PRODUCTION POTENTIAL OF TWO FODDER GRASSES UNDER DIFFERENT MANAGEMENT PRACTICES

By
G. RAGHAVAN PILLAI

THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE

Doctor of Philosophy
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1986

DECLARATION

I hereby declare that this thesis entitled "Production potential of two fodder grasses under different management practices" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

G Raghavan Pillai

(G. RAGHAVAN PILLAI)

Vellayani,
29--12--1986.

CERTIFICATE

Certified that this thesis, entitled "Production potential of two fodder grasses under different management practices" is a record of research work done independently by Sri. G. Raghavan Pillai under the guidance and supervision of Dr. N. Sadanandan, former Chairman and subsequently 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.

Madhavan Nair KP

K.P. MADHAVAN NAIR,
Chairman, Advisory Committee,
Professor of Agronomy,
College of Agriculture.

Vellayani,
29--12--1986.

Approved by:

Chairman

Prof. K.P. Madhavan Nair

Members:

1. Dr. N. Neelakantan Potti

2. Dr. V. Muraleedharan Nair

3. Dr. M.M. Koshy

4. Dr. K.C. George

External Examiner

ACKNOWLEDGEMENTS

With immense pleasure I express my profound sense of gratitude to my respected guide Sri. K.P. Madhavan Nair, Professor of Agronomy, College of Agriculture, Vellayani for his valuable guidance and precious suggestions both as a member and as Chairman of the Advisory Committee, during the course of this investigation and sustained interest and help in preparation of this thesis. I am deeply indebted to him.

I am grateful to Dr. C. Sreedharan, Professor and Head, Department of Agronomy, College of Horticulture, Kerala Agricultural University for his very valuable suggestions, timely advices and sincere help, during the entire period of this research work. I feel inadequacy of words in expressing my sincere gratitude to him.

I am extremely thankful to Dr. M.M. Koshy, Dean i/c, Faculty of Agriculture, Kerala Agricultural University and Director, Centre of Excellence for Tropical Soils, College of Agriculture, Vellayani for his most helpful suggestions and appropriate timely advices during the entire period of investigation and submission of the thesis. But for him

I would not have submitted this document at this juncture. I am indebted to him very much.

I am extremely thankful to Dr. K.C. George, Professor of Statistics, College of Veterinary and Animal Sciences, Mannuthy for his sincere advices and valuable suggestions in the statistical analysis, presentation and interpretation of the results.

I am thankful to Dr. V. Muraleedharan Nair, Professor of Agronomy, Communication Centre, Mannuthy for his sincere help in the preparation and presentation of this thesis.

I express my sincere thanks to Dr. N. Sadanandan, former Chairman of Advisory Committee for all the help and guidance given in his capacity as Professor of Agronomy, Dean, Faculty of Agriculture and later as Director of Post Graduate Studies during my course of study, field and laboratory work and correction of the manuscript.

I must keep in record my reverences and gratitude to late Sri. E.J. Thomas, Professor of Agricultural Statistics, College of Agriculture, Vellayani for his help in the statistical layout and designing of the programme.

I am extremely thankful to Dr. P. Saraswathy, Associate Professor, Department of Agricultural Statistics, College of Agriculture, Vellayani for all the help she rendered in the statistical analysis, interpretation of results, presentation of tables and each and every item of statistics incorporated in this thesis. Sri. C.T. Mukundan, Technical Assistant deserves my sincere thanks for the untiring help he has given in the statistical analysis of the data.

I am thankful to Dr. R.S. Aiyer, Professor and Head of the Department of Soil Science and Agricultural Chemistry, College of Agriculture for the constant encouragement, timely advices, strength and support luxuriously extended to me for the preparation and submission of this thesis.

I am also thankful to the members of staff of the Department of Agronomy, College of Agriculture, Vellayani during the period of investigation of the Research Project and write up of thesis for their unreserved co-operation and encouragement.

I am extremely thankful to Sri. Abdul Hameed, Professor of Agricultural Chemistry, for the help rendered in the chemical analysis.

I am grateful to Sri. K.P.P. Kurup, Managing Director, Trivandrum Regional Co-operative Milk Producers' Union for providing scientific literature on forages, Dr. Ramanujam, Scientist, Central Tubercrop Research Institute, Sreekaryam for his advices on the physiological aspects of this investigation, Sri. P. Shamsudeen, Sri. P. Girija Vallabhan and Sri. K. Sambasivan, Agricultural Officers of the KLD and MM Board for providing planting materials for the conduct of the experiment and valuable literature for the preparation of this thesis.

Finally but foremost my indebtedness are due to my mother Smt. C. Janaki Amma, my wife Smt. Padmaja and my children Rashmi and Ranjini for the unfailing moral and physical support and encouragement throughout the course of my research.

G. Raghavan Pillai

G. RAGHAVAN PILLAI

Vellayani,
29--12--1986.

CONTENTS

	Pages
INTRODUCTION	1-6
REVIEW OF LITERATURE	7-52
MATERIALS AND METHODS	53-70
RESULTS AND DISCUSSION	71-165
SUMMARY	166-180
REFERENCES	i-xxviii
APPENDICES	1-2
ABSTRACT	1-3

LIST OF TABLES

Table No.	Title
1.	Height of grasses in open area.
2.	Height of grasses in coconut garden.
3.	Height of stylosanthes in open area.
4.	Height of stylosanthes in coconut garden.
5.	Number of tillers of grasses in open area.
6.	Number of tillers of grasses in coconut garden.
7.	Leaf stem ratio of grasses in open area.
8.	Leaf stem ratio of grasses in coconut garden.
9.	Leaf stem ratio of stylosanthes in open area.
10.	Leaf stem ratio of stylosanthes in coconut garden.
11.	Leaf area index of grasses in open area.
12.	Leaf area index of grasses in coconut garden.
13.	Crop growth rate of grasses in open area.
14.	Crop growth rate of grasses in coconut garden.
15.	Crop growth rate of stylosanthes in open area.
16.	Crop growth rate of stylosanthes in coconut garden.
17.	Drymatter yield of grasses in open area.
18.	Drymatter yield of grasses in coconut garden.
19.	Drymatter yield of stylosanthes in open area.

20. Drymatter yield of stylosanthes in coconut garden.

21. Total drymatter yield of grasses and stylosanthes in open area.

22. Total drymatter yield of grasses and stylosanthes in coconut garden.

23. Crude protein content of grasses in open area.

24. Crude protein content of grasses in coconut garden.

25. Crude protein content of stylosanthes in open area.

26. Crude protein content of stylosanthes in coconut garden.

27. Combined crude protein yield of grasses and stylosanthes in open area.

28. Combined crude protein yield of grasses and stylosanthes in coconut garden.

29. Crude fibre content of grasses in open area.

30. Crude fibre content of grasses in coconut garden.

31. Correlation between drymatter, protein and fibre contents in grasses.

32. Crude fibre content of stylosanthes in open area.

33. Crude fibre content of stylosanthes in coconut garden.

34. Ash content of grasses in open area.

35. Ash content of grasses in coconut garden.

36. Ash content of stylosanthes in open area.

37. Ash content of stylosanthes in coconut garden.

38. Phosphorus content of grasses in open area.

39. Phosphorus content of grasses in coconut garden.
40. Phosphorus content of stylosanthes in open area.
41. Phosphorus content of stylosanthes in coconut garden.
42. Potassium content of grasses in open area.
43. Potassium content of grasses in coconut garden.
44. Potassium content of stylosanthes in open area.
45. Potassium content of stylosanthes in coconut garden.
46. Calcium content of grasses in open area.
47. Calcium content of grasses in coconut garden.
48. Calcium content of stylosanthes in open area.
49. Calcium content of stylosanthes in coconut garden.
50. Magnesium content of grasses in open area.
51. Magnesium content of grasses in coconut garden.
52. Magnesium content of stylosanthes in open area.
53. Magnesium content of stylosanthes in coconut garden.
54. K: (Ca + Mg) ratio of grasses in open area.
55. K: (Ca + Mg) ratio of grasses in coconut garden.
56. K: (Ca + Mg) ratio of stylosanthes in open area.
57. K: (Ca + Mg) ratio of stylosanthes in coconut garden.
58. Uptake of nitrogen by grasses in open area.
59. Uptake of nitrogen by grasses in coconut garden.
60. Uptake of nitrogen by stylosanthes in open area.
61. Uptake of nitrogen by stylosanthes in coconut garden.

62. Uptake of phosphorus by grasses in open area.

63. Uptake of phosphorus by grasses in coconut garden.

64. Uptake of phosphorus by stylosanthes in open area.

65. Uptake of phosphorus by stylosanthes in coconut garden.

66. Uptake of potassium by grasses in open area.

67. Uptake of potassium by grasses in coconut garden.

68. Uptake of potassium by stylosanthes in open area.

69. Uptake of potassium by stylosanthes in coconut garden.

70. Nitrogen content of soil after the experiment in open area.

71. Nitrogen content of soil after the experiment in coconut garden.

72. Phosphorus content of soil after the experiment in open area.

73. Phosphorus content of soil after the experiment in coconut garden.

74. Potassium content of the soil after the experiment in open area.

75. Potassium content of the soil after the experiment in coconut garden.

76. Economics of fodder production.

77. Yield of coconuts during the experimental period, and subsequent two years after the experiment.

LIST OF PLATES

Plate		In between pages
1.	Layout plan - experiment in open area.	61-62
2.	Layout plan - experiment in coconut garden.	61-62

LIST OF ILLUSTRATIONS

Figure		In between pages
1.	Climatic parameters during the experimental period.	55-56
2.	Response of grasses to different levels of nitrogen.	91-92
3.	Production potential of grasses under different levels of nitrogen.	93-94
4.	Response of stylosanthes to nitrogen in the absence and presence of phosphorus.	100-101
5.	Response of grass - stylosanthes mixture to nitrogen.	103-104
6.	Response of grass - stylosanthes mixture to nitrogen in the absence and presence of phosphorus.	105-106
7.	Effect of nitrogen on drymatter yield, crude fibre and crude protein.	119-120
8.	Yield of coconuts as influenced by fodder intercropping.	163-164

INTRODUCTION

INTRODUCTION

Kerala is unique in the sense that every inch of arable land is cultivated either with food crops or cash crops. The pressure on land is so acute that about 60 percent of the operational holdings are less than half a hectare. Although livestock rearing is an important subsidiary occupation in every household, the small size of the holding does not permit the farmer to have large scale fodder cultivation. Extensive pasture lands are also not available in plains to support the large cattle population. All these factors clearly point to the necessity for incorporating high yielding, drought resistant and nutritious perennial fodder varieties as complementary crops in our cropping systems (Anon, 1977 d).

Realising the importance of milk and milk production, the Government of Kerala started projects (under the Operation Flood II Programme) for boosting up milk production mainly through cattle improvement brought about by breeding and management. On the management side, the non-availability of sufficient green fodder is an important lacuna to be dealt with urgently (Anon, 1977 d).

Unlike other States, Kerala has special difficulties for forage production. As stated earlier it is not possible to set apart separate land for forage production. It has therefore become imperative that all efforts should be oriented to develop the fodder resources by introducing a judicious forage intercropping programme, suitable for partially shaded conditions existing in coconut gardens and homesteads. For this purpose selection of suitable fodder species and their management practices have to be worked out.

Systematic research on the agronomic aspects of tropical fodder crops has been taken up recently in India. However, work done in other centres of the country are not fully applicable to the existing conditions of the State on account of wide variations in agro-ecological situations as well as in cropping patterns. Coconut being the cash crop of the rich and the poor, it is highly essential to investigate whether the production of a forage intercropping system will affect the productivity of coconut and other existing crops. In fact studies conducted at C.P.C.R.I., Kasaragod, Kerala revealed that various cultural and manurial practices given to these intercrops indirectly benefited coconut (Anon, 1975 b). Trials conducted at the Regional Agricultural Research Station, Pilicode, Kerala also indicated that subsidiary crops with proper manuring will not adversely affect coconut yield (Anon, 1975 b). The interspaces of coconut palms received filtered sunlight, at varying intensities which is quite adequate to raise various crops tolerant and adaptable to such conditions. The fact that the bulk of coconut roots is confined laterally to an area of 1.8 m radius around the bole of the palm provides opportunity for 75 percent of the total soil mass not being effectively utilised by coconut roots (Anon, 1975 b).

In order to get high tonnage and high quality fodder there is nothing better than mixed cropping of protein rich leguminous fodder crops with grasses of wide adaptability. The legumes, besides providing nutritious and palatable fodder, enrich soil by way of symbiotic fixation of nitrogen. Cultivated fodder grasses produce green forage with low protein content, while leguminous fodder crops although rich in protein have only low fodder production potential. By growing them together, the quality and quantity of the produce could be improved or enhanced.

Fertilizer application is yet another measure adopted recently to boost the forage production which improves the quality as well as the yield of biomass. The importance of nitrogen in forage production is well known. Experiments at College of Agriculture, Vellayani indicated that guinea grass responded to nitrogen upto 200 kg/ha under rainfed condition in the open as well as in partial shade condition (Anon, 1978 a). But its response to nitrogen in conjunction with varying doses of phosphorus and vice-versa, when grown as a sole crop or as mixtures, has not been assessed so far. Such aspects of setaria grass (Setaria anceps) were also not studied although both grasses have proved their adaptability in this region. Phosphorus is vital in legume nutrition and development of tropical pastures and hence it is necessary to study its effect on the growth and chemical composition of tropical legumes (Andres and Robins, 1969 a). Phosphorus is not only essential for the legume plants but also essential for the animals that graze on them. The herbage eaten by cattle should necessarily contain at least 0.15 percent phosphorus (Andrew and Robins, 1969 a). As the protein and fibre content of the plant are the most important constituents affecting the quality of fodder, the quantities of these components at different levels of phosphorus application have great bearing on the feeding value of fodder (De Geus, 1977).

Guinea and setaria grasses are very popular in Kerala as they are quick growing, palatable and nutritious. These are tolerant to shade and drought conditions and are grown mixed with a variety of legumes especially Stylosanthes guianensis by farmers, in the absence of rational recommendations. The production potential of these grass legume mixtures in the open and in coconut gardens with varying levels of nitrogen and phosphorus has not been studied so far. The combining ability of these grasses and legumes under such situations has also not been investigated in detail. Hence the present investigation was taken up with the following objectives.

i) To compare the fodder production potential of Guinea and Setaria grasses under partial shade and in the open

ii) To investigate the effect of legume (stylosanthes) intercropping on the productivity of the above grasses under open and partial shade

iii) To study the effect of phosphorus application on the productivity of these grasses in open and partial shade

iv) To assess the nitrogen requirement of these grasses when grown in coconut garden and in the open area, and

v) To investigate the effect of fodder intercropping on the yield of coconut palms.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The present investigation was undertaken with the object of studying the fodder production potential of guinea and setaria grasses grown in various combinations, involving four levels of nitrogen, two levels of phosphorus and intercropping with _Stylosanthes_ _guianensis_. The relative fodder production efficiencies of these grasses were also assessed in the open field and also as an intercrop in existing coconut garden. The relevant literature on the management of guinea and setaria grasses as well as the performance of these crops as influenced by applied nitrogen and phosphorus, legume intercropping, partial shade and other pertinent aspects are reviewed hereunder. Other related fodder grasses and crops are also taken into consideration wherever necessary.

2.1. Influence of Nitrogen on Yield attributes, Yield and Quality of Fodder crops

Nitrogen constitutes the backbone of intensive grassland management (De Geus, 1977). Growth of crop plants is limited more often by a deficiency of nitrogen than by any other plant nutrient (Bogdan, 1977). As the vegetative parts of grasses comprise the economic yield, undoubtedly nitrogen plays the most important role in the production of herbage. The effect of nitrogen on various aspects of forage production are given below

2.1.1. Influence of nitrogen on yield and yield attributes of grasses.

Application of chemical fertilizers to fodder grasses has been a regular practice in many foreign countries, but in India this practice was started only about 30-40 years back and many of the tropical grasses have been found to respond well to the application of fertilizer nitrogen (Whyte, 1964).

Thomas (1978) while investigating the comparative performance of guinea and hybrid napier grasses found that nitrogen had a highly significant effect on plant height.

Trials conducted under the All India Co-ordinated project for research on forage crops at Vellayani on dinanath grass (Pennisetum pedicellatum) with 0, 50 and 150 kg N/ha recorded a linear increase in plant height (Anon., 1978 a).

Abraham et al. (1980) also observed an increasing trend in the height of dinanath grass with increased levels of nitrogen application.

With regard to the number of tillers Bokade (1968) got a remarkable increase in tiller number in fodder oats due to nitrogen application. Increased density of tillers in Kikuyu grass (Pennisetum clandestinum) at 336 kg N/ha has been reported by Mears and Humphreys (1974). Inosaka et al. (1975) obtained increase in number of tillers in three varieties of panic grass with increased doses of nitrogen. Rathore and Vijayakumar (1977 a) recorded increased tiller production with increase in nitrogen fertilization in dinanath grass and fodder sorghum. Thomas (1978) also reported increased number of tillers in guinea grass with nitrogen doses upto 250 kg/ha.

On the other hand, Thangamuthu et al. (1974) reported that split or whole application of nitrogen upto 50 kg/ha failed to increase the tiller number in guinea grass (Panicum maximum). Results from Rahuri (Anon., 1977 b) also indicated a lack of influence for nitrogen on tiller production in bajra (Pennisetum typhoides).

Leaf: stem ratio indicates the general succulence of the herbage. A ratio above (1.00) indicates more succulence. Thangamuthu et al. (1974) recorded lack of response to nitrogen on the leaf: stem ratio of grasses. Rathore and Vijayakumar (1977 a) got a significant decrease in leaf: stem ratio due to nitrogen application in fodder sorghum and dinanath grass. Trials at Rahuri (Anon., 1977 b) on fodder bajra revealed a progressive decrease in leaf: stem ratio with applied nitrogen upto 90 kg/ha. Thomas (1978) reported a significant reduction in leaf: stem ratio with 200 and 250 kg N/ha as compared with the lower level of 150 kg N/ha in guinea grass. The ratio was not significantly affected by nitrogen fertilization in dinanath grass eventhough a decreasing trend was obtained (Abraham et al. 1980).

Humphreys (1966) reported that in sunny environment the amount of radiation penetrating the lower layers of the sward was greater and hence carried more number of leaves without detriment to total grass yield. Ludlow et al. (1974) reported higher LAI values in full sunlight and lower values with decrease in light in the case of grasses. Increase in LAI with increased doses of nitrogen has been reported by Bunproma and Mobbayad (1978).

Experiments by Vicente-Chandler et al. (1961) have established the productivity and nitrogen responsiveness of guinea grass in the humid coastal area of Puerto Rico, where they got responses upto 900 kg N/ha recording a maximum green fodder yield of 163 t/ha/year. Lotero et al. (1967) obtained increase in green fodder yield from elephant grass (Pennisetum purpureum) upto 200 kg nitrogen/ha. Kritayanavach (1968) applied nitrogen to napier and hybrid napier grasses ranging from 0 to 780 kg/ha and got increased fresh weight upto the maximum level tried. Significant yield increases in orchard grass and brome grass were reported by each increment of nitrogen upto 240 kg/ha (Carter and Scholl, 1972). A fresh herbage yield of 226 t/ha/year in 12 cuts was recorded for sewage irrigated guinea grass (Narayanan and Dhabadghao, 1972). Significant increase in forage yield of hybrid napier with increased application of nitrogen upto 150 kg/ha has been reported from Pantnagar (Anon., 1972 a). Work done on dinanath grass varieties showed tremendous response upto 200 kg N/ha in Jabalpur (Anon., 1972 b). Crowder et al. (1977) stated that well fertilized and irrigated Panicum maximum produced 200 to 250 t/ha of green fodder in Columbia. Bogdan (1977) opined that a more realistic yield for guinea grass ranged between 15 and 50 tonnes of fresh herbage and can sometimes be still lower. Nitrogen application at 50 kg/ha after each cut gave a significant yield increase in guinea grass at Anand (Anon., 1977 c). Application of nitrogen @ 120 kg/ha increased the green fodder production of dinanath grass by 60 percent over control at Rahuri (Anon., 1979 a). An increase in yield of this grass with nitrogen application upto 150 kg/ha has been recorded at Vellayani (Anon., 1979 b). Guinea grass responded linearly upto 200 kg N/ha in experiments conducted over a period of three years under rainfed conditions at Vellayani (Anon., 1980). Fertilizer trials with hybrid napier variety NB-21 indicated that the grass responded upto 200 kg N/ha at Tamil Nadu Agricultural University, Coimbatore (Chandrasekharan et al. 1980). Sidhu (1980) obtained a green fodder yield of 175 t/ha at 420 kg N/ha from an evaluation trial of 85 vigorous lines of guinea grass obtained from CSIRO, Brisbane.

Little et al. (1959) got 40 percent increase in drymatter yield of napier grass with 800 lb N/acre under irrigated conditions. Vicente Chandler et al. (1959) obtained 46.72 t drymatter/ha by N nutrition over the lowest dose. Kritanayanavach (1968) obtained a linear increase in drymatter yield from hybrid napier with split application upto 780 kg N/ha. Linear increase in drymatter yield of Pennisetum purpureum with increase in the rate of applied nitrogen was recorded by Guerrero et al. (1970) on the alluvial soils of Costa-Rica. High responses of Panicum maximum to nitrogen fertilizer on drymatter yield were obtained in a number of countries, the responses being usually the highest at moderate doses of nitrogen (100-250 kg/ha) and decreasing gradually at still higher applications. An increase of 38 kg drymatter production per kg of applied nitrogen was obtained by Grof and Harding (1970) in Queensland. Jones (1970) recorded in the case of setaria cv. Nandi a drymatter yield of 32 t/ha without fertilizer nitrogen, 44 t/ha at 112 kg N/ha and 58.6 t/ha when supplied with 336 kg N/ha. Response of drymatter yield to nitrogen rates on rye grass (Lolium perene) was linear between 0 and 336 kg/ha (Reid, 1972). Increased drymatter production by nitrogen application upto 250 kg/ha was obtained in dinanath grass (Anon., 1972 b). Increasing the nitrogen doses from zero to 100, 200, 300 and 400 kg/ha produced increased drymatter yield of guinea grass ranging from 0.309 to 2.97 t/ha at Coimbatore (Chandramoni et al. 1975). In a nitrogen response trial in Hawana, Crespo et al. (1975) obtained a maximum drymatter yield of 13.9 t/ha by guinea grass at 383 kg/ha. Setaria anceps responded well to fertilizer nitrogen and produced 30 to 65 kg drymatter from one kg nitrogen (Bogdan, 1977). He further reported a comparatively lower yield of 14.4 t drymatter/ha by guinea grass in French Guiana. A drymatter yield increase upto 23 t/ha by guinea grass was recorded with nitrogen fertilization upto 400 kg/ha in trials by CIAT at Quilichao (Anon., 1978 d). Sidhu (1980) also obtained responses for guinea grass upto 420 kg N/ha recording 29 t/ha of dry fodder yield.

2.1.3. Influence of nitrogen on quality of grasses.

Application of nitrogen greatly influences the physical and chemical feed value of the fodder produced (De Ceus, 1977).

2.1.3.1. Protein content.

Vicente-Chandler et al. (1959 and 1961) reported progressive and linear increase in protein content of guinea grass, recording values 7.8, 8.1, 9.0 and 11.1 percent respectively for 0, 225, 450 and 900 kg of applied N/ha/year. Butterworth (1967) observed that the crude protein content of guinea grass ranged from 4 to 14 percent. Hacker and Jones (1969) reported that crude protein content of setaria was 7.9 percent in medium fertility soils.

Several other scientists including Little et al. (1970) and Randhava and Gill (1977) also have reported the beneficial effect of nitrogen in increasing the protein content of napier and hybrid napier grasses.

Nitrogen fertilization produced highly significant increase in protein yield of forage and no other management practice appreciably influenced the protein yield of napier grass (Capieal and Ashcroft, 1972). Nitrogen is essential for plant growth because it is a constituent of all proteins and hence the quantity of nitrogen supplied to the crop may influence the protein yield (Russel, 1973). Kandaswamy et al. (1973) reported increased crude protein content in guinea grass at higher levels of nitrogen. Pereira and D' olivera (1976) recorded increased crude protein content of napier grass with increase in the rate of applied nitrogen upto 480 kg/ha. Similarly, Ogwang and Mugerwa (1976) observed that nitrogen application to hybrid napier gave increased crude protein content. Experiments on dinanath grass revealed a linear increase in crude protein content of the fodder with successive application of nitrogen upto 150 kg/ha (Anon., 1977 a). Results of trials by CIAT at Quilichao for three years indicated increase in protein content of guinea grass under varying doses of nitrogen from 0 to 400 kg/ha (Anon., 1978 d). Chadhokar (1978) also obtained similar results in para grass (Brachiaria mutica). Thomas (1978) reported significant increase in protein content of hybrid napier and guinea grass upto 250 kg N/ha. Chandini and Raghavan Pillai (1980) reported that crude protein content of guinea as 8.96 percent and that of setaria as 8.63 percent.

