at 5 per cent level

APPENDIX XI

Analysis of Variance: Chlorophyll

Source	df	Mean square					
		'a'		'b'		Total	
		1st obn.	2nd obn.	1st obn.	2nd obn.	1st obn.	2nd obn.
Block	2	0.6553	0.0510	3.9092*	8.6300**	2.8511	5.9390**
Shade	3	10.6500**	7.1250**	0.6860	11.0900**	17.6341**	33.0153**
Potash	3	0.3459	1.5676	0.3683	0.1249	1.0762	0.2201
S x K	9	0.4331	0.0846	0.3448	0.1473	1.1868	0.1598
Error	30	0.2019	0.1306	1.0583	0.6523	1.5106	0.6557

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XII

Analysis of Variance: Calcium

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.0076	0.0021*	0.0008	0.0006	0.0004
Shade	3	0.0018	0.0136**	0.0126**	0.0012**	0.0081**
Potash	3	0.0010	0.0008	0.0014	0.0013	0.0009
S x K	9	0.0013	0.0007	0.0005	0.0004	0.0003
Error	30	0.0032	0.0005	0.0006	0.0007	0.0003

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XIII

Analysis of Variance: Magnesium

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.0130**	0.0002	0.0033**	0.0032*	0.0036**
Shade	3	0.0156**	0.0121**	0.0065**	0.0118**	0.0105**
Potash	3	0.0006	0.0020*	0.0008	0.0004	0.0009**
S x K	9	0.0007	0.0004	0.0002	0.0007	0.0002
Error	30	0.0010	0.0004	0.0006	0.0007	0.0002

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XIV

Analysis of Variance: Potassium

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.0901	0.0346	0.0152	0.0180	0.0338*
Shade	3	9.6550**	4.1353**	1.6668**	0.2481**	0.8767**
Potash	3	8.6226**	0.1143	0.0224	0.0051	0.1294**
S x K	9	0.0451	0.0470	0.0143	0.0089	0.0134
Error	30	0.0453	0.0434	0.0149	0.0097	0.0097

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XV

Analysis of Variance: K: (Ca + Mg) ratio

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.14	0.04	0.02	0.02	0.03
Shade	3	0.63**	0.68**	1.35**	0.17**	0.74**
Potash	3	0.76**	0.09	0.01	0.004	0.06
S x K	9	0.04	0.04	0.02	0.009	0.02
Error	30	0.04	0.05	0.01	0.009	0.03

** Significant at 1 per cent level

APPENDIX XVI

Analysis of Variance: Phosphorus

Source	df	Mean square				
		1st cut	2nd cut	3rd cut	4th cut	Combined mean
Block	2	0.0005	0.0030	0.0001	0.0171	0.0017
Shade	3	0.0014	0.0087	0.0056	0.0075	0.0022
Potash	3	0.0043	0.0009	0.0069	0.0118	0.0018
S x K	9	0.0055	0.0032	0.0049	0.0054	0.0015
Error	30	0.0033	0.0041	0.0053	0.0090	0.0008

APPENDIX XVII

Analysis of Variance: Total soil nitrogen, Available phosphorus, and Available potash

Source	df	Mean square		
		Total N	Available P	Available K
Block	2	0.0163	135.69	599.08
Shade	3	0.0140	283.86**	616.97
Potash	3	0.0106	311.69**	1162.08*
S x K	9	0.0121	334.87**	290.75
Error	30	0.0172	57.18	278.72

* Significant at 5 per cent level

** Significant at 1 per cent level

SHADE TOLERANCE OF GUINEA GRASS var. *MACKUENII* UNDER DIFFERENT LEVELS OF POTASSIUM

BY

P. MULLAKOYA

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