Although considerable increase in crude protein content from applied nitrogen has been obtained, the effect of fertilizers was not always consistent as reported by Grof and Harding (1970) from Australia wherein the crude protein content in Panicum maximum remained almost unchanged when nitrogen rates were increased from 140 to 420 kg/ha. Thangamuthu and Sundaram (1974) observed no influence of nitrogen on protein content of fodder sorghum upto 150 kg/ha.

2.1.3.2. Crude fibre content

Studies by Johnson et al. (1967) in guinea grass revealed that crude fibre content of the forage was reduced by nitrogen application. Black (1968) reported that under high levels of nitrogen crude fibre content will be less and hence plant parts become more succulent, since the carbohydrates are mainly utilized for the synthesis of protoplasm rather than cell wall thickening. Tiwana et al. (1976) also reported a reduction in crude fibre content in hybrid napier with nitrogen application. Thomas (1978) found that crude fibre in guinea and hybrid napier was significantly reduced with increased nitrogen application upto 250 kg/ha. Reduction in crude fibre content with enhanced nitrogen application was also reported by Abraham et al. (1980) in dinanath grass.

However, Koter (1974) reported no reduction in crude fibre on account of nitrogen fertilization in cock's foot and timothy grasses.

2.1.3.3. Ash content

Ash content in perennial rye grass was found to decrease with increased doses of nitrogen (Demarquilly, 1970). Trials on fodder types of *Avena sativa* with 0, 100 and 200 kg N/ha revealed that ash content was reduced with each successive increase in the level of nitrogen (Anon., 1977 a). The same result was also obtained with *Pennisetum pedicellatum* at Vellayani (Anon., 1978 a).

Contrary to the above findings Huquet and Gillet (1974) obtained a slight increase in ash content due to nitrogen application. Tiwana and Puri (1976) also reported an increased ash content in oats by the application of nitrogen. The chemical composition and quality of fodder is greatly influenced by the soil nutrient status (De Geus, 1977).

However, Byasov (1974) obtained no effect for nitrogen on ash content of fodder maize.

2.1.3.4. Phosphorus content

Bahl et al. (1970) reported appreciable increase in phosphorus content of hay with increase in the levels of nitrogen.

But Acharya (1973) noticed that phosphorus content of dinanath grass remained unchanged with nitrogen application, although the yield increased significantly. Rai et al. (1979) also reported that phosphorus content of herbage under various levels of nitrogen remained unchanged in the case of Sehima-Heteropogon grass species at IGFRI, Jhansi.

McLean (1957) observed that the percentage of phosphorus was generally depressed in many fodder grasses with increased levels of nitrogen. Monterio and Werner (1977) studied the effect of nitrogen fertilization on guinea grass in Brazil and found that phosphorus content of the fodder was reduced by nitrogen application. Rathore and Vijaykumar (1977 b) observed a decreasing trend in the phosphorus content of grass due to nitrogen fertilization. A similar decrease in phosphorus content was reported from West Bengal (Anon., 1978 b) and by Abraham et al. (1980) at Vellayani. Ravikumar et al. (1979) found that phosphorus content decreased with increase in the levels of nitrogen in Cenchrus ciliaris at Jhansi. Kalra and Khokhar (1979) reported that phosphorus content was decreased by nitrogen fertilization at the University farm, Meerut.

2.1.3.5. Potassium content

Increased potassium content of grasses due to phosphorus application were reported by Hendrikson (1960). The occurrence of luxury consumption of potassium was reported by Henderson (1960) and Heaberg and Leaf (1960). Lorsen (1966) reported that potassium content of cock's foot and timothy grasses increased with increasing levels of nitrogen application. Reid et al. (1967) observed that nitrogen treated herbage at any stage of maturity generally contained higher level of potassium than grasses without nitrogen. An increased potassium uptake by increased nitrogen application was reported by Miranova (1971), Filipek et al.

(1975), Balasko (1977) and Hojjati et al. (1977) on forage grasses. Abraham et al. (1980) also obtained increase in potassium content due to application of nitrogen in Pennisetum pedicellatum.

2.1.3.6. Calcium and magnesium contents

Mc Allister (1966) noticed increase in calcium and magnesium uptake in Italian rye grass following heavy application of nitrogenous fertilizers. Koter (1974) reported that in Cocks' foot and timothy grasses the calcium content was decreased while magnesium content was not affected due to nitrogen fertilization. Repeated application of heavy dose of nitrogenous fertilizers to hybrid fodder maize increased the uptake of calcium and magnesium (Viswanath, 1975). Tiwana et al. (1975) observed an increase in calcium content with increased nitrogen application in hybrid napier. Rinne (1976) also reported increased uptake of calcium and magnesium by hybrid maize due to higher doses of nitrogen. An increase in magnesium content of grasses by nitrogen application was observed by Hojjati et al. (1977). Kurla and Khokhar (1979) reported that calcium content of fodder increased by nitrogen application. Calcium content in Chrysopogon fulvus showed slightly increasing trend with increase in the levels of nitrogen at the IGFRI, Jhansi (Dwivedi et al. (1980).

However, Rai et al. (1979) could not get any clear trend in the calcium content of Sehima-Heteropogon species due to nitrogen application.

2.1.3.7. Potassium: (Calcium + Magnesium) ratio

Kemp and T' Hart (1957) found that the quality of fodder is decided by the K: (Ca + Mg) ratio in the crop in addition to the nutrient contents. Grumes et al. (1970) concluded that there was a good relationship between the ratio and incidence of grass tetany (Hypomagnesaemia) in cattle. They indicated that when the ratio was less than 2.2, there were very few occurrences of grass tetany. Experiments on K: (Ca + Mg) ratio of nine cool season grasses by Thill and George (1975) also revealed that the ratio above 2.2 is dangerous to cattle and may result in hypomagnesaemia.

Khan and Ali (1969) reported that increasing levels of nitrogen decreased the K: (Ca + Mg) ratio in grasses. Mayland et al. (1975) observed that nitrogen fertilizer increased the concentration of Mg and Ca contents thus reducing the K: (Ca + Mg) ratio slightly.

2.2. Influence of nitrogen on yield attributes, yield and quality of fodder legumes

Literature on the influence of fertilizer nitrogen to sole crops of fodder is very meagre, since fodder legumes are usually grown mixed with grasses or cereal fodders. However, available literature relevant to the present investigation are reviewed.

Several workers (Nuthall and Whiteman, 1972; Henzell, 1968; Lowe, 1970) studied the influence of nitrogen fertilization on drymatter yield and nitrogen concentration of Medicago sativa and reported that drymatter yield was not affected by nitrogen fertilization in the first year, but in the second year it was reduced significantly. At higher nitrogen rates, yields were similar to those in untreated plots. Nitrogen concentration in the plant was increased by nitrogen fertilization at the highest nitrogen rate, but only during the second year of the trial (Colman and Mears, 1975).

Studies using isotopes have shown that pasture legumes generally obtain less than their share of available nitrogen when grown in competition with grasses and broadleaved weeds (if one judges their share by the proportion they contribute to the yield of forage). The fact that legumes usually die out from swards if they fail to nodulate, is additional evidence for their inability to compete for mineral nitrogen (Henzell, 1970). According to him (1970 a) it is unusual to obtain a large response to addition of mineral nitrogen as fertilizer, from effectively nodulated legume plants.

In a red clover - timothy mixture trial, in a dermo-podzolic soil in Moscow region, application of 150 kg Ammonium nitrate/ha had no effect on the hay yield of red clover in the first year, but in the second year the red clover yield was decreased from 3.3 to 1.72 t/ha (Khar'kov and Shekhovtseva, 1976). In a trial with red and white clover in pure swards and in mixtures with Poa pratensis, 0 - 150 kg N/ha in increments of 30 kg/ha, pure swards of clovers exhibited a slight yield increase in response to 30 - 60 kg N/ha, but remained stable at higher nitrogen rates (Drodsov and Lepkovich, 1976). Savova (1976) obtained increased hay yield of 13 percent due to application of 80 kg N/ha in the first year, but thereafter there was no increase in yield.

Solonko and Rudin (1977) reported that in the case of lucerne, addition of 60 kg N/ha along with phosphorus and potassium increased the yield of crude protein.

Legume seedlings grown on a nitrogen deficient soil usually exhibit a period of nitrogen starvation after the seed reserves are exhausted and before the nodules become fully effective. Addition of mineral nitrogen at this time can cause an increase in legume growth that persists after mineral nitrogen has been exhausted and the plants become dependent on symbiotic nitrogen fixation (Skerman, 1977). He has also reported that a large response to fertilizer nitrogen by pure pasture legumes indicates a defect in the symbiosis system. In another study to find out the effects of combined application of 0-20 kg N/ha the nodulation and nutrient uptake by three Phaseolus aureus varieties were determined. It was found that nodulation was not affected with 10 kg N/ha and was decreased with 20 kg N/ha (Yadava and Chokhey Singh, 1978).

2.3. Influence of phosphorus on yield attributes, yield and quality of fodder

Black (1968) stated that the best response of crops to phosphorus was obtained in the early stages of crop growth but decreased gradually with the approach of maturity.

2.3.1. Influence of phosphorus on yield attributes and yield of grasses.

Grasses generally show more response to nitrogen than phosphorus (De Geus, 1977). Hence research results on phosphorus nutrition of grasses are comparatively less. The available literature on phosphorus nutrition of grasses relevant to the present investigation are reviewed.

Gervais (1960) revealed that timothy yield increased with applied phosphorus. Response of guinea grass to phosphorus depend to a great extent on the content of available phosphorus in the soil. Considerable increases in drymatter yield, from phosphorus, sometimes even greater than from nitrogen fertilizer, were obtained in phosphorus deficient soils. Application of 34 and 68 kg phosphorus/ha increased the total three year drymatter yield from 26.6 to 35.5 and 35.7 t/ha respectively in Uganda (Wendt, 1970).

Blunt and Humphreys (1970) obtained increased yields of setaria grass when fertilized with phosphorus. Under conditions of satisfactory nitrogen supply, grasses are more responsive to phosphorus addition (Narwal et al. 1977). Javier et al. (1977) observed that herbage yield of guinea grass cv. Common was increased significantly with

100 to 150 kg P_2O_5/ha. Monteiro and Werner (1977) also reported that application of phosphorus promoted initial growth and drymatter production of guinea grass. Phosphorus application at 100 kg/ha produced the best drymatter yield in Pangola grass (Portieles, 1978). Sanches et al. (1979) reported significant response of napier grass upto 200 kg P_2O_5/ha in Llanos Orientales, Colombo. Ravikumar et al. (1979) reported that in Cenchrus ciliaris, the drymatter yield was increased significantly with levels of phosphorus from 0 - 60 kg P_2O_5/ha at Jhansi. Dwivedi et al. (1980) reported from Jhansi that application of phosphorus to Chrysopogon fulvus significantly increased the dry fodder yield, but 20 kg and 40 kg P_2O_5/ha were on par. However, successful competition by grasses for applied phosphate has also occurred under conditions of low nitrogen supply (Humphreys, 1981).

Contrary to the above, several other workers did not get yield response of grasses due to phosphorus fertilization. Application of phosphorus had no significant effect on drymatter yield of Heteropogon contortus (Dhabadghao et al. 1965; Bahl et al. 1970). Faroda (1970) and Shankaranarayanan et al. (1973) obtained no significant effect of phosphorus on drymatter yield in Cenchrus ciliaris. Oyenuga and

Olubago (1975) found that the response of the grass Chloris gayana to applied phosphorus was less marked. Similar non-significant results were also reported by Rathore and Vijayakumar (1977 a). In a trial with guinea grass at 0, 30 and 60 kg P_2O_5/ha there was no significant effect on the fodder yield (Plucknett, 1979). Ravikumar and Shankaranarayanan (1980) obtained no significant response to levels of phosphorus in the case of Sehima nervosum. Phosphorus application did not show any significant response on the green forage and drymatter yield of dinanath grass (Mukherjee et al. 1981).

Adepetu and Barber (1978) obtained significant response of phosphorus to root growth and non-significant response on tiller production. They also recorded better utilization of phosphorus for crop growth under shade condition.

2.3.2. Influence of phosphorus on quality of grasses.

Ravikumar and Sankaranarayanan (1980) obtained increase in crude protein content in the case of Sehima nervosum with phosphorus levels of 30, 60 and 90 kg P_2O_5/ha. Dwivedi et al. (1980) reported that application of phosphorus showed slight increase in crude protein content with increasing levels of phosphorus from 0 to 40 kg/ha.

Kandaswamy et al. (1973) obtained no effect on the crude protein content of guinea grass due to the application of P_2O_5 at 0, 30 and 60 kg/ha. But Warmsley et al. (1978) found that though the drymatter yield of Pennisetum purpureum was significantly increased by the application of phosphorus, the crude protein content was not affected. Ravikumar et al. (1979) observed a decrease in crude protein content in Cenchrus ciliaris with increasing levels of phosphorus.

Shankaranarayanan et al. (1973) obtained an increase in phosphorus content of Heteropogon contortus due to phosphorus fertilization.

Bahl et al. (1970) observed that phosphate application did not influence the calcium and crude fibre content but showed a tendency to bring about increased phosphorus content in the hay.

Hutton (1970) reported that phosphorus application decreased the potassium content of grasses but did not affect calcium content and increased magnesium content in most species. Andrew and Robins (1971) also recorded similar findings.

Dwivedi et al. (1980) observed increase in calcium and phosphorus content with applied phosphorus in the case of <u>chrysopogon fulvus</u>. Phosphorus content in fodder did not show any definite trend due to varying levels of applied phosphorus(Ravikumar et al. 1979).

Mukherjee et al. (1981) obtained a decrease in ash content in a trial of <u>dinanath</u> grass under three levels of phosphorus (0, 30 and 60 kg P_2O_5/ha) at Kalyani.

Hendrikson (1960) found that phosphorus application reduced the K: (Ca + Mg) ratio of pasture grasses.

2.4. Influence of phosphorus on yield attributes and yield of legumes

Legumes show good response to phosphorus since it is a constituent of protein (Hadjehristodoulou, 1973). Deficiency of phosphorus, more than any other element, limits the realisation of the production potential of the tropical legumes.

Good yield responses were obtained from the use of 200 kg/ha of dicalcium phosphate for stylosanthes, in an experiment in Zaire (Jurion and Henry, 1969). Garg et al. (1970) found increase in the number of leaves in cowpea with increase in phosphorus application. Phosphorus increased the yield of legumes but its effect decreased with increasing levels of available phosphorus in the soil (Gutierrez, 1971). Haggar (1971) also reported that drymatter yield of stylosanthes was increased by the application of phosphorus. Similar findings were recorded in other studies also by Olsen and Moe (1971). Good response in fodder yield to phosphorus application was reported by Robinson and Jones (1972), Bruce (1976) and Chandini and Raghavan Pillai (1980). Jones (1974) obtained significant increase in yield of _Stylosanthes gracilis_ by phosphorus fertilization upto 100-200 kg/ha in acid phosphorus deficient red yellow latosol. De Geus (1977) reported that in the case of stylosanthes maximum leafiness was obtained with moderate levels of nitrogen and phosphorus.

In an experiment with _Stylosanthes guianensis_ fertilized with phosphorus at 25, 50, 100 and 200 kg/ha as superphosphate in the granitic sandy loam soil of North Queensland, Bruce et al. (1978) found that maximum drymatter yield was obtained with 25 kg P_2O_5/ha while yield was reduced by 100 or 200 kg P_2O_5/ha.

2.4.2. Influence of phosphorus on the quality of legume fodder

Suttie (1970) observed that increasing phosphorus application increased the protein and phosphorus content in Stylosanthes guianensis.

Omueti and Oyenuga (1970) and Gill et al. (1972) reported increase in protein and calcium contents of cowpea fodder due to phosphorus fertilization.

Falade (1973) while studying the effect of phosphorus on the growth and mineral composition of tropical pasture legumes found that in Stylosanthes gracilis contents of potassium and calcium were decreased and that of magnesium was unaffected by phosphorus application.

Oyenuga and Olubajo (1975) have recorded the beneficial influence of phosphorus fertilization in increasing the protein content of Stylosanthes gracilis.

Bhagwan Das et al. (1975) found that the application of phosphorus at the rate of 40 kg P_2O_5/ha increased the crude protein yield from 4.19 to 4.92 q/ha and it increased to 5.32 q/ha at 80 kg P_2O_5/ha in fodder cowpea. The crude protein content of Stylosanthes guianensis varied from 10 to 25 percent of the drymatter (Bogdan, 1977).

Faroda and Tomer (1970) found that phosphorus application had no effect on the potassium and calcium contents while Govindaswamy (1978) observed a positive influence for phosphorus application in increasing the calcium content of cowpea fodder.

Jones (1974) found that with 100 to 200 kg P_2O_5/ha, the concentration of phosphorus in Stylosanthes gracilis ranged from 0.1 to 2.5 percent. He further reported that the yield and crude fibre content of stylo was increased due to phosphorus fertilization.

Significant effect of phosphorus treatment on the protein content of stylosanthes was also reported by Eng et al. (1978).

Scholles et al. (1978) studied the residual effect of application of phosphorus fertilizers on lucerne and soybean and recorded that the phosphorus concentration in plants were increased by levels of phosphorus ranging from 200 to 400 kg P_2O_5/ha.

Jarrel and Beverly (1981) have opined that dilution effect is a condition wherein a crop is responding to an element, its drymatter production increased but the concentration of the element decreases. Substantial increases in protein yield of grass legume fodder were also reported due to the influence of nitrogen, phosphorus and legume intercropping by Balasundaram et al. (1975) and Balbatti (1980).

Increases in total protein yield due to phosphorus application were reported in sorghum legume fodder mixture by Meera Bai and Raghavan Pillai (1982) and in maize legume mixture by Mercy George (1982).

2.5. Influence of intercropping on yield attributes, yield and quality of fodder legumes

Cultivation of grasses and legumes together has undoubtedly improved the yield and quality of herbage without the use of expensive nitrogenous fertilizers. However, tropical legumes fix nitrogen to lesser extent than temperate region legumes and as such their beneficial effect is comparatively smaller.

2.5.1. Influence of intercropping on yield attributes and yield of legumes

Both harmful and beneficial effects due to intercropping have been reported.

Thompson (1958) noticed suppressed growth of sorghum due to heavy intertwining effect of legumes.

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

Kristozov (1964) observed inhibition of growth of maize when grown mixed with soybean.

Increase in fodder yield due to grass-legume association has been reported by Salcedo (1969) in a study on the yield and chemical composition of grasses alone, legume alone and grass-legume mixture.

Singh and Guleria (1979) revealed that intercropping soybean with maize did not affect adversely the growth and development of maize measured in terms of plant height, functional leaves per plant, leaf area index and drymatter accumulation.

Chandini and Raghavan Pillai (1980) reported increase in height of guinea and setaria grasses due to intercropping with stylosanthes. However, tiller production was reduced due to legume intercropping.

Daulay et al. (1968) recorded increased forage yield by 20 to 30 percent in grass + legume mixture as compared to grass alone in the arid regions of Rajasthan. But Singh and Chatterjee (1968) reported reduction in yield of grass grown in mixture.

Oyenuga and Olubajo (1969) in a two year trial with four tropical grass-legume mixtures, reported maximum dry-matter yield by the mixture guinea grass + centrosema + stylosanthes. Grof and Harding (1970) found that Stylosanthes guianensis formed the most balanced mixture compared with other legumes, the legume contributing 47 percent of the herbage. Haggar (1971) found that a mixture of Rhode's grass + Stylosanthes gracilis sward gave the same yields of herbage drymatter as Rhode's grass sward given 84 and 187 kg N/ha respectively. Valasquiz and Bryan (1974) observed that the average drymatter percentage of the associated pangola grass was lower than that of control in a grasslegume mixture trial with legumes. Reports from C.P.C.R.I. showed increased fodder yields by hybrid napier and stylosanthes in mixtures (Anon., 1975 b). Moog et al. (1978) observed no significant difference between treatments in total or annual yields when guinea grass was grown in pure stand and mixed with stylosanthes.

Chauhan et al. (1971) reported that total dry forage yield increased significantly due to intercropping of cowpea, as compared to anjan grass grown alone.

Kitamura et al. (1975) observed that the drymatter yield of mixed stand were intermediate between those of pure stand in the case of Setaria anceps grown mixed with Desmodium intortum cv. greenleaf.

Chandini and Raghavan Pillai (1980) recorded maximum fodder yield by guinea + stylosanthes mixture which was superior to non-intercropping but on par with setaria + stylosanthes mixture.

2.5.2. Influence of intercropping on quality of fodder

Crops grown in association influenced some quality parameters such as crude protein, crude fibre, total ash and mineral content.

In several grass-legume mixtures, greater nitrogen yields were obtained from mixtures on unit area of land than from pure stand of grass and legume each (James and Frank, 1942).

Increase in crude protein content of grasses due to legume intercropping has been reported by Moore (1962) and Manitkar and Shukla (1974).

Patel et al. (1966) reported that the crude protein, phosphorus and calcium contents of guinea grass grown mixed with lucerne were significantly higher than those of guinea grass grown alone. They further obtained a higher content of crude fibre in guinea grass when grown alone as compared to the mixed crop of guinea grass and lucerne.

Singh et al. (1971) noticed that growing jowar alone produced fodder with least crude protein and more crude fibre contents, while fodder from a mixture of jowar and cowpea in the ratio 3:1 had a high content of crude protein and moderate content of crude fibre. They also observed that increasing the proportion of legume in the fodder tended to increase the crude protein but reduced the crude fibre content.

Thairu (1972) reported that the nitrogen content of a mixture of setaria + desmodium was considerably higher than that of setaria grass grown alone without added nitrogen. The nitrogen yield of the grass component was increased by 10 to 15 percent due to association with legumes.

Julen (1976) opined that calcium content of grasses grown alone was often lower than grown in mixture with legumes.

Charles (1976) suggested that one of the advantages of grass legume mixtures over pure stands was higher crude protein and mineral content for the mixed crop.

Kitamura et al. (1978) found that for both legumes and grasses the crude protein content was higher in a mixed stand of Desmodium intortum cv. Greenleaf and Setaria anceps cv. Kazangula as compared to the pure stands.

Chandini and Raghavan Pillai (1980) also recorded increase in crude protein, calcium, magnesium and phosphorus contents and decrease in crude fibre content due to intercropping with legumes. They also observed significant reduction in the K: (Ca + Mg) ratio due to legume intercropping.

2.6. Influence of legume on non-legume and vice versa in grass-legume association

Leather (1897) was the pioneer scientist in India to ponder over the speculation that legumes might benefit non-legumes growing along with them. Salcedo et al. (1960)

and Ahlawat et al. (1964) recorded increased fodder yield due to association with legumes. The beneficial effects of legume association in increasing the nitrogen content was observed by Moore (1962) in Nigeria where the nitrogen percent in shoots of star grass Cyanadon plectostachys was raised from 1.8 to 2.4 as a result of association with Centrosema pubescens. Very low rates of nitrogen transfer from legumes to non-legumes over periods of six months to two years was observed by Henzell (1962). He also observed that the quantity of nitrogen transferred to non-legume by different legumes vary irrespective of the quantity fixed by each legume (Henzell, 1970).

Tisdale and Nelson (1973) reported that legumes usually get a lesser share of potassium when grown along with grasses which show a greater affinity for monovalent cations. Whitney et al. (1967 a) observed transfer of nitrogen from centrosema to associated grass. He found that centrosema fixed 240 lb of nitrogen per acre in pure stand and 110 lb nitrogen per acre when grown with grass. Out of this 6 to 11 percent was transferred to grass grown in association. Whitney and Green (1969) recorded that Desmodium canum fixed nearly 100 kg N/ha of which an estimated one third was transferred. The quantity of nitrogen fixed by a legume is positively related to plant growth and each 1000 kg dry weight of legume shoots represents 20 to 40 kg nitrogen fixed from the atmosphere. These gains are sensitive to management as there is little opportunity for transfer of nitrogen in situ in a cut and carry fodder use system (Whitney et al. (1967 b). Bogdan (1977) reported that legumes release nitrogen to the soil only when at least parts of the plants die out and decompose. He also observed that when grass and legume are grown together the grass always takes more potassium especially so in a high yielding grass like guinea.

Contrary to the above findings, several other scientists reported that non-legumes do not get benefit from associated legumes. Madok (1940) observed no beneficial effect of legume on non-legume in 20 out of 26 experiments. Ayyangar (1942) observed that yield of sorghum was reduced when it was sown mixed with pulses. Thompson (1958) and Dey et al. (1958) also recorded suppressed growth of sorghum due to heavy intertwining effect of legumes. Whitney et al. (1967 b) showed that Desmodium canum actually depressed the yield of nitrogen in associated grass. Rehm et al. (1975) found no supply of nitrogen from alfalfa to the associated grass under irrigated condition. Skerman

(1977) observed that a legume cannot produce enough symbiotic nitrogen to meet the potential production limit of a grass in a grass-legume sward.

Influence of non-legume on legume also has been reported by De Geus (1977). Madok (1940) found that growth of guar was suppressed by jowar when grown together and there was 20 to 35 percent loss in height and 42 to 63 percent loss in weight of the jowar plants.

When legumes and grasses were grown in various combinations to determine the competition exerted by one species over another, it was found that grasses yielded more when competing with legumes than when competing with each other (Dus Arthur, 1971). According to Tisdale and Nelson (1973) legumes have a better capacity to absorb the divalent cations from the soil than grasses.

Nihal Singh and Khatri (1972) found that the available phosphorus content of the soil was increased due to the application of phosphorus fertilizers to legumes.

Balbatti (1980) obtained maximum nitrogen content in sandy loam soil due to the application of 200 kg N/ha to hybrid napier grass.

2.7. Influence of fodder crops on soil characteristics

White et al. (1976) reported that total nitrogen content of the soil was increased by growing forage grasses. According to Neyra and Dobereiner (1977) tropical grasses could fix atmospheric nitrogen in association with nitrogen fixing bacteria. The legume components in the grass legume mixture have prominent place in crop rotations and crop mixtures as their role in the building up of soil fertility is well known (De Geus, 1977). He further reported that microbes in the presence of phosphorus increase the C.E.C. of the soil in the rhizosphere of stylosanthes.

Ayyangar (1942) found that intercropped legumes increased the available phosphorus, potassium and calcium in the soil by the greater solvent action of their root exudates and their ability to bring these nutrients to the surface layer. The productivity of grass legume pastures is limited by the capacity of the legume component to fix nitrogen.

Tropical legumes generally fix between 100 and 200 kg N/ha (Caro Costas and Vicente-Chandler, 1956).

Singh and Chatterjee (1968) reported that nitrogen increased in grass-legume pasture and that nitrogen accumulated in the soil wherever legumes grew well.

Calcium ions stimulate the uptake of potassium and the uptake of calcium is markedly influenced by even small amounts of potassium ions (Andrew and Robins, 1969 b; Whelan and Edwards, 1975).

Ludlow et al. (1974) and Ramos et al. (1977) obtained increases in C.E.C. of the soils which were cropped with stylosanthes.

Significant increases for available nitrogen, phosphorus and potassium of the soil were noted when stylosanthes was grown (Bruce, 1976; Singh and Singh, 1975).

In the mixed stands of <u>Setaria anceps</u> and <u>Desmodium intortum</u>, Kitamura et al. (1975) found that the legume contributed 60 to 240 kg N/ha.

Gillard (1977) reported a significant increase in soil nitrogen when grown with stylosanthes, but noted a decrease in potassium content which was ascribed to an increased uptake of potassium by the pasture. Lal (1979) also recorded significant increase in soil nitrogen content due to stylosanthes.

Andrew and Robins (1969 b) observed that phosphorus has the capacity to increase the activity of the root nodule bacteria and other organisms in the rhizosphere of legumes.

2.8. Influence of shade on productivity of fodder crops

Literature available on the influence of varying shade intensities on the productive efficiency of grasses and associated legumes is very meagre, and hence works pertaining to other related crops are reviewed.

The influence of shade has been studied since very early times. Duggar (1903) reported that shading, either partially or completely, reduced the carbon dioxide assimilation and thereby decreased the availability of constructive materials for plants. Italian rye grass when grown under full day light and 36 percent day light, and supplied with 0 to 120 kg N/ha the drymatter production in unshaded plants increased in later stages of plant growth.

Roberts and Struckmeyer (1939) observed increase in height of plants due to shading. However, in shaded plants response to nitrogen remained constant. Moreover nitrogen increased the LAI and decreased the number of tillers per plant (Burton, 1959 a). Rhykerd et al. (1959) recorded that leaf: stem ratio of legumes was greatly influenced by the quantity and intensity of light. The growth of alfalfa was affected adversely by shading when it was grown with sorghum.

Pears and Leedr (1969) in an experiment on lucerne plants in growth chambers under high and low light intensities (32-45 K lux, 13-14 K lux) have shown that total drymatter production were greater under high light intensity. Subramonian et al. (1971) while studying the effects of nitrogen and phosphorus observed significant increase in plant height by incremental doses of nitrogen, while phosphorus failed to evoke any response in shade. Agboola and Fayemi (1971) observed competition for light between maize and legume, wherein legume was suppressed by maize shade. Fisher (1975) found that shading always reduced growth of wheat plants in direct proportion to the reduction in radiation. Sreedharan (1975) observed that tiller production in most crop plants will be higher under higher intensities of sunlight. In experiments involving different plant densities, maize plants grew taller as mutual shading increased the leaf: stem ratio (Duncan, 1975). The height and LAI of grain sorghum plants decreased with increasing levels of shade from 0 to 50 percent (Palis and Bustrillos, 1976). Tarila et al. (1977) reported that in cowpea higher light intensity reduced plant height.

Wong and Wilson (1980) observed increased LAI in shaded green panic swards. They also observed a decreased LAI in shaded legume plant. Humphreys (1981) reported the highest authenticated crop growth rates in the range of 50-54 g drymatter/m^2/day for C_4 grasses and 34-39 g/m^2/day for C_3 legumes. Mullakoya (1982) obtained maximum number of tillers in guinea grass under full sunlight and minimum number with 75 percent shade.

Influence of shade on the yield of fodder crops has been reported by many workers (Kurup, 1971; Erickson, 1977; Wong and Wilson, 1980).

Benedict (1941) reported that plants of <u>Agropyron cristatum</u>, <u>Agropyron smithi</u> and <u>Bontelova gracilis</u> grown in shade had smaller dry weight. Erickson (1977) evaluated forage yields of six grasses and six legumes at 100, 70, 45 and 27 percent daylight using polypropylene netting. He found that the nitrogen content of grasses increased with shading. The most shade tolerant grasses were guinea, cori and signal. Under 27 percent day light yields were between 8 and 15 t/ha/year. The highest yields were obtained at 45 and 27 percent daylight under no nitrogen treatment. Stylosanthes was found to be the least shade tolerant fodder legume. But Plucknet (1979) noticed increased fodder yield of stylosanthes in coconut shade.

Skerman (1977) recorded more nitrogen fixation in shade than in open area. Wong and Wilson (1980) in a shading experiment observed that the shoot yield of green panic was increased with shading of 60 and 40 percent of full sunlight.

Shade influences the quality of fodder also. In general protein content increases and carbohydrate content decreases with shade. According to Burton (1959 b) root and rhizome development were halved by deep shade and available carbohydrates in the forage were reduced, particularly at low levels of fertility.

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 percent of light intensity and serious lodging occurred as a result of reduction in fibre content. Potassium contents were approximately doubled and calcium and magnesium contents were increased under shade.

Palis and Bustrillos (1976) observed increase in protein with increase in light intensity in the case of grain sorghum plants subjected to 0, 25 and 50 percent shade.

Moursi et al. (1976 a) observed nitrogen accumulation in all the plant parts in wheat due to shading from a trial under varying intensities of 20 to 100 percent full sunlight.

Under shaded situations the crude protein content of grasses due to association with legumes was more than that under open condition (Papanicolaou et al. 1977).

According to Wong and Wilson (1980) nitrogen accumulation in all the plant components of green panic was markedly improved by shading. In the case of guinea grass also increase in crude protein was noticed due to shading (Mullakoya, 1982).

Sreedharan (1975) and Ramanagowda (1981) reported that under shade conditions are more favourable for protein synthesis than in open area.

2.9. Influence of coconut palms on the productivity of fodder

The effect of coconut palms on intercrops has been studied by many workers. Apart from competition for nutrients and water, the main effect of coconut on intercrops will manifest in the shading effect by the palms. The degree of shading by palms will largely depend upon age, spacing and soil fertility (Santhirasegaram, 1966). Very young and very old palms will not shade intercrops severely. Heavy canopy produced from about 5th to 20th year of growth permits low levels of light intensity to reach the understory for the growth of intercrops. Nelliat et al. (1974) have reported the relative degree of shading by the coconut at different ages. Steel and Humphreys (1974) have also shown the degree of shading of coconut at different ages. They found that light transmission at noon through 30 to 50 year old palms spaced 10 to 12 m apart was 77 to 80 percent of full sunlight.

Appadurai (1968) reported that cori grass (Brachiaria miliformis) responds readily to N fertilization in the shaded coconut groves and nitrogen fertilizers had increased the efficiency of the grass to compete with weeds.

Screening trials conducted by Sahasranaman and Pillai (1976) at Kasaragod showed that guinea grass (Panicum maximum) gave green fodder yield of 50 to 60 t/ha under coconut shade. Of the several varieties and types of guinea available, plants having a more postrate growth habit are most suitable for coconut pastures (Weightman, 1977). In a 15 month grazing period guinea grass was grazed 9 times and produced 605 cow grazing days per hectare, 126 t/ha fresh forage and 18 t/ha drymatter (Plucknett, 1979). The shade tolerance and high yields of guinea grass coupled with drought resistance and tolerance of less fertile soils have caused it to be used under coconuts in a number of countries.

Among different fodder legumes tried Stylosanthes guianensis is better adapted for less fertile soils carrying older and widely spaced palms (Plucknett, 1979).

In a trial with guinea and hybrid napier var. Pusa giant, in coconut garden under different doses of nitrogen (100, 150 and 200 kg/ha) it was observed that guinea was superior to hybrid napier and both the grasses responded upto 200 kg/ha (Anon., 1980).

2.10. Influence of fodder intercropping on the productivity of coconut

Very useful and critical works on this subject have been done in Sri Lanka and Western Samao where the effects of pasture species, fertilization and grazing intensity have been studied in detail. In the early work the effect of four grasses on coconut yield was compared. *Paspalum commersonii* provided fewest grazing days per hectare per year and also produced lowest nut yields. Palisade grass (*Brachiaria brizantha*) and cori grass (*Brachiaria miliformis*) were about equal in grazing days and nut yield, while guinea grass (*Panicum maximum*) provided the highest number of grazing days but with a slightly lower nut yield than two *Brachiaria* species.

Improved coconut yields following intercropping have been reported in several countries (Kotalawala, 1968; Kuttappan, 1971; Sethi, 1963; Sahasranaman, 1964). Beneficial effects derived by the palms were usually attributed to improved fertilization and plant nutrition, weed control and other cultural practices provided for the intercrop. Apparently the increased attention given to the intercrop compensates markedly for possible yield reduction in coconut which might result on account of competition between the crops. Thus it is seen that coconut usually prospers in mixed farming system, provided adequate care is given to both the coconut and intercrops.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was taken up with a view to assess the fodder production potential of two tropical grasses under different management techniques, and to find out their comparative yielding abilities in the open as well as in coconut garden. The study was also aimed at investigating the effect of intercropping fodder crops on the yield of coconut palms.

3.1. Experimental site

The experiment was conducted in Block No. IV, on the eastern side of the meteorological observatory of the Instructional farm attached to the College of Agriculture, Vellayani.

3.1.1. Soil

The soil of the experimental site is sandy loam with the following analysis.

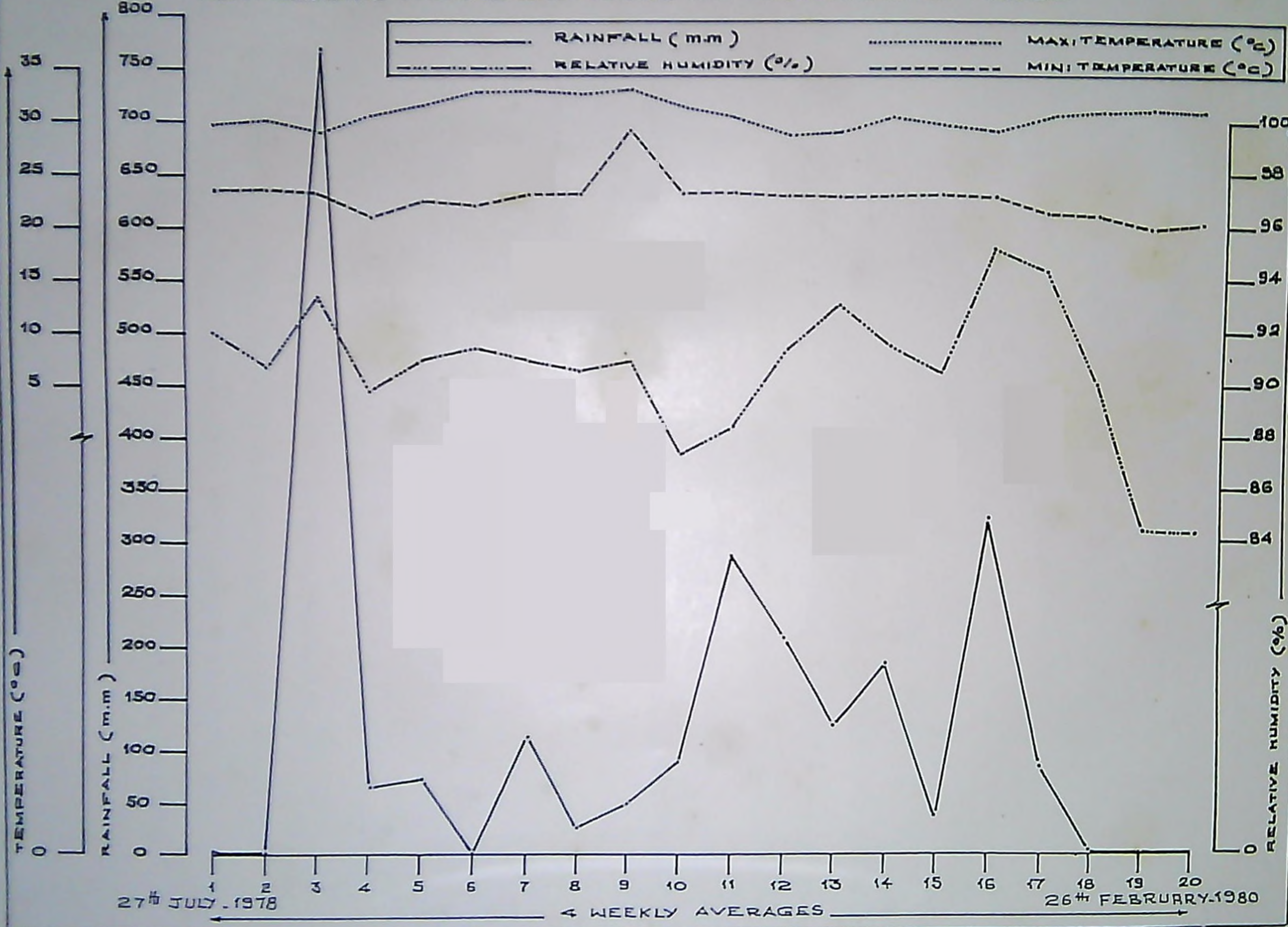
	Open area	Coconut garden
a. Physical properties		
a.i. Mechanical analysis		
Coarse sand	44.82	44.85

	Open area	Coconut garden
Fine sand	19.82	19.84
Silt	19.84	19.82
Clay	14.87	14.82
Loss on ignition	0.65	0.67
Textural class	Sandy loam	Sandy loam
a.ii. Physical constants		
Field capacity	14.6 percent	14.5 percent
Permanent wilting point	6.5 percent	6.4 percent
Water stable aggregates (>0.25 mm)	71.42 percent	71.24 percent
b. Chemical properties		
Soil pH	4.80	5.00
Organic carbon	0.49%	0.50%
Total nitrogen	0.048%	0.048%
Total phosphorus	0.089%	0.090%
Total potassium	1.04%	1.039%
Total CaO	0.16%	0.17%
Total MgO	0.27%	0.28%
Total CEC	4.4 me/ 100 g. soil	4.5 me/ 100 g. soil
Available nitrogen	229 kg/ha	230 kg/ha
Available phosphorus	29 kg/ha	30 kg/ha
Available potassium	90 kg/ha	89 kg/ha

3.2. Season and climate

The experiment was started in the month of July 1978 and continued upto February 1980. The meteorological data viz. rainfall, maximum and minimum temperatures and relative humidity for the above period are presented in Appendix I and depicted in Figure 1. The average values of the climatic parameters for the past 24 years are presented in Appendix II. During the first year a total rainfall of 603 mm was received. The maximum and minimum temperatures ranged from 30.86°C to 28.98°C and 23.40°C to 22.42°C respectively. During the second year the total rainfall received was 541 mm and the maximum and minimum temperatures varied between 31.03 to 28.20°C and 22.83 to 20.10°C. The average sunshine hours during the first and second years varied between 4.20 to 6.60 and 4.30 to 6.40 respectively. The experimental area in the coconut garden received 50-59 percent of the light that received under the open condition. The light intensity was measured by using Lux meter. The receipt of solar radiation was 6420 to 6860 ft.c. in open area and 3806 to 4106 ft.c. in coconut garden.

FIG_1. CLIMATIC PARAMETERS DURING THE EXPERIMENTAL PERIOD



58

3.4. Cropping history of the field

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

3.5. Materials

3.5.1. Guinea Grass (Panicum maximum. Jacq.)

The slips of guinea grass were taken from the collection of the All India Co-ordinated Project for Research on Forage Crops, Vellayani. A local strain of the grass which was very prominent and adaptive to the locality was used for the experiment. It is drought resistant, shade tolerant and can be mixed well with legumes apart from its responsiveness to higher nitrogen levels. It is well relished by all categories of livestock.

3.5.2. Setaria Grass (Setaria anceps. Stapf.)

The slips of this grass were obtained from Regional Station, Kulathupuzha of the Kerala Livestock Development and Milk Marketing Board. Setaria anceps cv. Kazangula was used for this experiment. Kazangula is very popular throughout the State in the open as well as in the coconut garden as a pure crop and in mixture with legumes. It is also drought resistant and fertilizer responsive. The grass is well relished by cattle.

3.5.3. Brazilian lucerne or Stylo (Stylosanthes guianensis. Aubl (S.W.)

Stylosanthes gracilis redesignated as Stylosanthes guianensis is a perennial drought resistant and nutritious pasture legume, native to Brazil. It is also useful as a good cover crop. The fodder is relished by cattle. The seeds of stylo cv. Schoefield were obtained from the Kerala Livestock Development and Milk Marketing Board. The seeds recorded 92 percent germination.

3.5.4. Fertilizers

Urea (45.6% N), Single superphosphate (16% P_2O_5) and muriate of potash (60% K_2O) were used for the experiment.

3.5.5. Rhizobium culture

The liquid rhizobium culture for innoculation of stylosanthes seed was obtained from the Division of Plant Pathology, College of Agriculture, Vellayani.

3.6. Methods

The design adopted was 4×2^3 confounded factorial with two control plots tagged to each block having two replications. It was an assymmetrical factorial experiment with 2 levels each of varieties, phosphorus and intercropping and 4 levels of nitrogen. The 32 treatment combinations are split up into 2 groups so as to confound the highest order interaction VPIN taking the 4 levels of nitrogen as the combination of 2 pseudofactors N_1 and N_2 each at 2 levels.

3.6.1. Treatments

A. Varieties	v_1	-	Guinea grass
	v_2	-	Setaria grass
B. Intercroppings	i_o	-	No intercropping
	i_1	-	Intercropping with *Stylosanthes guianensis*
C. Levels of phosphorus	p_o	-	No P_2O_5
	p_1	-	60 kg P_2O_5/ha
D. Levels of nitrogen	n_1	-	50 kg N/ha
	n_2	-	100 kg N/ha

n_3 - 150 kg N/ha

n_4 - 200 kg N/ha

E. Control - Two control plots without intercropping and with 0 levels of phosphorus and nitrogen for the 2 varieties.

3.6.2. Treatment combinations (32)

T_1 $v_1i_op_on_1$ = Guinea + no intercrop + no P + 50 kg N

T_2 $v_1i_op_on_2$ = Guinea + no intercrop + no P + 100 kg N

T_3 $v_1i_op_on_3$ = Guinea + no intercrop + no P + 150 kg N

T_4 $v_1i_op_on_4$ = Guinea + no intercrop + no P + 200 kg N

T_5 $v_1i_op_1n_1$ = Guinea + no intercrop + 60 kg P + 50 kg N

T_6 $v_1i_op_1n_2$ = Guinea + no intercrop + 60 kg P + 100 kg N

T_7 $v_1i_op_1n_3$ = Guinea + no intercrop + 60 kg P + 150 kg N

T_8 $v_1i_op_1n_4$ = Guinea + no intercrop + 60 kg P + 200 kg N

T_9 $v_1i_1p_on_1$ = Guinea + Stylo intercrop + no P + 50 kg N

T_{10} $v_1i_1p_on_2$ = Guinea + Stylo intercrop + no P + 100 kg N

T_{11} $v_1i_1p_on_3$ = Guinea + Stylo intercrop + no P + 150 kg N

T_{12} $v_1i_1p_on_4$ = Guinea + Stylo intercrop + no P + 200 kg N

T_{13} $v_1i_1p_1n_1$ = Guinea + Stylo intercrop + 60 kg P + 50 kg N

T_{14} $v_1i_1p_1n_2$ = Guinea + Stylo intercrop + 60 kg P + 100 kg N

T_{15} $v_1i_1p_1n_3$ = Guinea + Stylo intercrop + 60 kg P + 150 kg N

T_{16} $v_1 i_1 p_1 n_4$ = Guinea + Stylo intercrop + 60 kg P + 200 kg N

T_{17} $v_2 i_o p_o n_1$ = Setaria + no intercrop + no P + 50 kg N

T_{18} $v_2 i_o p_o n_2$ = Setaria + no intercrop + no P + 100 kg N

T_{19} $v_2 i_o p_o n_3$ = Setaria + no intercrop + no P + 150 kg N

T_{20} $v_2 i_o p_o n_4$ = Setaria + no intercrop + no P + 200 kg N

T_{21} $v_2 i_o p_1 n_1$ = Setaria + no intercrop + 60 kg P + 50 kg N

T_{22} $v_2 i_o p_1 n_2$ = Setaria + no intercrop + 60 kg P + 100 kg N

T_{23} $v_2 i_o p_1 n_3$ = Setaria + no intercrop + 60 kg P + 150 kg N

T_{24} $v_2 i_o p_1 n_4$ = Setaria + no intercrop + 60 kg P + 200 kg N

T_{25} $v_2 i_1 p_o n_1$ = Setaria + Stylo intercrop + no P + 50 kg N

T_{26} $v_2 i_1 p_o n_2$ = Setaria + Stylo intercrop + no P + 100 kg N

T_{27} $v_2 i_1 p_o n_3$ = Setaria + Stylo intercrop + no P + 150 kg N

T_{28} $v_2 i_1 p_o n_4$ = Setaria + Stylo intercrop + no P + 200 kg N

T_{29} $v_2 i_1 p_1 n_1$ = Setaria + Stylo intercrop + 60 kg P + 50 kg N

T_{30} $v_2 i_1 p_1 n_2$ = Setaria + Stylo intercrop + 60 kg P + 100 kg N

T_{31} $v_2 i_1 p_1 n_3$ = Setaria + Stylo intercrop + 60 kg P + 150 kg N

T_{32} $v_2 i_1 p_1 n_4$ = Setaria + Stylo intercrop + 60 kg P + 200 kg N

Control

$v_1 i_o p_o n_o$ - Guinea + no intercrop + no P + no N

$v_1 i_o p_o n_o$ - Setaria + no intercrop + no P + no N

Replications = 2

Number of blocks per replication = 2

Number of plots per block = 16 + 2 = 18 (2 control plots $v_1 i_o p_o n_o$ and $v_2 i_o p_o n_o$ are tagged to each block).

Total number of plots = 72

Gross plot size = 4.8 x 4.8 m

Spacing = 40 x 20 cm for legumes and grasses

Net plot size = 3.2 x 3.8 m

The experiment was conducted simultaneously in the open and in the coconut garden.

3.6.3. Details of cultivation

The experimental area in the open field was dug twice, weeds and stubbles removed, clods were broken and the field was laid out into blocks and plots. The individual plots were again thoroughly dug and levelled (Plate 4.1).

An adjacent coconut garden was selected for the experiment under partial shade. There were 29 coconut palms of 50-60 years old with uniform crown shape and height. Around the bole of each palm an area of 1.8 m radius was left out as effective root zone of coconut palms and the rest of the area in the coconut garden was dug twice, weeds and stubbles were removed, clods were broken and blocks and

PLATE - 1. LAY-OUT PLAN - EXPERIMENT IN OPEN AREA

→ N

REPLICATION. I	BLOCK. I.	$v_1 i_0$ $p_0 n_2$	$v_2 i_0$ $p_1 n_2$	$v_1 i_1$ $p_1 n_3$	$v_2 i_1$ $p_0 n_3$	$v_2 i_0$ $p_1 n_3$	$v_2 i_0$ $p_0 n_0$	$v_1 i_0$ $p_1 n_4$	$v_1 i_1$ $p_1 n_2$	$v_2 i_0$ $p_0 n_1$
		$v_2 i_0$ $p_0 n_4$	$v_2 i_1$ $p_0 n_2$	$v_1 i_0$ $p_0 n_0$	$v_1 i_0$ $p_0 n_3$	$v_1 i_1$ $p_0 n_4$	$v_2 i_1$ $p_1 n_4$	$v_1 i_1$ $p_0 n_1$	$v_2 i_1$ $p_1 n_1$	$v_1 i_0$ $p_1 n_1$
	BLOCK. II.	$v_2 i_1$ $p_0 n_4$	$v_2 i_0$ $p_0 n_0$	$v_1 i_0$ $p_1 n_2$	$v_2 i_0$ $p_0 n_3$	$v_2 i_0$ $p_1 n_1$	$v_1 i_0$ $p_0 n_4$	$v_2 i_1$ $p_1 n_2$	$v_1 i_1$ $p_1 n_1$	$v_1 i_1$ $p_0 n_2$
		$v_1 i_0$ $p_1 n_3$	$v_2 i_1$ $p_0 n_1$	$v_2 i_0$ $p_1 n_4$	$v_1 i_0$ $p_0 n_1$	$v_1 i_1$ $p_0 n_3$	$v_1 i_1$ $p_1 n_4$	$v_2 i_0$ $p_0 n_2$	$v_1 i_0$ $p_0 n_0$	$v_2 i_1$ $p_1 n_3$
REPLICATION. II	BLOCK. I.	$v_2 i_0$ $p_0 n_0$	$v_1 i_0$ $p_0 n_0$	$v_2 i_1$ $p_0 n_3$	$v_2 i_1$ $p_0 n_2$	$v_1 i_0$ $p_1 n_1$	$v_2 i_0$ $p_0 n_1$	$v_2 i_0$ $p_1 n_2$	$v_2 i_1$ $p_1 n_4$	$v_1 i_1$ $p_0 n_1$
		$v_2 i_0$ $p_0 n_4$	$v_1 i_0$ $p_0 n_3$	$v_2 i_1$ $p_1 n_1$	$v_1 i_1$ $p_1 n_3$	$v_2 i_0$ $p_1 n_3$	$v_1 i_1$ $p_0 n_4$	$v_1 i_0$ $p_0 n_2$	$v_1 i_1$ $p_1 n_2$	$v_1 i_0$ $p_1 n_4$
	BLOCK. II.	$v_2 i_1$ $p_1 n_3$	$v_1 i_0$ $p_0 n_4$	$v_1 i_1$ $p_1 n_1$	$v_2 i_0$ $p_1 n_1$	$v_2 i_0$ $p_0 n_3$	$v_1 i_1$ $p_0 n_2$	$v_1 i_0$ $p_1 n_3$	$v_2 i_0$ $p_0 n_2$	$v_1 i_0$ $p_0 n_0$
		$v_2 i_0$ $p_1 n_4$	$v_1 i_0$ $p_1 n_2$	$v_2 i_1$ $p_0 n_4$	$v_2 i_1$ $p_0 n_1$	$v_1 i_1$ $p_1 n_4$	$v_1 i_1$ $p_0 n_3$	$v_2 i_0$ $p_0 n_0$	$v_1 i_0$ $p_0 n_1$	$v_2 i_1$ $p_1 n_2$

PLOT SIZE - 4.8 X 4.8 m

SPACING

GRASSES } 40 X 20 cm
STYLOSANTHES }

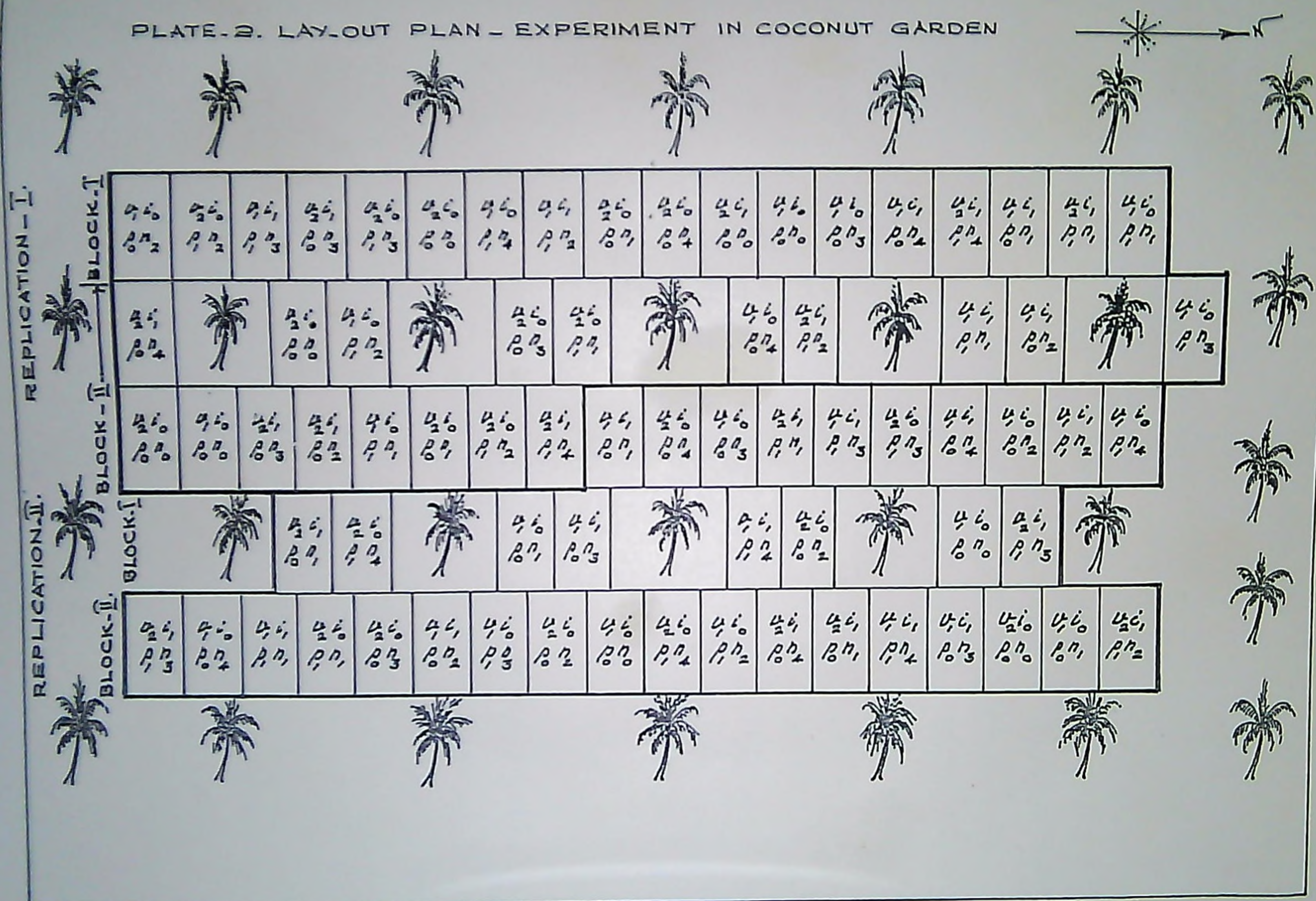
v_1 - GUINEA
v_2 - SETARIA

i_0 - NO INTERCROP
i_1 - STYLO INTERCROP

p_0 - No P_2O_5
p_1 - 60 kg P_2O_5/ha

n_1 - 50 kg N/ha
n_2 - 100 kg N/ha
n_3 - 150 kg N/ha
n_4 - 200 kg N/ha

PLATE-2. LAY-OUT PLAN - EXPERIMENT IN COCONUT GARDEN



plots were laid out (Plate 2).

3.6.4. Fertilizer application

Half the dose of nitrogen and full dose of phosphorus as per the treatments and a uniform dose of potash (50 kg K_2O/ha) were applied basally. The remaining dose of nitrogen was applied after the second harvest of grasses which was done two and a half months after planting. In the second year the first schedule of fertilizer application was done during the second week of June and the balance was top dressed after the second harvest of grasses during the month of October.

3.6.5. Methods of planting

3.6.5.1. Grasses: Young, healthy and uniform sized slips of guinea and setaria grasses were planted at the rate of 3 slips per hill. Planting was done on a drizzly day on 27.7.1978 at a spacing of 40 cm, between rows and 20 cm between hills.

3.6.5.2. Legumes: Rhizobium treated seeds of stylosanthes were dibbled on 27.7.1978 in between the grass rows and maintained uniform population by thinning two weeks after germination.

3.7. General condition of the crop

The general growth of grass slips was very good. Slips which did not establish were replanted with fresh slips after the second week of planting.

3.8. Interculture and weeding

The soil was slightly stirred and weeds were removed after the first harvest of grasses without damaging the intercrop. A second weeding and raking were also done along with top dressing. In the second year also raking and weeding operations were carried out twice along with fertilizer applications.

3.8.1. Plant protection

As a prophylactic measure, 0.01 percent methylparathion (Metacid) and E.C. 0.03 percent Dithane M-45 were sprayed during the 3rd week to guard against the attack of stem borer and incidence of blast disease. In the second year also this was repeated during the 3rd week after first dose of fertilizer application.

3.9. Harvest

Twelve cuts of grasses were taken from individual net plots during the course of two years coinciding with abundant growth or 50 percent flowering. In summer months during the period from February to May no harvest was made since the growth of the grasses was not sufficient.

In the case of stylosanthes also twelve cuts were taken, along with the harvest of grass.

3.10. Observations recorded

3.10.1. Growth characters

For recording growth characters ten hills of grasses and five plants of stylosanthes were selected randomly.

3.10.1.1. Height of grasses

For grasses, the height of plants was recorded the day prior to each harvest. The height was measured in cm from the base of the plant to the tip of the tallest leaf, in all the observation hills and the means worked out.

3.10.1.2. Height of stylosanthes

For stylo, the height was measured in cm from the base of the plant to the growing tip of the longest branch. The recordings were made a day prior to each harvest. The mean height of plants for two years of the experiment was found out.

3.10.2. Tiller count

The number of tillers of grasses in each hill was counted on the day prior to each harvest and recorded and the means were worked out.

3.10.3. Leaf area index of grass

The leaf area index of grasses was found out on the day prior to each harvest. The mean LAI for the 2 years of the experiment was worked out.

3.10.4. Leaf-stem ratio

The samples taken for dry matter were separated into leaf and stem, dried, weighed and the ratio was recorded for both grasses and legume.

3.11. Crop growth rate

The mean crop growth rate (CGR in $g/m^2/day$) was calculated from the dry matter yield per plot, the number of days taken for the harvest (interval of harvest) and the area of the plot in m^2 for each harvest in respect of grasses and stylo. Mean CGR for the two years was then computed.

3.12. Dry matter yield of fodder

The green matter yield of both grasses and legume from the net plot area were recorded immediately after harvest and used for the computation of the dry matter yield. For this the samples from each cut were first sun dried and then oven dried to a constant weight at 80°C. The dry matter content was computed for each treatment and the mean dry matter yield of fodder worked out.

3.13. Yield of coconuts

The yield of coconuts (number of nuts/tree) per harvest from the plots and border line in the coconut garden where the experiment was carried out was recorded during the experimental period and the succeeding two years. Then the average yield of nuts/tree/year was computed.

3.14. Quality characters

3.14.1. Plant samples

The grass and stylo plant samples were first dried in shade and subsequently dried in an oven at 80°C and ground in a Wiley mill.

3.14.2. Crude Protein

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

3.14.3. Crude protein yield

From the crude protein content of grass and stylo, the combined crude protein yield was calculated.

3.14.4. Crude Fibre

Crude fibre contents of grass and stylo were determined by the A.O.A.C. method (1975).

3.14.5. Phosphorus, Potassium, Calcium and Magnesium

One gram of powdered sample was digested with triple acid mixture (Nitric acid, Sulphuric acid and Perchloric acid) (Jackson and Ulrish, 1959), 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 Eel flame photometer.

Calcium and magnesium were determined from an aliquot of the triple acid digest with EDTA (Cheng and Bray, 1951).

3.14.6. K: (Ca + Mg) ratio

This ratio for grass and stylo was calculated for each harvest and the mean for the 2 years was computed and analysed.

3.15. Uptake studies

The total uptake of nitrogen, phosphorus and potassium by grasses and stylo in open area and coconut garden during the crop growth period were calculated based on the contents of these nutrients and the drymatter produced by these crops at each harvest.

3.16. Soil analysis

The total nitrogen and the available phosphorus and potassium of a composite soil sample collected prior to the experiment and the soil samples collected from individual plots after the experiment were estimated. Total nitrogen was determined by modified microkjeldahl method (Jackson, 1967). Available potassium was determined by Ammonium acetate method (Jackson, 1967).

3.16. Statistical analysis

The data generated from the 4×2^3 factorial experiment were analysed by ANOVA technique (Cochran and Cox, 1965). Wherever the difference between the treatment was significant, critical difference at 5 percent probability level was worked out.

The response functions of both grass together, each grass separately and each grass when intercropped with stylosanthes were worked out and depicted for both open area and coconut garden.

The economics of fodder production and cost benefit ratio have been worked out by taking the cost of cultivation, cost of inputs, yield and its price for both open area and coconut garden. The economic optimum for nitrogen use has been worked out.

With the objective of studying the effect of N and P on the production potential of stylo when it was grown with grasses, analysis was done by excluding the treatment combinations with "no intercropping of stylo". This analysis is treated as that of a 4×2^2 factorial experiment confounding NVP.

3.17. Correlation studies

The correlations were worked out for drymatter yield, crude protein and crude fibre.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

Field experiments were conducted in the Instructional Farm, College of Agriculture, Vellayani during the period from 1978 to 1980 to compare the production potential of two fodder grasses viz. guinea and setaria alone and intercropped with stylosanthes and also to assess the effect of nitrogen and phosphorus application on these crops under shade and open conditions. The treatments consisted of factorial combinations of two pure crops of grasses (guinea and setaria), two levels of intercropping (with and without stylosanthes), four levels of nitrogen (50, 100, 150 and 200 kg N/ha) and two levels of phosphorus (0 and 60 kg P_2O_5/ha). There were two control plots tagged to each block without intercropping and under zero levels of phosphorus and nitrogen for the two grasses. There were altogether 32 treatment combinations. Two experiments with the same set of treatments were simultaneously laid out, one in the open area and the other in an adjacent coconut garden with 50 percent shade intensity. From the data collected for the two years of the experiment, their means were worked out and statistical analysis was done. The results obtained and their discussion are presented below.

4.1. Growth Characters

4.1.1. Height of grasses.

The mean height of grasses are presented in Tables 1 and 2, respectively for open area and coconut garden.

It is seen that in coconut garden the height of setaria grass was significantly more than that of guinea grass.

This increase in height recorded by setaria may be due to the varietal character of the grass.

Neither intercropping with stylosanthes nor application of nitrogen or phosphorus could exert any significant influence on height of grasses under both the situations. The interaction effects were also not significant.

It was also noticed that in open area the difference between the mean height of grasses due to treatments and under control was not significant. But in coconut garden the treatment mean (83.20 cm) was significantly higher than the height of grasses recorded under control.

The results presented in Tables 1 and 2 revealed

Table 1. Height of grass at harvest in open area (cm).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	71.10	71.14	71.70	70.54	70.75	71.46	71.35	70.91	71.12
Setaria (v_2)	71.91	72.51	72.69	71.72	70.67	73.06	71.26	73.83	72.21
Intercropping									
None (i_o)			71.91	71.09	71.17	71.49	71.02	72.33	71.50
Stylo-santhes (i_1)			72.47	71.17	70.25	73.03	71.59	72.42	71.82
Phosphorus levels (kg/ha)									
0 (p_o)					71.00	72.64	71.63	73.51	72.19
60 (p_1)					70.42	71.88	70.98	71.24	71.13
Mean					70.71	72.26	71.30	72.37	71.66

Control: Guinea grass (v_1) - 71.22
Setaria grass (v_2) - 69.18

Type of pair comparison of means	S.E.	C.D. (0.05)
V; I; P	0.626	--
N; VI; VP; IP	0.885	--
VN; IN; PN	1-252	--

*Significant

Table 2. Height of grass at harvest in coconut garden (cm).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	Mean
Grasses									
Guinea (v_1)	81.05	80.57	79.65	81.96	80.65	81.32	79.50	81.76	80.81
Setaria (v_2)	85.77	85.40	86.08	85.09	84.53	85.39	85.96	86.47	85.59
Intercropping									
None (i_o)			83.27	83.55	84.22	82.32	83.09	84.03	83.41
Stylosanthes (i_1)			82.46	83.51	80.97	84.40	82.38	84.19	82.99
Phosphorus levels (kg/ha)									
0 (p_o)					82.21	83.24	82.99	83.04	82.87
60 (p_1)					82.98	83.48	82.48	85.18	83.53
Mean					82.59	83.36	82.73	84.11	83.20

Control: Guinea grass (v_1) - 75.38
Setaria grass (v_2) - 78.63

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P	0.702	1.423
N; VI; VP; IP	0.994	--
VN; IN; PN	1.404	--

*Significant

that grasses grown under shade recorded more height than those grown in open area. It is quite natural that plants grown in shade always grow taller than those grown in full sunlight (Roberts and Struckmeyer, 1939). The increased plant height observed in shade in the present study is in line with the findings of Panicker et al. (1969) in tobacco and Mullakoya (1982) in guinea grass. The 'light inhibition of growth' on stem elongation in many species of plants was reported as early as 1872 by Sachs and later by Duncan in 1975. At higher light intensity a growth inhibitor flavinoid Quarcetin - Glycosyl - Camarate (QGC) as described by Mumford et al. (1961), Furaya and Calston (1965), Chumakovskiy and Kefeli (1968) and Eliassova (1971), was reported to be regulating or inhibiting the stem elongation in pea. They demonstrated sphectrophotometrically that an increase in light intensity causes vigorous accumulation of QGC, resulting in a decreased rate of growth of pea stem. Lokhart (1961) opined that 'light inhibition of growth' can be alleviated by the application of gibberellic acid. Gibberellin concentration in the plant is more at low light intensity and its content goes down when the plants were exposed to light (Kefeli, 1978). The increase in height shown by grasses grown in coconut garden in the present study may possibly be due to the maintenance of a higher concentration of gibberellic acid as light induced disintegration of this hormone is least in shade.

4.1.2. Height of stylosanthes.

The mean height of stylosanthes in open area and in coconut garden are presented in Tables 3 and 4 respectively.

Significant difference in the height of stylosanthes was noticed due to intercropping with the two grasses both in the open area and in coconut garden. The maximum height recorded by stylo in association with guinea was 25.52 cm in open area and 32.58 cm in coconut garden, while due to association with setaria the height was 24.87 cm and 32.49 cm respectively in the two situations. This may be due to the influence of differential tillering habit of two grasses as shown in Tables 5 and 6. Guinea grass is absolutely a tussock type grass with compactly packed tillers allowing more interspace between hills than setaria. This favourable situation would have helped the legume component to grow taller when grown with guinea grass. Chandini and Raghavan Pillai (1980) also observed increase in height of *Stylosanthes gracilis* due to intercropping with guinea grass.

Table 3. Height of stylosanthes in open area (cm).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	24.65	26.39	25.55	25.66	25.49	25.39	25.52
Setaria (v_2)	24.12	25.63	24.86	24.92	24.90	24.82	24.87
Phosphorus levels (kg/ha)							
0 (p_o)			24.32	24.49	24.42	24.32	24.39
60 (p_1)			26.08	26.09	25.97	25.89	26.01
Mean			25.20	25.29	25.19	25.10	25.20

$. Indicates height of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0426	0.0904
N; VP*	0.0603	0.1279
VN; PN	0.0852	--

*Significant

Table 4. Height of stylosanthes in coconut garden (cm).

Treatments	Phosphorus levels (kg/ha) 0 (p_o)	60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	Mean
$. Grasses							
Guinea (v_1)	31.57	33.59	32.63	32.60	32.57	32.51	32.58
Setaria (v_2)	31.44	33.54	32.59	32.47	32.47	32.43	32.49
Phosphorus levels (kg/ha)							
0 (p_o)			31.56	31.53	31.49	31.45	31.51
60 (p_1)			33.66	33.55	33.55	33.49	33.56
Mean			32.61	32.54	32.52	32.47	32.53

$. Indicates height of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0217	0.0460
N*; VP	0.0307	0.650
VN; PN	0.0434	--

*Significant

The significant effect of phosphorus application has been noted both in open area and coconut garden. The influence of phosphorus on legumes is a well established fact.

Nitrogen has also been found to be significantly influencing the plant height. As the nitrogen level was increased the plant height has also proportionately reduced. Leguminous crops are not favoured by addition of large quantities of nitrogen which affects their growth.

The interaction V x P was significant in the open area only which may be due to the manifestation of the main treatment effects.

4.2. Number of tillers in grasses

The mean number of tillers per clump are given in Tables 5 and 6 for open area and coconut garden respectively.

There was no significant difference in tiller production between the two grasses in the open area, whereas guinea grass produced significantly higher number of tillers in coconut garden. The setaria grass being shade sensitive produced only lesser number of tillers under partial shade.

Table 5. Number of tillers of grass in open area.

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	18.22	17.81	18.00	18.04	16.45	17.93	18.66	19.03	18.02
Setaria (v_2)	18.20	17.85	17.70	18.37	16.74	17.74	18.60	19.05	18.02
Intercropping									
0 (i_o)			18.40	18.04	16.28	18.47	19.00	19.14	18.22
Stylosanthes (i_1)			17.29	18.36	16.90	17.21	18.26	18.94	17.83
Phosphorus levels (kg/ha)									
0 (p_o)					16.27	17.76	18.38	18.99	17.85
60 (p_1)					16.91	17.92	18.89	19.09	18.20
Mean					16.59	17.84	18.63	19.04	18.02

Control: Guinea grass (v_1) - 14.99

Setaria grass (v_2) - 13.62

Type of pair comparison of means	S.E.	C.D. (0.05)
V; I; P	0.311	--
N*; VI; VP; IP	0.441	0.893
VN; IN; PN	0.624	--

*Significant

Table 6. Number of tillers of grass in coconut garden.

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylo-santhes	0	60	50	100	150	200	
	(i_0)	(i_1)	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	13.58	13.33	13.20	13.70	12.66	13.98	13.67	13.54	13.46
Setaria (v_2)	12.73	12.88	12.61	13.01	12.31	12.15	13.28	13.50	12.80
Intercropping									
0 (i_0)			13.07	13.24	12.29	13.13	13.66	13.57	13.15
Stylo-santhes (i_1)			12.76	13.46	12.68	13.00	13.29	13.47	13.11
Phosphorus levels (kg/ha)									
0 (p_0)					12.26	12.74	13.31	13.36	12.91
60 (p_1)					12.71	13.39	13.64	13.68	13.35
Mean					12.48	13.07	13.48	13.52	13.13

Control: Guinea grass (v_1) - 10.86

Setaria grass (v_2) - 10.27

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I; P	0.269	0.545
N^*; VI; VP; IP	0.381	0.771
VN; IN; PN	0.539	--

*Significant

The data on drymatter production (Table 18) also revealed that this variety has given only lesser drymatter yield in shade.

The effect of intercropping on tillering was not significant under both situations. The effect of phosphorus application was also not significant in tiller production, although it has numerically increased the number of tillers under both situations. The role of phosphorus is more effective towards root growth (Adepetu and Barber, 1978) and as such significant response may not be obtained for tiller production.

Unlike the effect of phosphorus the nitrogen levels exerted significant influence on tiller production both in the open area and in coconut garden. There was progressive increase in tiller number with increase in nitrogen levels under open conditions. However the levels 100 kg and 150 kg, and 150 kg and 200 kg were on par. 50 kg N/ha produced the least number of tillers. The same trend was seen under partial shade condition also. However, the response to nitrogen was lesser under shaded situations and the treatments 50 kg and 100 kg were on par, and 100 kg, 150 kg and 200 kg were also on par. The significant correlations obtained between tiller number and yield (r = 0.6839 for open area and r = 0.5939 for coconut garden) further strengthens their relationship under both situations (Humphreys, 1978).

The mean number of tillers recorded due to treatments in open area (18.02) and in coconut garden (13.13) were significantly higher than the number of tillers noted under the respective controls in both the situations.

A comparison of the data on tiller production in open and partial shade conditions clearly indicated that tiller production was more in the open area. This is in line with the common observation that in most crops tiller production will be higher under higher intensity of sunlight (Sreedharan, 1975). In an experiment on guinea grass, Mullakoya (1982) obtained maximum number of tillers in full sunlight and the lowest with 75 percent shade.

4.3. Leaf-stem ratio

4.3.1. Leaf-stem ratio of grasses.

The mean leaf-stem ratio of grasses in open area and under partial shade are presented in Tables 7 and 8

Table 7. Leaf: stem ratio of grass in open area.

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	2.382	2.060	2.238	2.203	2.318	2.242	2.167	2.156	2.221
Setaria (v_2)	2.001	1.951	2.003	1.948	1.815	2.000	1.857	2.131	1.975
Intercropping									
0 (i_o)			2.155	2.227	2.190	2.205	2.063	2.037	2.191
Stylosanthes (i_1)			2.086	1.925	1.943	2.037	2.061	1.980	2.005
Phosphorus levels (kg/ha)									
0 (p_o)					2.037	1.961	2.138	2.346	2.120
60 (p_1)					2.096	2.281	1.986	1.941	2.076
Mean					2.066	2.121	2.062	2.143	2.098

Control: Guinea grass (v_1) - 2.54

Setaria grass (v_2) - 2.05

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P	0.081	0.164
N; VI; VP; IP	0.115	--
VN; IN; PN	0.161	--

*Significant

Table 8. Leaf: stem ratio of grass in coconut garden.

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	1.935	2.033	1.985	1.983	1.937	2.103	1.956	1.940	1.984
Setaria (v_2)	1.470	1.468	1.456	1.483	1.457	1.553	1.403	1.463	1.469
Intercropping									
0 (i_o)			1.716	1.689	1.743	1.697	1.611	1.758	1.702
Stylosanthes (i_1)			1.725	1.777	1.651	1.960	1.748	1.645	1.751
Phosphorus levels (kg/ha)									
0 (p_o)					1.715	1.772	1.698	1.696	1.720
60 (p_1)					1.680	1.885	1.661	1.707	1.733
Mean					1.697	1.828	1.680	1.701	1.726

Control: Guinea grass (v_1) - 2.01

Setaria grass (v_2) - 1.40

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P	0.058	0.117
N; VI; VP; IP	0.082	--
VN; IN; PN	0.116	--

*Significant

respectively.

It is seen that the two grasses differed significantly in this respect both in open and under partial shade. Guinea grass was found superior under both situations. This is a direct indication of the higher leafyness in guinea as compared to setaria which can be attributed to the genetic superiority of guinea grass.

Intercropping with stylo influenced the leaf-stem ratio of grasses in the open area only. It is seen that the leaf-stem ratio of grasses was lesser with stylo intercropping. This may probably be due to the combined effect of higher number of new tiller production, higher drymatter production, and higher leafiness in the non-intercropped plots (Table 5) on account of the increased availability of land area for their growth and nourishment free of competition from intercrop. However, this difference was not reflected in the drymatter yield as seen in Table 17.

Both phosphorus and nitrogen could not exert any influence on the leaf-stem ratio of grasses under both situations. This is in conformity with the findings of Thangamuthu et al. (1974) in guinea grass and Abraham et al. (1980) in dinanath grass.

It was also observed that the difference between the treatment mean and absolute controls was not significant in both the situation. But in both situations guinea recorded higher leaf-stem ratio than setaria, under absolute control.

A comparison of the data in open and in partial shade reveals that the leaf-stem ratio of grasses in the open was higher than that of partial shade. The greater availability of sunlight in the open has greatly enhanced vigorous growth and higher tillering in grasses resulting in the higher production of larger leaves. This has been clearly shown in the LAI (Table 11 and 12) which was more in the open.

4.3.2. Leaf-stem ratio of stylosanthes.

The mean leaf-stem ratio of stylosanthes are given in Table 9 for open area and in Table 10 for partial shade.

It is seen that under both situations the main treatment effects of grass varieties and nutrient applications were significant in the leaf-stem ratio. While V x N and P x N interactions were significant under open condition, V x P interaction was significant under shade only.

Table 9. Leaf-stem ratio of stylosanthes in open area.

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	1.477	1.697	1.480	1.720	1.625	1.525	1.587
Setaria (v_2)	1.493	1.716	1.505	1.745	1.635	1.535	1.605
Phosphorus levels (kg/ha)							
0 (p_o)			1.370	1.647	1.540	1.385	1.485
60 (p_1)			1.615	1.817	1.720	1.675	1.706
Mean			1.492	1.782	1.630	1.530	1.595

$. Indicates the leaf-stem ratio of stylosanthes when inter-cropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0027	0.0057
N*; VP	0.0039	0.0082
VN*; PN*	0.0076	0.0161

*Significant

Table 10. Leaf-stem ratio of stylosanthes in coconut garden.

Treatments	Phosphorus levels (kg/ha) 0 (p_o)	60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	Mean
$. Grasses							
Guinea (v_1)	2.211	2.300	2.085	2.407	2.322	2.207	2.556
Setaria (v_2)	2.261	2.301	2.102	2.442	2.352	2.227	2.281
Phosphorus levels (kg/ha)							
0 (p_o)			2.052	2.392	2.307	2.192	2.236
60 (p_1)			2.135	2.457	2.367	2.242	2.300
Mean			2.093	2.425	2.337	2.217	2.268

$. Indicates leaf-stem ratio of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0048	0.0102
N*; VP*	0.0068	0.0145
VN; PN	0.0097	--

*Significant

Leaf-stem ratio of stylo when grown in association with guinea grass was more than that grown along with setaria in open area. The fact that the drymatter yield and crop growth rate (Tables 19 and 15) recorded by stylo were also higher in open area when intercropped with guinea grass clearly indicates that leafiness of stylo was accelerated due to association with guinea grass.

However, this trend was not observed under partial shade, wherein the leaf-stem ratio of stylo grown along with guinea was less. The data on height (Table 4) revealed that stylo grown with guinea grass recorded more height. When the height is more it is but natural to produce more stem drymatter. Therefore the leaf-stem ratio of stylo was also less when grown along with guinea grass in partial shade.

Application of phosphorus significantly increased the leaf-stem ratio of stylo in both situations. Phosphorus being an essential primary nutrient for tropical fodder legumes (De Geus, 1977) its application enhances the vegetative growth of legumes especially leaf growth and development. This result is in conformity with the findings of Chandini and Raghavan Pillai (1980).

Significant increase in the leaf-stem ratio was noticed with increase in levels of nitrogen from 50 kg to 100 kg and thereafter it showed a decreasing trend with further incremental doses of 150 kg and 200 kg. This indicated that nitrogen upto 100 kg was sufficient to produce the maximum leafiness, and higher levels of nitrogen were not helpful in further increasing the production of leaves which was exhibited in the rates at higher levels.

The P x N interaction significantly influenced the leaf-stem ratio in the open area only. The leaf-stem ratio obtained under p_1n_2 was the highest which was on par with p_1n_3. This indicated that a combination of 60 kg P_2O_5/ha and 100 kg N/ha was sufficient to produce maximum leafiness in *Stylosanthes gracilis*, when grown as an intercrop. De Geus, (1977) has also recorded maximum leafiness in stylosanthes with combinations of moderate levels of nitrogen and phosphorus. The same trend, although not significant, was observed in coconut garden. The higher values recorded in shade, may be attributed to the high leafiness and increased vigour of legumes noticed in shade than under full sunlight (Humphreys, 1981). The interactions V x N in the open area, and V x P in coconut garden were significant, which may be attributed due to their main treatment effects.

4.4. Leaf Area Index of grasses

The mean LAI of grasses are presented in Table 11 for open area and in Table 12 for partial shade conditions.

It is seen that the difference between the two grasses and nitrogen levels was significant under both situations. However, the effects of intercropping and phosphorus application were not significant in either situations.

The LAI of guinea grass was higher than that of setaria both in the open as well as in partial shade. According to Humphreys (1978) the quantity of light interception can be broadly related to the amount of leaf area present. The data presented in Tables 7 and 8 reveal that guinea has recorded higher leaf-stem ratio than setaria indicating that the utilization of sunlight was more in the case of guinea. Thus guinea has exhibited a higher ability to utilize solar radiation for the development of vegetative plant parts. The genetic superiority of guinea has been an added advantage in this respect. The Tables 13 and 14 of crop growth rate and Tables 17 and 18 on drymatter yield also showed the superior performance of guinea in both the situations.

Table 11. LAI of grass in open area.

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylo-santhes	0	60	50	100	150	200	
	(i_o)	(i_1)	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	4.846	4.862	4.855	4.854	4.775	4.820	4.888	4.935	4.854
Setaria (v_2)	4.781	4.755	4.780	4.756	4.717	4.747	4.785	4.822	4.768
Intercropping									
None (i_o)			4.822	4.805	4.732	4.780	4.843	4.900	4.814
Stylo-santhes (i_1)			4.812	4.805	4.760	4.787	4.830	4.857	4.808
Phosphorus levels (kg/ha)									
0 (p_o)					4.745	4.790	4.842	4.892	4.817
60 (p_1)					4.747	4.777	4.831	4.865	4.805
Mean					4.746	4.783	4.836	4.878	4.811

Control: Guinea grass (v_1) - 4.512

Setaria grass (v_2) - 4.565

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I; P	0.0009	0.019
VI; VP; IP	0.013	0.027
N^*; VN; IN; PN	0.019	--

*Significant

Table 12. LAI of grass in coconut garden.

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	4.676	4.718	4.685	4.709	4.613	4.671	4.728	4.776	4.697
Setaria (v_2)	4.640	4.611	4.638	4.614	4.575	4.602	4.647	4.680	4.626
Intercropping									
None (i_o)			4.655	4.662	4.575	4.631	4.687	4.741	4.659
Stylo-santhes (i_1)			4.668	4.661	4.613	4.642	4.688	4.715	4.665
Phosphorus levels (kg/ha)									
0 (p_o)					4.586	4.640	4.687	4.733	4.661
60 (p_1)					4.602	4.633	4.688	4.722	4.661
Mean					4.594	4.636	4.688	4.728	4.661

Control: Guinea grass (v_1) - 4.255
Setaria grass (v_2) - 4.267

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P	0.023	0.046
N*; VI; VP; IP	0.032	0.065
VN; IN; PN	0.045	--

*Significant

It can be seen that LAI increased significantly with increase in nitrogen levels both under shade and open. The influence of nitrogen in increasing the vegetative growth in plants is well known. The increase in leaf number and leaf area might have led to an increase in LAI. The leaf-stem ratio and drymatter yield (Tables 7, 8, 17 and 18) also increased with incremental doses of nitrogen. Increase in LAI with increased doses of nitrogen has been reported by Bunpsoma and Mobhayad (1978).

In both the situations, the difference in LAI between the two grasses under control was not significant. While the mean LAI due to treatments was significantly higher than the LAI noted under absolute control in both the situations.

A comparison of the data from the open area and partial shade revealed that the LAI values recorded in the open were higher than that of the partial shade. The characters like leaf-stem ratio, crop growth rate and dry-matter yield were also higher in the open as compared to partial shade. In sunny environment, the amount of radiation penetrating the lower layers of the sward was greater and as such carried more number of leaves without detriment to total grass yield (Humphreys and Robinson, 1966). Higher LAI values in full sunlight and lower values with decrease in light to grasses were also reported by Ludlow et al. (1974).

4.5. Crop growth rate

4.5.1. Crop growth rate of grasses.

The mean crop growth rate (general mean of 2 years are given in Table 13 for open area and in Table 14 for partial shaded condition.

The two grasses exhibited significant difference in crop growth rate under both situations. Guinea grass recorded a higher crop growth rate than setaria both in open and in partial shade. Differences in the rate of growth of species and cultivars arise from differences in the photosynthetic efficiency of the green surfaces of the sward (Humphreys, 1981). Photosynthetic efficiency is primarily under genetic control and the difference in crop growth rate noticed between the two grasses in this study may be attributed due to the genetic variation of the grasses.

While the effect of phosphorus application was not

Table 13. Crop growth rate of grass in open area (gm/m^2/day).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	2.415	2.486	2.596	2.305	2.170	2.533	2.615	2.485	2.450
Setaria (v_2)	2.176	2.143	2.163	2.156	1.821	2.020	2.108	2.691	2.160
Intercropping									
None (i_o)			2.513	0.078	1.876	2.201	2.498	2.607	2.295
Stylosanthes (i_1)			2.246	2.384	2.115	2.352	2.225	2.568	2.315
Phosphorus levels (kg/ha)									
0 (p_o)					2.190	2.228	2.455	2.646	2.380
60 (p_1)					1.801	2.325	2.268	2.530	2.231
Mean					1.995	2.276	2.361	2.588	2.305

Control: Guinea grass (v_1) - 1.392
Setaria grass (v_2) - 1.535

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P	0.132	0.266
N*; VI; VP; IP	0.186	0.377
NV; NI; NP	0.263	--

*Significant

Table 14. Crop growth rate grass in coconut garden ($gm/m^2/day$).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	2.054	1.963	1.893	2.124	1.877	2.128	2.018	2.011	2.009
Setaria (v_2)	1.433	1.643	1.428	1.648	1.430	1.458	1.683	1.580	1.538
Intercropping									
None (i_o)			1.636	1.851	1.692	1.825	1.736	1.721	1.743
Stylo-santhes (i_1)			1.685	1.921	1.615	1.762	1.966	1.870	1.803
Phosphorus levels (kg/ha)									
0 (p_o)					1.695	1.655	1.768	1.525	1.660
60 (p_1)					1.612	1.932	1.933	2.066	1.886
Mean					1.653	1.793	1.851	1.795	1.773

Control: Guinea grass (v_1) - 1.370
Setaria grass (v_2) - 1.200

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P*	0.095	0.192
N; VI; VP; IP	0.134	--
VN; IN; PN	0.190	--

*Significant

significant in open area, it significantly increased the crop growth rate under partial shade conditions. The better response obtained under shade (Table 61) may be explained from the point of view of better utilization of phosphorus under shaded condition (Adepetu and Barber, 1978).

Nitrogen levels increased the crop growth rate of grasses, but significant response was obtained only in open area. The significant difference was noticed only between 50 kg and 200 kg N/ha with regard to the crop growth rate indicating that a wide level of nitrogen is required to influence this character. The drymatter production also showed an increasing trend as in the case of crop growth rate but the increase was significant only upto 150 kg N/ha (Table 17). Thus it is seen that there existed a relationship between crop growth rate and yield.

The difference in crop growth rate between the two grasses grown under control was not significant in open area, while in coconut shade guinea recorded a higher crop growth rate than setaria. The mean crop growth rate due to treatments was significantly higher than the crop growth rates under control in both the situations.

A comparison of the results from open and partial shade revealed that the crop growth rate was considerably lesser in shade. The reduced crop performance as reflected in LAI and tiller production (Tables 6 and 12) were all responsible for the reduced crop growth rate.

4.5.2. Crop growth rate of stylosanthes.

The mean crop growth rate of stylosanthes are presented in Table 15 for open area and in Table 16 for partial shaded condition.

There was significant variation in the crop growth rate of stylosanthes grown in association with the grasses under both the situations. It is seen that the crop growth rate was significantly higher when grown with guinea grass. The lesser competition between the guinea grass and stylo resulted in higher crop growth rate of stylosanthes when grown together.

Application of phosphorus also has significantly increased the crop growth rate of stylo in both the situations. The data on the height of plants (Tables 3 and 4) revealed significant increase due to phosphorus application.

Table 15. Crop growth rate of stylosanthes in open area (gm/m^2/day).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_0)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. <u>Grasses</u>							
Guinea (v_1)	0.446	0.570	0.494	0.554	0.495	0.491	0.508
Setaria (v_2)	0.446	0.563	0.489	0.553	0.491	0.484	0.504
<u>Phosphorus levels (kg/ha)</u>							
0 (p_0)			0.439	0.468	0.440	0.437	0.446
60 (p_1)			0.544	0.638	0.546	0.538	0.567
Mean			0.491	0.553	0.493	0.488	0.506

$. Indicates CGR of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0009	0.0020
N*; VP*	0.0014	0.0029
VN; PN*	0.0042	0.0089

*Significant

Table 16. Crop growth rate of stylosanthes in coconut garden (gm/m^2/day).

Treatments	Phosphorus levels (kg/ha) 0 (p_o)	60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	Mean
$. Grasses							
Guinea (v_1)	0.456	0.580	0.504	0.563	0.506	0.500	0.518
Setaria (v_2)	0.454	0.571	0.498	0.560	0.499	0.494	0.513
Phosphorus levels (kg/ha)							
0 (p_o)			0.448	0.476	0.451	0.446	0.455
60 (p_1)			0.554	0.647	0.554	0.548	0.575
Mean			0.501	0.561	0.502	0.497	0.516

$. Indicates CGR of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0008	0.0017
N*; VP*	0.0014	0.0030
VN; PN	0.0020	--

*Significant

The drymatter yield also increased with levels of phosphorus (Tables 19 and 20). As there is universal response to phosphorus application by legumes the higher crop growth rate noted due to phosphorus fertilization is fully justified in this investigation also.

The effect of nitrogen doses was significant on the crop growth rate and a uniform trend was observed under both situations. The growth rate increased significantly from 50 kg N/ha to 100 kg N/ha and thereafter showed a significant decrease with increases in nitrogen doses. Perusal of the data on uptake of nitrogen (Tables 60 and 61) showed that the uptake was maximum under 100 N/ha and then it decreased with further higher doses of nitrogen. Tropical legumes usually show an initial response at lower nitrogen doses and thereafter remain more or less stable or show a negative response (Drosdov and Lepkovich, 1976).

The interactions V x P was significant in both the situations and P x N was significant in open area only, which may be attributed to their main treatment effects.

A comparison of the data from open and under partial shade also revealed that the crop growth rate of stylosanthes was higher in coconut shade. This may be attributed to the favourable microclimatic environment available in coconut garden which favoured a higher crop growth for stylo (Erickson, 1977). Data on plant height (Tables 3 and 4) also showed that the height was more in coconut garden than in open area. The light intensity of the area under experimentation was 50 percent as compared to open and it seems that this condition was ideal for the growth of stylosanthes. In an observational trial conducted at Vellayani it was observed that further increase of shade to more than 50 percent considerably ~~considerably~~ reduced the yield of legumes. Hence, it is to be inferred that 50 percent light intensity was ideal for stylosanthes.

4.6. Drymatter yield

4.6.1. Drymatter yield of grass.

The mean drymatter yield of grasses are presented in Tables 17 and 18 for open area and partial shade condition respectively.

There was significant difference in drymatter yield between the two grasses in open area as well as under partial shade. Guinea grass has given significantly higher drymatter

Table 17. Drymatter yield of grass in open area (t/ha).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylosanthes	0	60	50	100	150	200	
	(i_o)	(i_1)	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	7.558	7.527	7.283	7.803	6.546	7.641	7.887	8.096	7.543
Setaria (v_2)	7.354	7.251	7.265	7.340	6.416	7.155	7.754	7.885	7.303
Intercropping									
None (i_o)			7.299	7.613	6.611	7.410	7.786	8.018	7.456
Stylosanthes (i_1)			7.249	7.529	6.351	7.386	7.855	7.964	7.389
Phosphorus levels (kg/ha)									
0 (p_o)					6.039	7.357	7.710	7.990	7.274
60 (p_1)					6.924	7.439	7.931	7.991	7.571
Mean					6.481	7.398	7.821	7.991	7.422

Control: Guinea grass (v_1) - 4.492
Setaria grass (v_2) - 5.177

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I; P^*	0.085	0.173
VI^*; VP^*; IP^*	0.121	0.245
VN^*; IN; PN^*	0.171	0.344

*Significant

Table 18. Drymatter yield of grass in coconut garden (t/ha).

Treatments	Intercropping None	Intercropping Stylo-santhes	Phosphorus levels (kg/ha) 0	Phosphorus levels (kg/ha) 60	Nitrogen levels (kg/ha) 50	Nitrogen levels (kg/ha) 100	Nitrogen levels (kg/ha) 150	Nitrogen levels (kg/ha) 200	Mean
	(i_o)	(i_1)	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	6.839	6.892	6.498	7.233	6.243	7.179	7.214	6.826	6.865
Setaria (v_2)	6.013	6.414	6.065	6.362	5.881	6.086	6.336	6.550	6.213
Intercropping									
None (i_o)			6.389	6.463	6.081	6.610	6.451	6.561	6.426
Stylo-santhes (i_1)			6.174	7.132	6.043	6.655	7.099	6.815	6.653
Phosphorus levels (kg/ha)									
0 (p_o)					6.026	6.349	6.531	6.220	6.282
60 (p_1)					6.097	6.916	7.019	7.156	6.797
Mean					6.062	6.633	6.775	6.688	6.539

Control: Guinea grass (v_1) - 4.775
Setaria grass (v_2) - 4.265

Type of pair comparison of means	S.E.	C.D. (0.05)
V^* ; I^* ; P^*	0.086	0.175
N^* ; VI^* ; VP^* ; IP^*	0.122	0.248
NV^* ; NI^* ; NP^*	0.173	0.350

*Significant

yield than setaria grass under both situations. This may be attributed to the genetic superiority of guinea over setaria. Superior performance of guinea has been reported by several workers (Sahasranaman and Pillai,(1976), Weightman (1977) and Anon (1980).

It was also observed that the drymatter yield recorded in open area was higher than that under partial shade. There was 8.98 percent reduction in drymatter yield in the case of guinea and 14.92 percent reduction in the case of setaria when grown under partial shade. Reduction in dryfodder yields to the tune of 5 to 10 percent has been reported in the case of guinea grass grown in coconut garden (Anon., 1980). According to Vicente-Chandler et al. (1961) guinea and setaria grasses are considered to be suitable for wet tropics and they perform well under good sunlight. Perusal of the Tables 5 and 6 on the number of tillers showed that tiller production was more in open area than in coconut gardens. The correlation coefficient showed (Table 31) that there was significant positive correlation between number of tillers and drymatter yield in both the situations. However, the yield was more correlated to tiller number in open area (r = 6.839) than under shade (r = 5.939). The higher number of tillers recorded in open area might have produced more drymatter in both the grasses under open situations. The superior performance of guinea even under an adverse condition of only 50 percent light intensity shows the genetic superiority and shade tolerance of this grass over setaria. Erickson (1977) has reported <u>Panicum maximum</u> as one of the shade tolerant fodder grasses of the wet tropics.

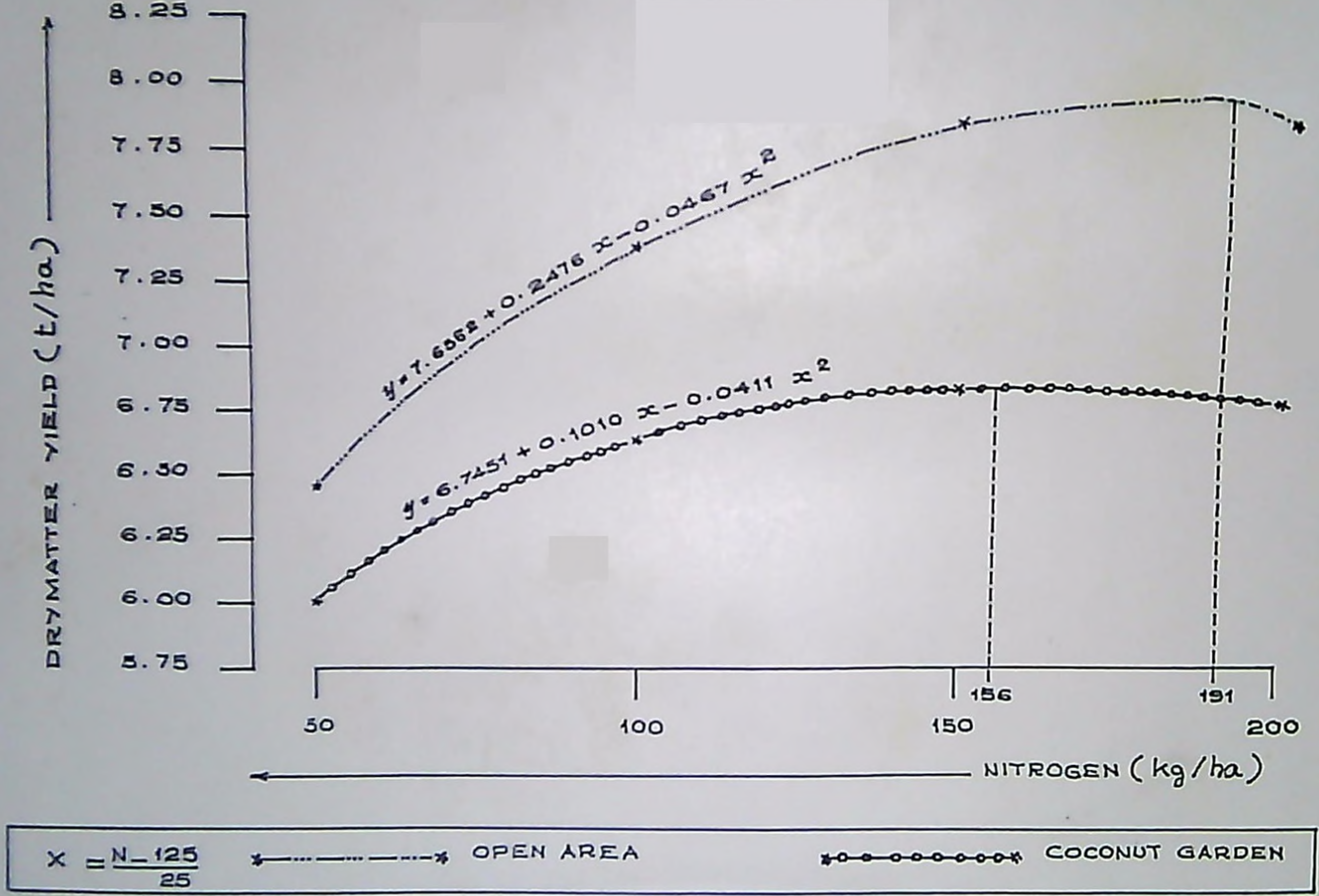
The effect of intercropping on the drymatter yield of grass was significant in coconut garden, whereas the effect was not significant in open area. Intercropping with <u>Stylosanthes gracilis</u> in shade has increased the drymatter yield in grass by 3.53 percent over no intercropping. This increase in drymatter yield may be attributed to the beneficial effect of nitrogen fixation by stylo in shade conditions. It was already reported that nitrogen fixation is more under shade than the open area (Skerman, 1977). This enhanced nitrogen availability might be the reason for higher fodder yield under shade situation. Increases in fodder yield due to association with legumes has been reported by Salcedo (1969) and Ahlawat et al. (1964).

The data presented in Tables 17 and 18 revealed significant influence due to phosphorus application. Phosphorus given @ 60 kg P_2O_5/ha recorded more drymatter yield both from open and from partial shade. It was also seen that the interaction V x P was significant and guinea grass gave significantly higher yield with phosphorus application, whereas phosphorus could not exert any significant influence on setaria grass.

The effect of nitrogen on drymatter yield was significant both in open area and in coconut garden. Increase in drymatter yield with increase in nitrogen levels has been recorded by the highest level of 200 kg N/ha in the open area. Although this level of 200 kg N/ha was on par with 150 kg N/ha this was significantly superior to 50 kg and 100 kg. However, response curve worked out showed that optimum response was obtained at 191 kg N/ha ($y = 7.6562 + 0.2476x - 0.04669x^2$) as shown in figure 2 where $x = \frac{N - 125}{25}$.

Under partial shade condition though an increase in drymatter production was noted with the increase in nitrogen level upto 150 kg N/ha, the levels 100, 150 and 200 kg N/ha were on par. The optimum dose of nitrogen

FIG. 2. RESPONSE OF GRASSES TO DIFFERENT LEVELS OF NITROGEN

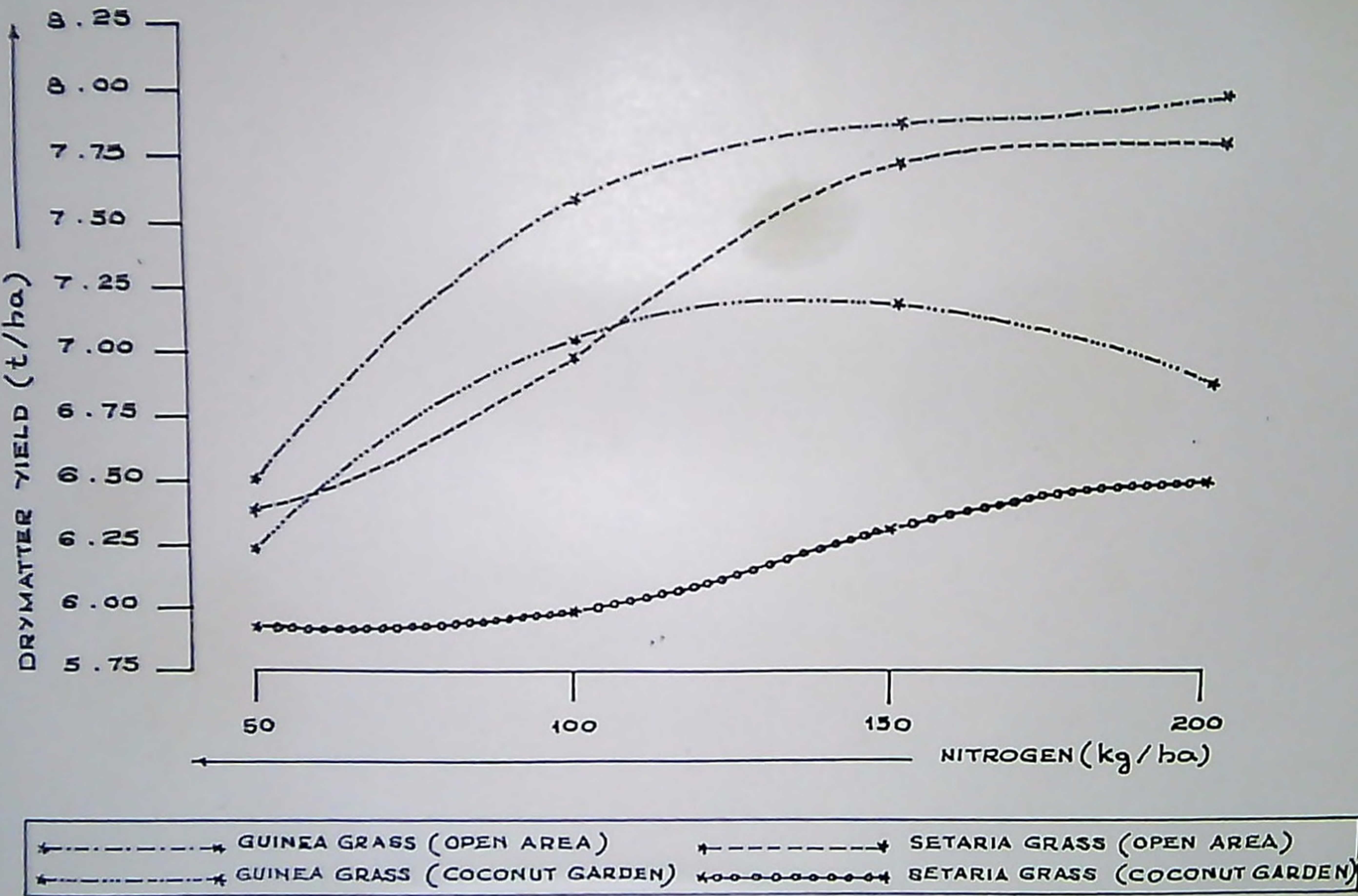


worked out for coconut garden was 156 kg N/ha ($y = 6.7451 + 0.101x - 0.04113x^2$) where $x = \frac{N - 125}{25}$. A comparison of the data on drymatter yield in open and in partial shade with respect to the response to nitrogen levels also showed that the drymatter yield was more in open area than under shade for that particular level of nitrogen. The drymatter production per kg of nitrogen applied was 18.34 kg when the nitrogen level was raised from 50 to 100 kg/ha, 8.46 kg for the level from 100 to 150 kg/ha and 3.40 kg for the level from 150 to 200 kg N/ha in the open area. The corresponding values under partial shade were 11.42 kg for the level 50 to 100 kg N/ha and 2.84 kg for 100 to 150 kg N/ha and then it showed a reducing effect on drymatter yield. Perusal of Table 5 on number of tillers revealed that 200 kg N/ha has given the highest tiller number. The optimum response for drymatter production was worked out to be 191 kg N/ha for open area. This shows that there exists a close relationship between the tiller number and drymatter production at the highest level of nitrogen. Whereas under partial shade (Table 6) maximum response was obtained at 100 kg N/ha beyond which the differences were not significant. The drymatter production also showed that beyond 100 kg nitrogen the levels did not significantly influence this aspect, while the response curve for the optimum dose was found to be 156 kg nitrogen.

It may be mentioned in this connection that the treatments in the present study were selected taking into account the previous results recorded in the station wherein the maximum response was seen only upto 200 kg nitrogen (Anon., 1973). Similar responses to moderate levels of nitrogen have been reported by Bogdan (1977). However, in the present study the response was only upto 150 kg N/ha for the open area and 100 kg N/ha for coconut garden.

The performance of the two grasses under both the situations is depicted in Figure 3. Although both grasses have given higher yields under open condition, guinea grass performed much better than setaria under partial shade condition. It was also seen that guinea grass responded to nitrogen fertilisation more than setaria especially at 150 kg N/ha. It was further noticed that the response of guinea decreased after 150 kg nitrogen under partial shade condition. The higher photosynthetic efficiency of guinea grass under open condition has already been reported (Humphreys, 1981). The present investigation also showed

FIG. 3. PRODUCTION POTENTIAL OF GRASSES UNDER DIFFERENT LEVELS OF NITROGEN



that guinea grass possesses high photosynthetic efficiency under shaded conditions especially at moderate levels of nitrogen.

The interaction V x P was significant both in open area as well as in partial shade. It was seen that guinea grass has given significantly high yield with 60 kg P_2O_5/ha in the open area whereas setaria has not responded to phosphorus under such situation. However, both the grasses have significantly responded to phosphorus application under partial shaded condition.

The I x P interaction was significant under both situations. Intercropping stylosanthes with grass in the absence of phosphorus even reduced the yield of grass whereas in the presence of phosphorus intercropping has given the maximum yield of grasses. The I x P interaction was significant because of the pronounced effect of phosphorus on the growth of the legume component which might have indirectly helped the grass for giving higher drymatter yield.

The interaction V x N was significant under both conditions. There was a progressive increase in drymatter yield of guinea grass with increase in nitrogen level upto 200 kg. But this was on par with 150 kg N/ha. Therefore it shows that for guinea 150 kg nitrogen was sufficient to produce maximum drymatter. In the case of setaria also similar trend was noted. In the case of guinea grass there was progressive increase in drymatter yield upto 150 kg level beyond which there was significant reduction at 200 kg. This shows that under shaded situation, the application of nitrogen beyond 150 kg/ha is not necessary for guinea grass and should not be recommended especially under coconut garden conditions. For setaria also 150 kg N/ha is just sufficient, as there was no appreciable increase in drymatter yield by increasing the nitrogen rate to 200 kg/ha.

The fact that I x N interaction was also significant under shade situations clearly indicating that when inter-cropping is practiced, the 150 kg level is sufficient and the nitrogen application beyond 150 kg results in a decrease in yield. Therefore, when grass is intercropped with legume the nitrogen may be given at the level 150 kg/ha for highest production of grasses under partial shade condi-tion.

The P x N interaction was significant in open as well as in partial shade condition. Under open condition in treatments receiving different levels of nitrogen and zero level of P_2O_5 an increase was noticed upto the highest level of 200 kg N/ha, whereas with 60 kg P_2O_5 significant response was obtained upto 150 kg nitrogen only beyond which the effect was not significant. But in shade condition under zero level of P_2O_5 there was progressive increase in yield only upto 150 kg beyond which there was a decrease, while with 60 kg P_2O_5 there was significant increase in yield only upto 100 kg level beyond which the increase was not significant. The uptake of nitrogen (Table 58) showed that under open conditions the highest level of 200 kg receiving zero P_2O_5 has given maximum uptake, while in the presence of 60 kg P_2O_5 the 150 kg level recorded significantly higher uptake beyond which it was not significant. In shade condition (Table 59) under zero level of P_2O_5 there seems to be no appreciable increase beyond 100 kg level. In the presence of 60 kg P_2O_5 the 100 kg level has given a very substantial and significant increase in nitrogen uptake beyond which there was no substantial increase. This is in agreement with the findings of Wendt (1970) and Narwal et al. (1977).

The interaction V x I was significant in both the situations. The mean yield from open area (Table 17) showed that growing stylo as intercrop has significantly influenced the grass yield more so in the case of guinea. In coconut garden also the same trend was noticed. Thus the superiority of guinea over setaria is once again established.

It was also noticed that the mean drymatter yields due to treatments were significantly higher than the yields obtained under absolute control in both the situations.

These results show that under reduced light intensities the response of grasses to nitrogen was less as already explained. The results of interaction also reveal that under partial shade situation, the application of phosphorus reduces still further the requirement of nitrogen from 150 to 100 kg/ha. When phosphorus was added the yield at 100 kg level of nitrogen was significantly increased. In other words the application of phosphorus seems to be a must under shade situations. This not only reduces the requirement of nitrogen but also increases the yield at the level of applied nitrogen.

4.6.2. Drymatter yield of stylosanthes.

The mean drymatter yield of stylo are presented in Table 19 and 20 for open area and for partial shade condition respectively.

There was significant difference in drymatter yield of stylo when grown in association with the two different grasses under both situations. It is seen that the fodder yield of stylo was more when intercropped with guinea grass than with setaria grass. This may probably be due to the differential tillering habit of the two grasses as explained earlier. Guinea grass is tussock type with clustered tillers whereas in setaria grass the tillers are not as compactly clustered together as in the case of guinea. This tussock tillering nature of guinea grass affords more interspace for stylo for growth and development. The fact that there was significantly more height recorded by stylo plants in guinea grass plots (Table 3 and 4) once again supports the favourable disbursement created by guinea grass in their interspaces for the growth of stylo. Oyenugo and Olubago (1969) also recorded highest drymatter yield by grass-legume mixtures consisting of guinea grass and stylosanthes.

Table 19. Drymatter yield of stylosanthes in open area (t/ha).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	3.509	4.465	3.886	4.356	3.881	3.825	3.987
Setaria (v_2)	3.506	4.402	3.820	4.337	3.837	3.812	3.954
Phosphorus levels (kg/ha)							
0 (p_o)			3.453	3.675	3.461	3.440	3.507
60 (p_1)			4.262	5.018	4.258	4.197	4.434
Mean			3.858	4.346	3.859	3.818	3.470

$. Indicates drymatter yield of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; P^*	0.0088	0.0187
N^*; VP^*	0.0125	0.0265
VN; PN^*	0.0177	0.0375

*Significant

Table 20. Drymatter yield of stylosanthes in coconut garden (t/ha).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	3.590	4.567	3.960	4.422	3.975	3.959	4.079
Setaria (v_2)	3.571	4.489	3.915	4.402	3.922	3.881	4.030
Phosphorus levels (kg/ha)							
0 (p_o)			3.525	3.742	3.547	3.510	3.581
60 (p_1)			4.350	5.082	4.850	4.330	4.528
Mean			3.937	4.412	3.903	3.920	4.054

$. Indicates drymatter yield of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; P^*	0.0076	0.0162
N^*; VP^*	0.0137	0.0290
VN; PN^*	0.0153	0.0324

*Significant

Phosphorus application significantly increased the drymatter yield of stylosanthes under both situations. The response of legumes to phosphorus application is well established (Hadjchristodoulou, 1971). The data on the height of plants also showed (Tables 3 and 4) significant increase due to phosphorus application. In the present study for the increase in the level from 0 to 60 kg P_2O_5/ha, the yield increase was of the order 31 kg drymatter per kg of P applied under both situations. Similar increases in fodder yield due to phosphorus fertilization in Stylosanthes guinensis has been reported by several workers (Jones (1974); Haggar (1971) and Bruce et al. (1978). The phosphorus utilization quotient (drymatter per unit of phosphorus uptake) was 265 and 294 for open and for partial shade respectively.

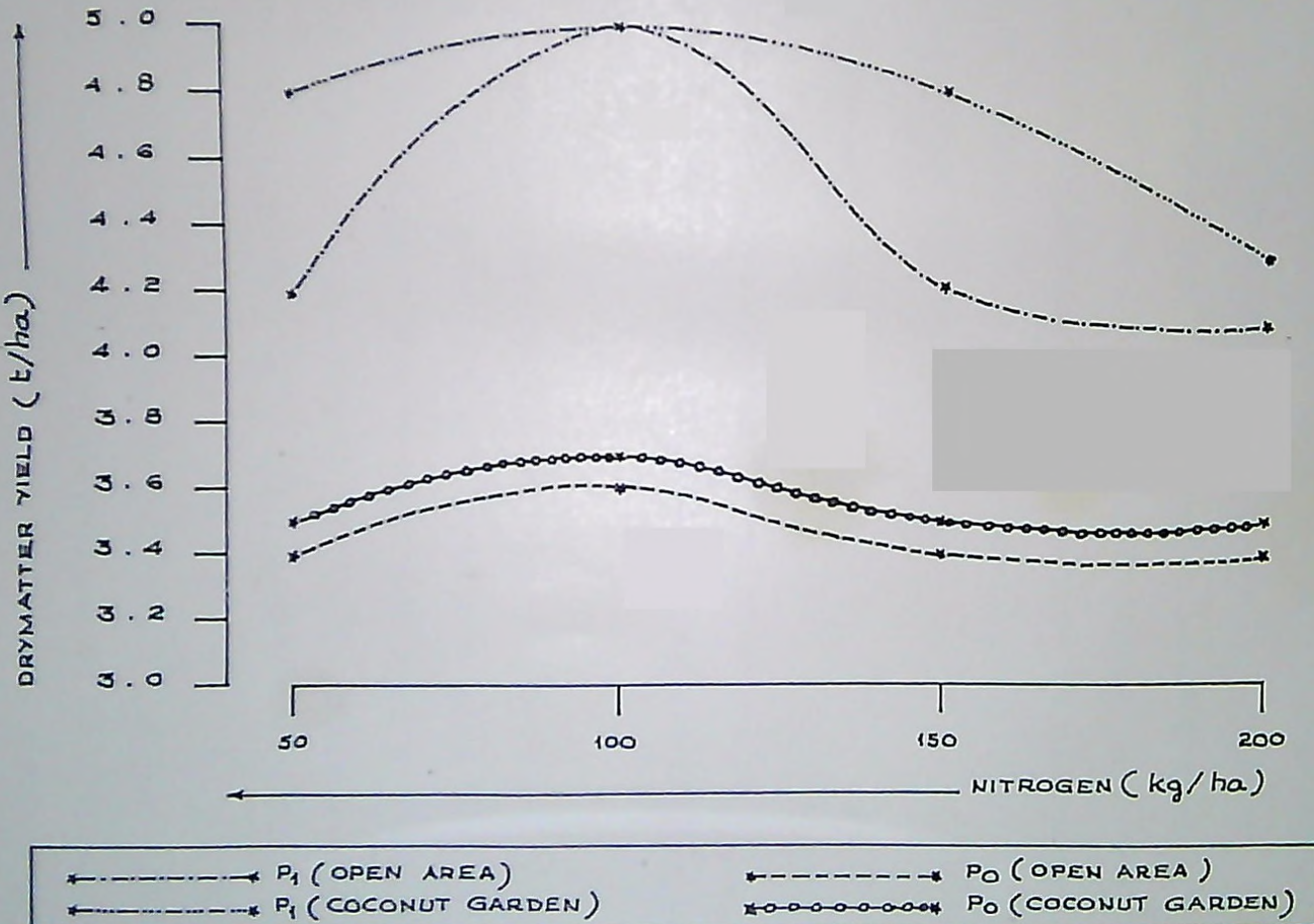
The effect of nitrogen application was significant both in open and in partial shaded condition. Nitrogen doses increased the drymatter yield of stylo upto 100 kg and thereafter the yield decreased. The response to different levels of nitrogen under both situations are more or less uniform. At higher levels of nitrogen the growth of legume was suppressed significantly. Lowe (1970) observed that at higher nitrogen levels, the fodder yields were similar to those in untreated plots in the case of Medicago sativa. Similar instances of reduced fodder yield due to higher levels of nitrogen have been reported by Drodsov and Lepkovich (1976) in red and white clovers.

The optimum level of N has been worked out to 114 kg/ha in open area ($y = 8.27275 - 0.0606x - 0.06625x^2$) and 115 kg/ha in coconut gardens ($y = 8.42394 - 0.05165x - 0.06294x^2$) for stylosanthes when grown in association with grasses as shown in figure 4.

The V x P interaction was significant under both situations. Under 60 kg level of phosphorus there was significant difference due to intercropping with grasses. It is seen that yield of stylo was lesser when grown with setaria. This may be due to the smothering effect of setaria on stylo as already explained.

P x N interaction effect was also significant under both situations. Nitrogen @ 100 kg/ha has given a significantly higher yield in the presence phosphorus, beyond which a decrease was observed in open as well as in partial shade.

FIG_4. RESPONSE OF STYLOSANTHES TO NITROGEN IN THE ABSENCE AND PRESENCE OF PHOSPHORUS



An overall comparison between the mean yields under open and partial shade revealed an increase in drymatter yield of stylosanthes when intercropped in coconut garden. Increased soil moisture, reduced light intensity and other favourable microclimatic conditions available in the coconut garden may be responsible for the increased yield of stylo in the partial shade (Plucknett, 1979).

4.6.3. Total drymatter yield of grass and stylo.

The mean total drymatter yield of grass and stylo are presented in Table 21 for open area and in Table 22 for partial shade.

It is seen from the tables that the difference between the grasses was significant under both situations. The treatment guinea grass intercropped with stylosanthes was found to be superior to setaria grass intercropped with stylosanthes. This may be due to the genetic superiority of guinea over setaria for higher fodder production. It may also be attributed to the better association of guinea with stylosanthes. Oyenugo and Olubago (1969) recorded maximum drymatter yield by grass-legume association consisting of guinea grass and stylosanthes. In a similar trial under

Table 21. Total drymatter yield of grass and stylo in open area (t/ha).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None (i_o)	Stylosanthes (i_1)	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
<u>Grasses</u>									
Guinea (v_1)	7.558	11.511	9.034	10.035	8.489	9.815	9.827	10.007	9.535
Setaria (v_2)	7.354	11.206	9.018	9.541	8.331	9.323	9.673	9.791	9.279
<u>Intercropping</u>									
None (i_o)			7.299	7.613	6.611	7.410	7.786	8.017	7.456
Stylosanthes (i_1)			10.753	11.963	10.209	11.729	11.714	11.781	11.358
<u>Phosphorus levels (kg/ha)</u>									
0 (p_o)					7.765	9.191	9.440	9.708	9.026
60 (p_1)					9.055	9.947	10.060	10.090	9.788
Mean					8.410	9.569	9.750	9.899	9.407

Control: Guinea grass (v_1) - 4.492

Setaria grass (v_2) - 5.177

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I*; P*	0.085	0.172
N*; VI; VP*; IP*	0.120	0.243
VN; IN; PN*	0.170	0.344

*Significant

Table 22. Total drymatter yield of grass and stylo in coconut garden (t/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	6.839	10.969	8.292	9.516	8.220	9.389	9.201	8.805	8.904
Setaria (v_2)	6.013	10.449	7.851	8.611	7.839	8.287	8.307	8.490	8.231
Intercropping									
None (i_o)			6.389	6.462	6.081	6.610	6.451	6.561	6.426
Stylosanthes (i_1)			9.753	11.664	9.978	11.066	11.057	10.734	10.709
Phosphorus levels (kg/ha)									
0 (p_o)					7.786	8.220	8.305	7.974	8.071
60 (p_1)					8.273	9.456	9.204	9.321	9.063
Mean					8.029	8.838	8.754	8.647	8.567

Control: Guinea grass (v_1) - 4.775
Setaria grass (v_2) - 4.265

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.087	0.176
N^*; VI; VP^*; IP^*	0.123	0.249
VN; VI; PN^*	0.174	0.352

*Significant

open area Chandini and Raghavan Pillai (1980) obtained higher fodder yield for guinea + stylosanthes combination. These results show the suitability of guinea + stylo association for open area as well as in coconut garden conditions.

The effect of intercropping with stylo was highly significant in both situations. The fodder yield increased on account of intercropping with stylosanthes. This may be due to the contribution from the legume component. Daulay et al. (1968) recorded increased forage yield in grass legume mixtures as compared to grass alone. The increase in total fodder yield in the present study was 52.3 percent in open area and 66.6 percent in coconut shade. Grof and Harding (1970) obtained 47 percent increase in total fodder yield due to intercropping with <u>Stylosanthes guianensis</u>.

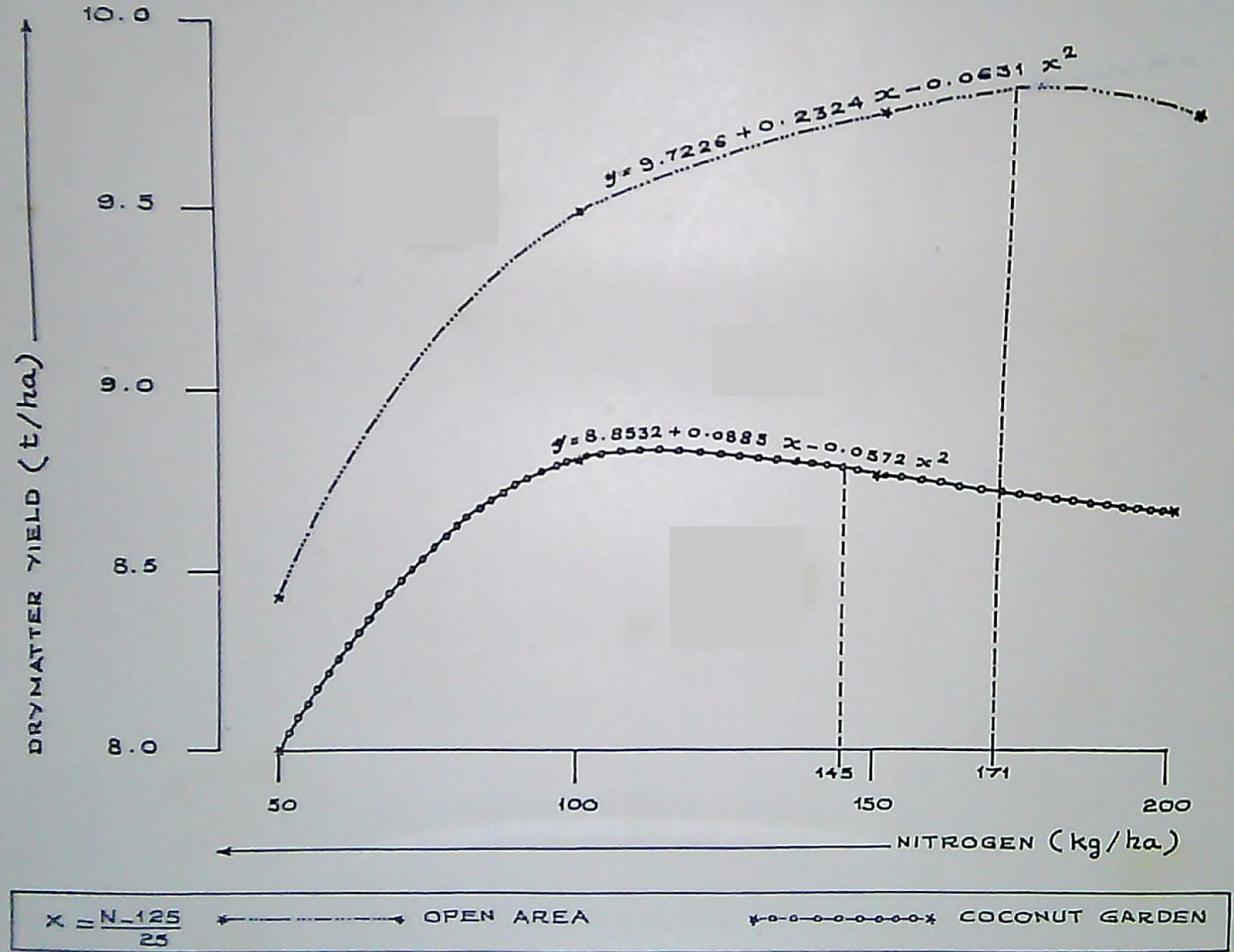
Phosphorus application has significantly increased the total fodder yield in both situations. Phosphorus application has increased the dryfodder yield in all cases and the same trend was manifested in the total fodder yield also. The increase in yield due to phosphorus application was found to be 8.4 percent in open area and 12.3 percent in coconut garden.

Nitrogen significantly increased the total fodder yield under both situations. Although increase in yield was noticed upto the maximum level of 200 kg N/ha tried in the open area, the optimum level was worked out to 171 kg N/ha ($y = 9.72263 + 0.2324x - 0.0631x^2$). In this connection it is to be noted that the optimum level for grass alone in open area was 191 kg N/ha (Figure 3). Thus there could be a saving of 20 kg/ha for obtaining maximum production in open area from grass-legume association (Figure 5).

In coconut garden significant increase in fodder yield was noticed upto 100 kg N/ha and thereafter the fodder yield decreased with further increase in nitrogen. The optimum level for grass + stylo under coconut garden condition was worked out to 145 kg N/ha ($y = 8.85325 + 0.0885x - 0.05725x^2$) (Figure 5). Here again the optimum level for grass alone was 156 kg N/ha (Figure 3). Therefore here also a saving of 11 kg N/ha was obtained for maximum production of fodder from grass-legume association.

The interaction effect of V x P was significant under both situations. Drymatter yield recorded under $v_1 \times p_1$ was significantly superior to $v_2 \times p_1$. This may be

FIG_5. RESPONSE OF GRASS_STYLOSANTHES MIXTURE TO NITROGEN



attributed to the increased uptake of phosphorus by guinea than setaria as given in Table 66 and 67.

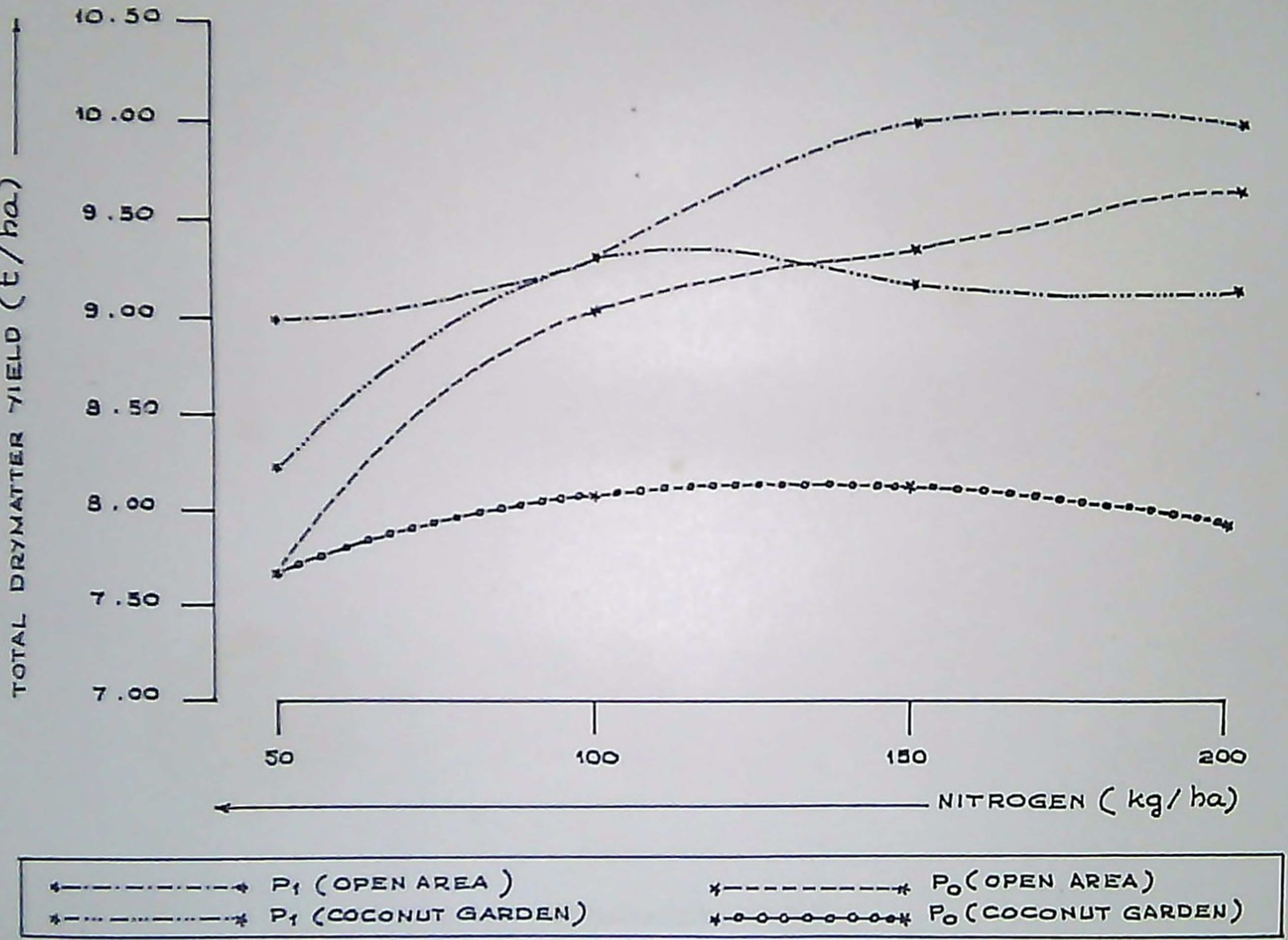
The interaction effect of I x P was also significant under both situations. The treatment combination involving intercropping of grass with stylo and given 60 kg phosphorus recorded maximum fodder yield in both situations. Chandini and Raghavan Pillai (1980) obtained significant increase in total fodder yield of grasses due to the interaction effect of phosphorus and intercropping with stylo in open area. This observation brings out the importance of legume intercropping coupled with phosphorus application for enhanced fodder production.

The interaction effect of P x N was also significant under both situations. In open area the response was obtained upto 100 kg level beyond which the increase was not significant. This result is to be compared with that of the P x N interaction (Table 17) of grass alone, wherein the response was upto 150 kg level in the absence and presence of phosphorus in open area. In other words, this points to the fact that the presence of phosphorus reduces the nitrogen requirement for total drymatter production. The importance of intercropping grass with stylosanthes lies in the fact that the quantity of fertilizer nitrogen can be reduced substantially by this practice in addition to the over all improvement in quantity. Thus there was a saving of 100 kg nitrogen by the addition of 60 kg P_2O_5 in the open area.

Under partial shade condition also in the presence of phosphorus the yield increase was substantial and significant at this particular level of nitrogen (100 kg/ha). The increase was to the extent of 36 percent for n_2p_1 (100 kg nitrogen and 60 kg P_2O_5) by the treatment grass + stylo over grass alone (Table 18) and 28 percent by guinea + stylo over guinea grass alone. Thus it is seen that the combined production of grass and stylosanthes was maximum with 100 kg nitrogen and 60 kg P_2O_5. This increased response of phosphorus was primarily due to the increase in drymatter production of stylosanthes under partial shade condition with phosphorus fertilization as given in Table 20 and shown in Figure 6.

The V x N interaction was significant under partial shade condition only. Guinea grass has given maximum total tonnage under 100 kg level, beyond which the yield decreased. In the case of setaria grass also a significant increase

FIG. 6. RESPONSE OF GRASS-STYLO MIXTURE TO NITROGEN IN THE ABSENCE AND PRESENCE OF PHOSPHORUS



was noticed only upto 100 kg level beyond which the increase was not significant.

It is seen that the production of grass in general was lesser in coconut garden than in the open area. Even under shaded situation guinea grass was better than setaria in yield. When guinea grass was grown under shade the decrease in yield was 19 percent as compared to open. But when stylosanthes was intercropped there was an increase of 29.7 percent. This, more than offsets the decrease in production of guinea grass under partial shade and at the same time increases the quality of forage (Tables 23, 24, 27 and 28).

4.7. Quality

Like quantity, the fodder quality is also very important from the point of view of animal nutrition. First of all the fodder produced must be acceptable and palatable to the cattle apart from its nutrient contents. The important quality parameters are contents of crude protein, crude fibre, ash, phosphorus, potassium, calcium, magnesium and K: (Ca + Mg) ratio.

The results relating to the above quality aspects are presented and discussed below.

4.7.1. Crude protein content of grasses.

The mean crude protein content of grasses are presented in Table 23 for open area and 24 for partial shade.

There was significant difference between the two grasses on crude protein content under both situations, due to intercropping, phosphorus application and different levels of nitrogen. Interaction effect I x P was also significant in both situations.

Crude protein content of guinea grass was significantly higher than that of setaria in open area as well as in partial shade conditions. The crude protein content of guinea grass was 8.36 percent in the open and 8.65 percent under partial shade as compared to 8.05 percent and 8.10 percent respectively for setaria grass. The difference in the quality factor may be attributed to the varietal differences of the two grasses. According to Butterworth (1967) the crude protein content of guinea grass ranged from 4 to 14 percent. Vicente-Chandler et al. (1959)

Table 23. Crude protein content of grass in open area (%).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	8.32	8.39	8.33	8.33	8.33	8.35	8.37	8.37	8.36
Setaria (v_2)	8.02	8.07	8.03	8.07	8.04	8.04	8.04	8.07	8.05
Intercropping									
None (i_o)			8.17	8.17	8.16	8.17	8.18	8.18	8.17
Stylo-santhes (i_1)			8.19	8.27	8.22	8.21	8.24	8.27	8.23
Phosphorus levels (kg/ha)									
0 (p_o)					8.16	8.18	8.19	8.19	8.18
60 (p_1)					8.21	8.21	8.22	8.25	8.22
Mean					8.18	8.19	8.20	8.22	8.20

Control: Guinea grass (v_1) - 7.92

Setaria grass (v_2) - 7.68

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I*; P*	0.007	0.015
N*; VI; VP; IP*	0.010	0.021
VN; IN; PN	0.015	--

*Significant

Table 24. Crude protein content of grass in coconut garden (%).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	8.57	8.73	8.60	8.71	8.62	8.62	8.66	8.71	8.65
Setaria (v_2)	8.01	8.20	8.05	8.15	8.05	8.09	8.11	8.17	8.10
Intercropping									
None (i_o)			8.25	8.33	8.27	8.27	8.29	8.34	8.29
Stylosanthes (i_1)			8.40	8.53	8.40	8.44	8.48	8.55	8.47
Phosphorus levels (kg/ha)									
0 (p_o)					8.30	8.31	8.31	8.39	8.33
60 (p_1)					8.37	8.40	8.45	8.50	8.43
Mean					8.33	8.35	8.38	8.44	8.38

Control: Guinea grass (v_1) - 8.29

Setaria grass (v_2) - 7.60

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.009	0.019
N^*; VI; VP; IP^*	0.013	0.027
VN; IN; PN	0.019	--

*Significant

recorded values of crude protein content of guinea grass ranging from 7.8 to 11.1 percent. Chandini and Raghavan Pillai (1980) obtained crude protein content of guinea as 8.96 percent and of setaria as 8.63 percent. Hacker and Jones (1969) reported that the crude protein content of setaria was 7.9 percent.

The crude protein content of grasses grown under both situations was found to increase due to the association with Stylosanthes guianensis. However the protein content of grass was found to be more under partial shade. Perusal of the data on nitrogen content of soil (Tables 58 and 59) also revealed that there was increase in nitrogen content under both situations, particularly under partial shade. This means that the crude protein content of grass might have been increased by the association with stylo. This phenomenon was more pertinent in shade than in open area (Papanicolaou et al. 1977).

Increase in crude protein content of grasses due to legume intercropping was reported by Moore (1962) in Cynodon species, by Manitkar and Shukla (1974), Charles (1976) and Kitamura et al. (1975) in setaria grass and by

Chandini and Raghavan Pillai (1980) in guinea and setaria grasses.

Phosphorus application has increased and crude protein content of grasses in open as well as in partial shade. Increase in crude protein content of grasses due to phosphorus fertilization was reported by Dwivedi et al. (1980) and Ravikumar and Shankaranarayanan (1980). Phosphorus being one of the main constituents of protein, might have favourably influenced the crude protein content of grasses in the present study. Data on phosphorus uptake also revealed (Table 66 and 67) the highly significant effect due to phosphorus application.

The crude protein content of grasses increased significantly with increase in nitrogen levels in the open, as well as in partial shade. However, the increase was more in partial shade than in open area. The effect of nitrogen in influencing the protein content of plants is well known. Nitrogen is essential for plant growth because it is a constituent of all proteins and therefore the quantity of nitrogen supplied to the crop may influence the protein yield (Russel, 1973). Nitrogen increases the protein yield of forage and no management practice other than the application of nitrogen appreciably influenced the protein content of grass (Capriel and Ashcroft, 1972). Increases in crude protein with incremental doses of nitrogen has been reported by several workers (Vicente-Chandler et al. (1959, 1961), Little et al. (1959), Kandaswamy et al. (1973), Pereira and D' Olivera (1976), Randhava and Gill (1977), Thomas (1978) and Anon. (1978d).

The crude protein content of grass was significantly influenced by the interaction effect of intercropping and phosphorus levels (I x P) in both situations. This increase in crude protein content might be due to the beneficial effect of stylo intercropping coupled with phosphorus application. The applied phosphorus might have stimulated the growth of stylosanthes resulting in higher availability of nitrogen to the associated grass, and consequently significant increases in the crude protein content of grasses were noticed in this study.

It was also noted that in both situations the difference between the two grasses under absolute control was significant wherein guinea recorded higher crude protein content than setaria. The treatment means (8.20 percent and 8.38 percent) were significantly higher than the absolute controls in open area and coconut garden.

Comparison of the results from open area and partial shade showed that the crude protein values obtained in partial shade was more than that recorded in open area. This is the agreement with the findings of several workers. Wong and Wilson (1980) has recorded nitrogen accumulation in all the plant components of green panic due to shading. Moursi et al. (1976) observed similar results in wheat from a trial under varying intensities of 20 to 100 percent full sunlight. Myhr and Saebo (1969) observed that in some grass species crude protein contents were approximately doubled by shading. Mullakoya (1982) also obtained increase in crude protein content due to shading of Panicum maximum.

4.7.2. Crude protein content of stylosanthes.

The mean crude protein content of Stylosanthes are presented in Tables 25 and 26 for open area and for partial shade condition respectively.

Application of phosphorus showed a significant effect in increasing the crude protein content of stylo in open area and in coconut gardens. According to Bogdan (1977) the crude protein content of Stylosanthes guianesis

Table 25. Crude protein content of stylosanthes in open area (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
\$. Grasses							
Guinea (v_1)	14.11	15.27	14.72	14.69	14.66	14.71	14.69
Setaria (v_2)	14.27	15.27	14.72	14.78	14.87	14.71	14.77
Phosphorus levels (kg/ha)							
0 (p_o)			14.15	14.21	14.24	14.17	14.19
60 (p_1)			15.28	15.25	15.30	15.25	15.27
Mean			14.72	14.73	14.77	14.71	14.73

\$. Indicates crude protein content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
VP*	0.0372	0.0788
N; VP	0.0526	--
VN; PN	0.0743	--

*Significant

Table 26. Crude protein content of stylosanthes in coconut garden (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	14.70	15.79	15.17	15.28	15.30	15.23	15.24
Setaria (v_2)	14.77	15.79	15.27	15.28	15.30	15.26	15.28
Phosphorus levels (kg/ha)							
0 (p_o)			14.67	14.76	14.78	14.73	14.73
60 (p_1)			15.77	15.81	15.82	15.76	15.79
Mean			15.22	15.22	15.30	15.24	15.26

$. Indicates the crude protein content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.2138	0.4532
N; VP	0.3023	--
VN; PN	0.4274	--

*Significant

varies from 10 to 25 percent of the drymatter. The beneficial effect of phosphorus fertilization in increasing the nitrogen content of stylosanthes was observed by Suttie (1970), Oyenuga and Olubago (1975) and Eng et al. (1978). The increased nitrogen fixation consequent on phosphorus application might be the reason for registering higher crude protein content in stylosanthes in the present study.

The different levels of nitrogen could not exhibit any significant effect on the crude protein content under either situation. This may be because, the lowest level tried was enough for the legume crop to retain the protein content at a reasonable level. Further increase in nitrogen might have helped only to increase the drymatter production rather than protein content (Tables 19 and 20). The higher levels of nitrogen would have not only supplied enough nitrogen to the grasses, but also left considerable quantity of nitrogen in the soil, resulting in a decreased response to legume production. The trend is also reflected in the crude protein content of stylosanthes in the present investigation.

Comparison of the results from open area and coconut garden revealed that crude protein content of stylo recorded in partial shade was more than that recorded in open area. The reasons for increased protein content in shade may be due to the increased nitrogen fixation in shade as reported by Ramanagowda (1981).

4.7.3. Crude protein yield of grass and stylo fodder mixture.

The mean crude protein yield (kg/ha) of grass and stylo fodder mixture are given in Table 27 for open area and in Table 28 for partial shade.

It is seen that the two grasses differed significantly in this respect. Moreover the effect of stylo intercropping was also significant in both situations. The application of phosphorus and different levels of nitrogen increased the protein yield in open area as well as in partial shade.

The combined protein yield of guinea grass + stylosanthes was significantly higher than that of setaria + stylosanthes in both situations. This is due to the higher drymatter yield and higher protein content of guinea grass. The reasons for obtaining higher yield and protein content have been discussed earlier.

The combined protein yield of stylo intercropped

Table 27. Combined crude protein yield of grass and stylosanthes in open area (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	629.21	1219.68	854.94	993.95	831.22	959.98	946.13	960.44	924.44
Setaria (v_2)	590.20	1172.47	833.95	928.72	798.36	897.71	911.39	917.88	881.33
Intercropping									
None (i_o)			596.64	622.77	539.90	606.27	636.98	655.67	609.70
Stylo-santhes (i_1)			1092.24	1299.90	1089.68	1251.42	1220.54	1222.65	1196.07
Phosphorus levels (kg/ha)									
0 (p_o)					732.45	863.66	878.17	898.50	844.44
60 (p_1)					892.13	994.03	979.35	979.82	961.34
Mean					814.79	928.84	928.76	939.16	902.89

Control: Guinea grass (v_1) - 398.07
Setaria grass (v_2) - 357.72

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I*; P*	7.042	14.261
N*; VI; VP*; IP*	9.957	20.170
VN; IN; PN	14.079	--

*Significant

Table 28. Combined crude protein yield of grass and stylosanthes in coconut garden (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	586.72	1228.71	824.25	991.17	839.92	960.24	933.43	897.27	907.71
Setaria (v_2)	481.36	1144.94	752.52	873.78	773.60	830.66	815.04	833.30	813.15
Intercropping									
None (i_o)			527.85	540.23	503.55	548.08	536.02	548.51	534.04
Stylo-santhes (i_1)			1048.92	1324.73	1109.97	1242.82	1212.44	1182.06	1186.82
Phosphorus levels (kg/ha)									
0 (p_o)					758.82	805.03	809.75	779.95	788.39
60 (p_1)					854.69	985.88	938.72	950.62	932.48
Mean					806.76	895.45	874.23	865.29	860.43

Control: Guinea grass (v_1) - 393.17

Setaria grass (v_2) - 324.14

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	6.832	13.836
N^*; VI; VP^*; IP^*	9.660	19.567
VN^*; IN^*; PN^*	13.660	--

*Significant

plots were significantly higher than that of non-intercropped plots under both situations.

Application of phosphorus significantly increased the total protein yield. This may be attributed to the higher drymatter yield and higher protein content recorded by the main crop and intercrops, the reasons for which have already been discussed. Similar results were reported by Meera Bai and Raghavan Pillai (1982) and Mercy George (1982).

Application of nitrogen also significantly increased the protein yield upto n_2 (100 kg/ha) level. The beneficial influences of intercropping as well as application of nitrogen fertilizers to the main crop and intercrop has already been explained. The data on protein content (Table 23 and 24) also substantiated this beneficial effect. The drymatter yield was also increased by these treatments. Therefore the combined effects of the treatments on the protein content and drymatter yield have been reflected in the protein yield. The present results are in agreement with that of Patel et al. (1966), Balasundram et al. (1973) and Balbatti (1980).

The interaction V x P was significant in both the situations. In open area (Table 27) in the case of guinea grass when 60 kg phosphorus was applied the increase in crude protein yield was found to be 139 kg while the increase was only 95 kg in the case of setaria grass. In the absence of phosphorus much difference was not observed in crude protein yield between two grasses while in the presence of phosphorus guinea was found superior to setaria. In coconut garden (Table 28) the increase in crude protein yield was 167 kg and 121 kg for guinea and setaria respectively. In the absence and in the presence of phosphorus guinea was superior to setaria.

Due to the interaction effect of I x P, 96 percent increase in crude protein yield was recorded by stylo intercropping over non-intercropping

In the case of absolute controls, under both situations, guinea in combination with stylo recorded significantly higher crude protein yield than setaria-stylo combination. The treatment means also were higher than the combined crude protein yields noted under absolute controls.

4.7.4. Crude fibre content of grasses.

The mean crude fibre content of grasses are presented in Tables 29 and 30 for open area and coconut garden respectively.

The difference between the two grasses with respect to crude fibre content of grasses was significant in both the situations. Between the grasses, guinea recorded a significantly lower crude fibre content than setaria grass. This may be attributed to the varietal character of guinea grass. The content of crude fibre is a qualitative character of grasses and it decides the acceptability to animals. Thus in the case of crude fibre content also guinea was found superior to setaria grass. It is an accepted fact that guinea grass is well relished by cattle due to its succulence and low fibre content than setaria grass.

The effect of stylo intercropping was significant only in coconut garden while the effect of phosphorus application was significant on the crude fibre content of grasses in open area only. Perusal of the tables 29 and 30 further reveals that there was an inverse relationship between crude fibre content and nitrogen levels. The crude

Table 29. Crude fibre content of grass in open area (%).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	32.48	32.45	32.50	32.44	32.56	32.49	32.43	32.40	32.47
Setaria (v_2)	33.48	33.47	33.48	33.46	33.53	33.48	33.43	33.46	33.47
Intercropping									
None (i_o)			33.03	32.93	33.06	33.01	32.97	32.89	32.98
Stylo-santhes (i_1)			32.95	32.98	33.03	32.96	32.89	32.97	32.96
Phosphorus levels (kg/ha)									
0 (p_o)					33.04	32.99	32.93	33.00	32.99
60 (p_1)					33.05	32.98	32.93	32.86	32.95
Mean					33.04	32.99	32.93	32.93	32.97

Control: Guinea grass (v_1) - 32.59
Setaria grass (v_2) - 33.73

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P*	0.013	0.027
N*; VI; VP; IP*	0.019	0.39
VN; IN*; PN*	0.027	0.055

*Significant

Table 30. Crude fibre content of grass in coconut garden (%).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	31.33	31.30	31.33	31.30	31.38	31.36	31.26	31.26	31.31
Setaria (v_2)	32.25	32.22	32.23	32.24	32.24	32.24	32.23	32.24	32.24
Intercropping									
None (i_o)			31.81	31.77	31.83	31.81	31.77	31.75	31.79
Stylo-santhes (i_1)			31.76	31.77	31.80	31.78	31.72	31.75	31.76
Phosphorus levels (kg/ha)									
0 (p_o)					31.82	31.80	31.76	31.74	31.78
60 (p_1)					31.81	31.79	31.73	31.75	31.77
Mean					31.81	31.80	31.75	31.75	31.77

Control: Guinea grass (v_1) - 31.42

Setaria grass (v_2) - 32.34

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P	0.010	0.021
N^*; VI; VP; IP	0.015	0.029
VN^*; IN; PN	0.021	0.041

*Significant

fibre content of grasses decreased significantly due to increased doses of nitrogen application, and the highest fibre content was recorded under the lowest level of 50 kg N/ha which gradually decreased with additional increment upto 150 kg N/ha. The results on crude protein content of grass (Tables 23 and 24) revealed that the plots where the lowest level of nitrogen was applied recorded the lowest value, while the plots which received 200 kg N/ha recorded the highest protein content. The drymatter yield (Tables 17 and 18) of grasses were also found lower under low levels of nitrogen. It might be inferred that these plots with higher levels of nitrogen produced more succulent plants with reduced fibre content. With higher levels of nitrogen in the plant the carbohydrates are utilized for the synthesis of protoplasm rather than for the thickening of the cell wall (Black, 1968). The present results are in agreement with the findings of Tiwana et al. (1975) and Thomas (1978).

The interaction effects of I x P (Intercropping x Phosphorus application), I x N (Intercropping x Nitrogen levels), and P x N (Phosphorus x Nitrogen) were significant in the open area and, V x N (Grasses x Nitrogen) was significant under partial shade conditions. These interaction effects however showed the same trend as their main treatment effects.

It was also seen that under absolute control the crude fibre content of setaria was significantly higher than guinea in both situations, indicating the superiority of guinea grass over setaria. The treatment means in open area (32.97 percent) and in coconut garden (31.77 percent) were significantly lower than the crude fibre content noticed under absolute control. This clearly indicated that different management practices improved the quality and palatability of the fodder.

A comparison of the data on crude fibre content in open and in partial shade (Tables 29 and 30) revealed that both grasses contained only less fibre content when grown in coconut shade than in the open. This might be due to the increased utilization of assimilates for improvement of the quality such as protein, thereby reducing the fibre content of grasses. They drymatter yields recorded under open area were also higher than in coconut shade (Tables 17 and 18), which gives an indication that the drymatter yield and fibre content were complimentary characters. Naturally when drymatter content was less the succulence will be more leading to a lesser fibre content. Myhr and Saebo (1969) also observed reduction in fibre content in grass species due to shading.

4.7.5. Correlation between drymatter, protein and fibre contents in grass.

The correlation coefficients worked out between drymatter yield and crude protein, drymatter yield and crude fibre and crude protein and crude fibre contents of grass are presented in Table 31 for open area and for partial shade.

The mean drymatter yield (Tables 17 and 18), crude protein content (Tables 23 and 24) and crude fibre content (Tables 29 and 30) revealed a definite relationship between these characters with respect to nitrogen fertilization. This relationship is illustrated in Figure 7.

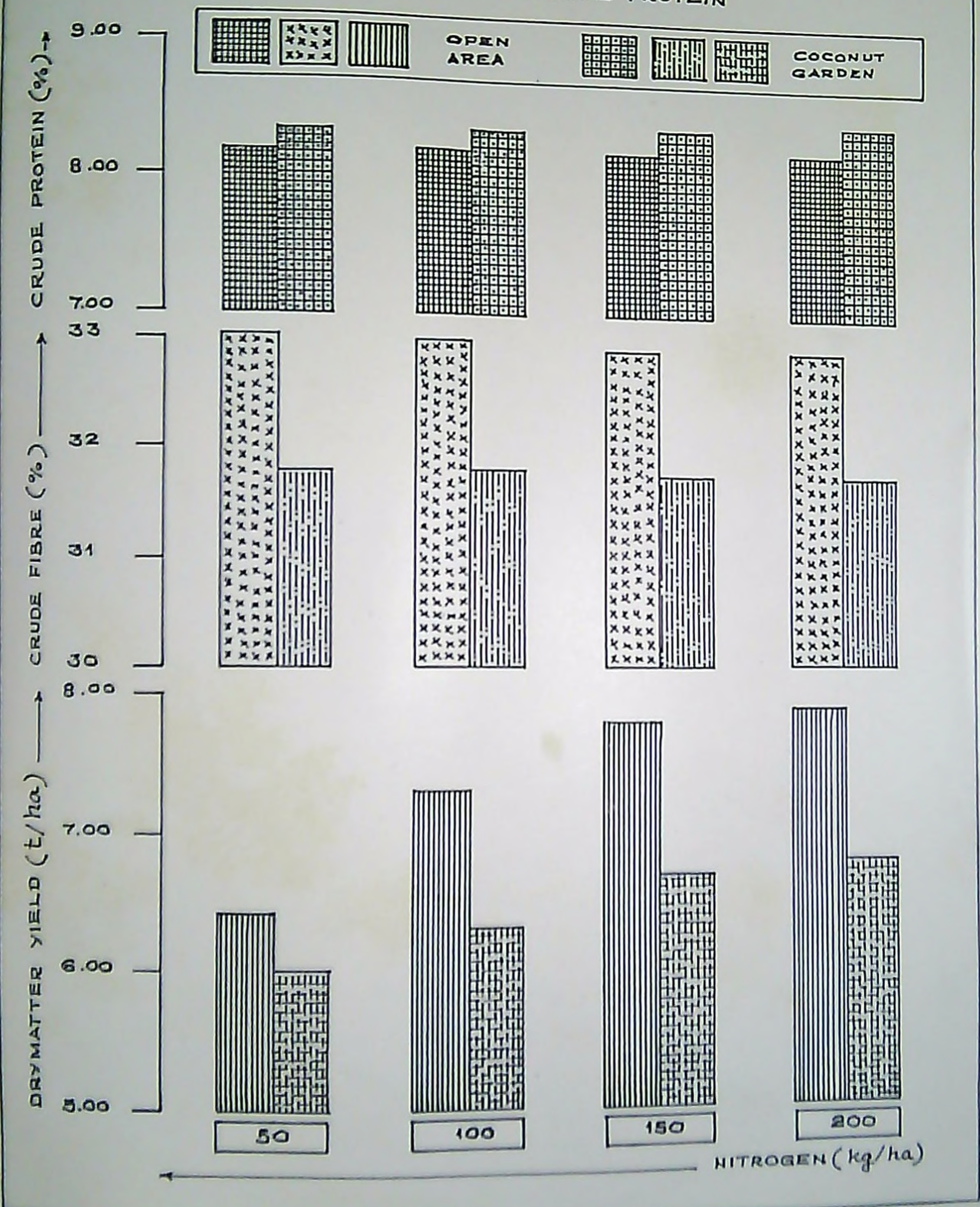
The figure shows that when the nitrogen level was increased the fibre content was decreased and the protein content was increased. Thus an inverse relationship between the fibre and protein content was established. The correlation Table 31 showed that there was positive and significant

Table 31. Values of simple correlation coefficients.

Sl. No.	Characters correlated	Correlation coefficients	
		Open area	Coconut garden
1.	Correlation between dry matter yield and crude protein.	0.578**	0.657**
2.	Correlation between dry matter yield and crude fibre.	-0.193 NS	-0.401**
3.	Correlation between crude fibre and crude protein	-0.759**	-0.873**

**Significant at 0.01 level

FIG. 7. EFFECT OF NITROGEN ON DRYMATTER YIELD, CRUDE FIBRE AND CRUDE PROTEIN



correlation between drymatter yield and crude protein under both situations. Under partial shade a comparatively higher correlation coefficient than under open area was also observed. There was negative correlation between drymatter and crude fibre under both situations, but the same was significant only under partial shade.

The correlation between crude fibre and crude protein was also negative and significant under both situations. All these factors were responsible for the final observation that as the drymatter yield of grass was increased, the fibre content was decreased with an increase in protein content.

Protein content represents the digestible energy of fodder. When drymatter yield is higher, protein content is also higher, while fibre content is lesser. This relationship has very high practical utility as far as animal feeding is concerned. In this case wastage of fodder will be reduced and it will be well relished by the cattle; at the same time the forage will be more digestible and nutritious to the animals. Any step to increase the protein content of forage by nitrogen nutrition is thus desirable (De Geus, 1977).

4.7.6. Crude fibre content of stylosanthes.

The mean crude fibre content of stylosanthes are presented in Tables 32 and 33 for open area and coconut garden respectively.

It is seen that the effect of phosphorus, and interaction effect of phosphorus x nitrogen (P x N) were alone significant in open area as well as under partial shade. The difference between grasses and effect due to different levels of nitrogen were not significant.

The fibre content of stylosanthes increased significantly due to the application of phosphorus in both the situations. As already reported by several workers, phosphorus increases the growth of stylosanthes (Haggar, 1971, Jones, 1974). This naturally leads to an increase in the crude fibre content of the fodder as well.

The interaction effect of P x N was significant in both situations. This may be due to the main treatment effect of phosphorus.

A comparison of the data from open and from partial shade further revealed that the fibre content was always

Table 32. Crude fibre content of stylosanthes in open area (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0	60	50	100	150	200	
	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
$. Grasses							
Guinea (v_1)	29.05	30.06	29.52	29.56	29.57	29.57	29.55
Setaria (v_2)	29.12	30.01	29.59	29.66	29.48	29.54	29.57
Phosphorus levels (kg/ha)							
0 (p_0)			29.09	29.06	29.13	29.07	29.09
60 (p_1)			30.02	30.16	29.92	30.04	30.03
Mean			29.56	29.61	29.52	29.56	29.56

$. Indicates crude fibre content of stylosanthes when inter-cropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.0222	0.0736
N; VP	0.0315	--
VN; PN*	0.0445	0.1472

*Significant

Table 33. Crude fibre content of stylosanthes in coconut garden (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0	60	50	100	150	200	
	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
$. Grasses							
Guinea (v_1)	28.88	29.77	29.38	29.30	29.36	29.26	29.32
Setaria (v_2)	28.82	29.77	29.29	29.25	29.35	29.29	29.29
Phosphorus levels (kg/ha)							
0 (p_o)			28.77	28.70	28.96	28.98	28.85
60 (p_1)			29.91	29.85	29.75	29.57	29.77
Mean			29.34	29.27	29.35	29.27	29.31

$. Indicates crude fibre content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.0552	0.1171
N; VP	0.0781	--
PN*	0.1104	0.2341

*Significant

lower in partial shade than in open area. When the fibre content is more the succulence is naturally lesser and fodder becomes coarse and rough. This was also evidenced from the data on leaf-stem ratio of stylosanthes (Tables 9 and 10) which showed a higher value under partial shade.

4.7.7. Ash content of grasses.

The mean ash content of grasses are presented in Table 34 and 35 for open area and for coconut garden respectively.

The effect of intercropping with stylosanthes alone was significant under both situations.

It is seen that the ash content of grasses grown alone was more than that from the intercropped plots. The ash content is a fair estimate of the mineral content of fodder. The fact that there was severe competition for mineral elements between grass and stylo in the intercropped plots clearly explains the reason for reduced ash content of grasses in the intercropped plots. The situation was further worsend by the increased absorption of minerals by the legume intercrop. It is already known that the legumes

Table 34. Ash content of grass in open area (%).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	10.47	10.29	10.33	10.42	10.41	10.37	10.36	10.37	10.38
Setaria (v_2)	10.36	10.40	10.37	10.39	10.33	10.40	10.40	10.38	10.38
Intercropping									
None (i_o)			10.38	10.44	10.42	10.37	10.44	10.43	10.41
Stylosanthes (i_1)			10.32	10.37	10.33	10.40	10.32	10.32	10.34
Phosphorus levels (kg/ha)									
0 (p_o)					10.39	10.44	10.27	10.31	10.35
60 (p_1)					10.35	10.34	10.49	10.44	10.40
Mean					10.37	10.39	10.38	10.38	10.38

Control: Guinea grass (v_1) - 10.85

Setaria grass (v_2) - 10.31

Type of pair comparison of means	S.E.	C.D. (0.05)
V; I; P	0.032	0.064
N; VI*; VP; IP	0.045	0.091
VN; IN; PN*	0.063	0.129

*Significant

Table 35. Ash content of grass in coconut garden (%).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	10.27	10.08	10.13	10.22	10.21	10.17	10.16	10.17	10.18
Setaria (v_2)	10.17	10.20	10.17	10.20	10.12	10.24	10.20	10.18	10.18
Intercropping									
None (i_o)			10.18	10.26	10.22	10.20	10.24	10.23	10.22
Stylosanthes (i_1)			10.11	10.17	10.12	10.21	10.12	10.12	10.14
Phosphorus levels (kg/ha)									
0 (p_o)					10.18	10.24	10.07	10.11	10.15
60 (p_1)					10.15	10.17	10.29	10.24	10.21
Mean					10.17	10.20	10.18	10.17	10.18

Control: Guinea grass (v_1) - 10.65
Setaria grass (v_2) - 10.11

Type of pair comparison of means	S.E.	C.D. (0.05)
V; I*; P	0.032	0.065
N; VI*; VP; IP	0.045	0.092
VN; IN; PN*	0.064	0.130

*Significant

have a better capacity to absorb the divalent cations from the soil than the grasses (Tisdale and Nelson, 1973). The chemical composition and quality of fodder is greatly influenced by the soil nutrient status (De Geus, 1977).

The interaction effect V x I (grasses x intercropping) also revealed that wherever stylo production was more the ash yield of grass was significantly reduced. As the guinea grass plots have recorded significantly higher stylo production they have registered lower ash contents also.

The interaction P x N (Phosphorus x Nitrogen) was significant under both situations. The ash content was the highest under p_1n_3 in both situations. This may be due to the direct influence of phosphorus at 150 kg level of nitrogen.

It was also seen that the ash content of guinea was significantly higher than setaria grown under control in both the situations. But the treatment means of both situations (10.38 percent and 10.18 percent) were found to be lower than that of guinea and higher than setaria recorded under absolute control.

Comparison of the data from open area and partial shade revealed that ash content was more in the open where the growth of stylo was less and the growth of grass was more.

4.7.8. Ash content of stylosanthes.

The mean ash content of stylosanthes are given in Tables 36 and 37 for open and for coconut garden respectively.

The effect of phosphorus application was significant both in open as well as in partial shade. However the effect of nitrogen levels, and the interaction effect of P x N were significant only in open area.

Application of phosphorus significantly increased the ash content of stylo under both situations. This increase in ash content may be due to the increased content of bases in stylosanthes as evidenced from the data on potassium, calcium and magnesium contents (Tables 44, 45, 48, 49, 52 and 53). Thus the increase in ash content is a clear reflection of these mineral constituents in stylo fodder.

Nitrogen levels upto 100 kg N/ha significantly increased the ash content of stylosanthes in open area only.

Table 36. Ash content of stylosanthes in open area (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	10.77	11.26	11.01	11.07	11.01	10.98	11.02
Setaria (v_2)	10.76	11.28	11.01	11.07	11.01	11.01	11.03
Phosphorus levels (kg/ha)							
0 (p_o)			10.74	10.84	10.74	10.76	10.77
60 (p_1)			11.27	11.30	11.28	11.28	11.27
Mean			11.01	11.07	11.01	10.99	11.02

$. Indicates ash content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.0031	0.0065
N*; VP	0.0043	0.0092
VN; PN*	0.0061	0.0129

*Significant

Table 37. Ash content of stylosanthes in coconut garden (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	10.45	11.15	10.79	10.84	10.80	10.77	10.80
Setaria (v_2)	10.36	11.12	10.66	10.79	10.75	10.74	10.74
Phosphorus levels (kg/ha)							
0 (p_o)			10.34	10.49	10.40	10.39	10.40
60 (p_1)			11.11	11.14	11.15	11.13	11.13
Mean			10.73	10.82	10.77	10.76	10.77

$. Indicates ash content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.0225	0.0476
N; VP	0.0317	--
VN; PN	0.0449	--

*Significant

Under partial shade an increase was observed from 50 kg N/ha to 100 kg N/ha although the effect was not significant. In general there was an increase in the ash content upto (150 kg N/ha) beyond which there was a decrease in ash content. This was more specific in open area.

The P x N (phosphorus x nitrogen) interaction on ash content was significant in open area only. A perusal of the Table 36 showed that the effect of phosphorus was more pronounced than that of nitrogen under such situations. So this interaction effect may be mainly due to the effect of phosphorus as already discussed.

Comparison of the Tables 36 and 37 showed that the ash content of stylo, when grown in open area was more than that grown in partial shade. It is seen from the drymatter production (Tables 19 and 20) that stylo has given higher drymatter yield under partial shade. So the available minerals/bases in the soil would have been efficiently extracted by the better growth of stylo in partial shade with the result the mineral contents in these plots were lesser due to the dilution efeect as suggested by Jarrel and Beverly (1981). This is more so under acid soil situations of the present investigation where the soil content of bases are invariably low.

4.7.9. Phosphorus content of grasses.

The mean phosphorus content of grasses are given in Tables 38 and 39 for open area and for coconut garden respectively.

It is seen that the main effect of grasses, intercropping with stylosanthes, and phosphorus application and the interaction effect of V x I were significant under both situations, whereas the interaction effect of P x N was significant only under partial shade.

The phosphorus content of guinea grass was significantly more than setaria in both situations. This may probably be due to the high foraging capacity of roots of guinea grass.

Intercropping showed a significant influence on the phosphorus content of grasses in both the situations. In the open area intercropping significantly increased the phosphorus content of both the grasses over no intercropping of which guinea was superior over setaria.

The phosphorus content in grasses was significantly

Table 38. Phosphorus content of grass in open area (%).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	0.224	0.232	0.225	0.232	0.228	0.228	0.228	0.229	0.228
Setaria (v_2)	0.219	0.222	0.218	0.223	0.220	0.221	0.220	0.222	0.221
Intercropping									
None (i_o)			0.219	0.224	0.221	0.221	0.222	0.222	0.222
Stylosanthes (i_1)			0.224	0.231	0.227	0.228	0.226	0.228	0.227
Phosphorus levels (kg/ha)									
0 (p_o)					0.222	0.221	0.220	0.222	0.221
60 (p_1)					0.226	0.228	0.228	0.228	0.227
Mean					0.224	0.224	0.224	0.225	0.224

Control: Guinea grass (v_1) - 0.219

Setaria grass (v_2) - 0.214

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.0004	0.0009
N; VI^*; VP; IP	0.0006	0.0014
VN; IN; PN	0.0009	--

*Significant

Table 39. Phosphorus content of grass in coconut garden (%).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylo-santhes	0	60	50	100	150	200	
	(i_o)	(i_1)	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	0.233	0.243	0.235	0.242	0.236	0.238	0.239	0.239	0.238
Setaria (v_2)	0.227	0.231	0.226	0.233	0.228	0.230	0.229	0.230	0.229
Intercropping									
None (i_o)			0.226	0.234	0.229	0.230	0.231	0.231	0.230
Stylo-santhes (i_1)			0.234	0.240	0.236	0.239	0.237	0.238	2.237
Phosphorus levels (kg/ha)									
0 (p_o)					0.230	0.230	0.229	0.232	0.230
60 (p_1)					0.235	0.238	0.239	0.237	0.237
Mean					0.232	0.234	0.234	0.234	0.233

Control: Guinea grass (v_1) - 0.227

Setaria grass (v_2) - 0.225

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.00050	0.0010
N^*; VI^*; VP; IP	0.0007	0.0014
VN; IN; PN^*	0.0010	0.0020

*Significant

increased by the application of phosphorus both in open and partial shade. A definite increase in the phosphorus content of grasses was also observed due to phosphorus application (Tables 38 and 39). Similar increase in phosphorus content was reported by Shankaranarayanan et al. (1973) in Heteropagon contortus. Dwivedi et al. (1980) obtained increased phosphorus content in Chrysopogon fulvus grass due to the application of phosphorus.

The V x I interaction was significant under both situations. The varietal effect of guinea grass on phosphorus content has already been discussed. The intercropping effect also revealed that in plots were stylo was grown phosphorus content was more. So it is quite natural that the guinea grass + stylosanthes plots have recorded the highest phosphorus content under both situations.

P x N interaction was significant only in partial shade (Table 39). More than the effect of nitrogen, the effect of phosphorus was manifested which has already been explained.

There was no significant difference in phosphorus contents between the two grasses grown under control in both situations, while the treatment means (0.224 percent in open area and 0.233 percent in coconut garden) were significantly higher than the respective phosphorus contents of grasses noticed under control.

Comparison of the data (Tables 38 and 39) from open and coconut garden revealed that the phosphorus content under partial shade was higher than that of open area. The data on drymatter yield of stylosanthes also showed that it was maximum under partial shade (Table 20).

4.7.10. Phosphorus content of stylosanthes.

The mean phosphorus content of stylosanthes are given in Table 40 and 41 for open area and coconut garden respectively.

It is seen that none of the treatment effects nor their interactions were significant in the phosphorus content of stylo in the open. However, under partial shade the main treatment effects of phosphorus alone significantly influenced the phosphorus content of stylo. But the association with grasses did not show any significant influence on the phosphorus content of stylo in partial shade.

The phosphorus content of stylo was significantly

Table 40. Phosphorus content of stylosanthes in open area (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0	60	50	100	150	200	
	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
$. Grasses							
Guinea (v_1)	0.306	0.319	0.311	0.314	0.315	0.313	0.313
Setaria (v_2)	0.315	0.319	0.312	0.314	0.313	0.331	0.317
Phosphorus levels (kg/ha)							
0 (p_0)			0.306	0.307	0.307	0.324	0.311
60 (p_1)			0.316	0.320	0.321	0.320	0.319
Mean			0.311	0.314	0.314	0.322	0.315

$. Indicates phosphorus content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P	0.0032	--
N; VP	0.0045	--
VN; PN	0.0064	--

*Significant

Table 41. Phosphorus content of stylosanthes in coconut garden (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_0)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	0.293	0.302	0.298	0.298	0.299	0.296	0.298
Setaria (v_2)	0.294	0.302	0.300	0.298	0.298	0.296	0.298
Phosphorus levels (kg/ha)							
0 (p_0)			0.295	0.294	0.294	0.290	0.294
60 (p_1)			0.302	0.301	0.303	0.302	0.302
Mean			0.299	0.298	0.298	0.296	0.298

$. Indicates phosphorus content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0004	0.0008
N; VP	0.0005	--
VN; PN	0.0008	--

*Significant

increased due to phosphorus application in partial shade. Though not significant the same trend was noticed in open area also. Phosphorus generally increases the quality of fodder, especially legumes. Suttie (1970) observed that phosphorus application increases the phosphorus content of *Stylosanthes gracilis*. Jones (1974) also obtained phosphorus values ranging from 0.1 to 2.5 percent in *Stylosanthes gracilis* with the application of 100 to 200 kg P_2O_5/ha.

Comparison of the data from open and coconut garden showed that phosphorus content was more in the former. It may be seen that drymatter production was also less under open condition (Tables 19 and 20) and therefore it is presumed that when the production of stylo is less, the concentration of the nutrients in the fodder increases and vice versa and the probable reason may be attributed to the dilution effect (Jarrel and Beverly, 1981).

4.7.11. Potassium content of grasses.

The mean potash content of grass in open and in coconut garden are given in Tables 42 and 43 respectively.

The difference in potash content between grasses was

Table 42. Potash content of grass in open area (%).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	1.464	1.482	1.470	1.476	1.463	1.471	1.478	1.480	1.473
Setaria (v_2)	1.493	1.495	1.493	1.495	1.487	1.493	1.497	1.498	1.494
Intercropping									
None (i_o)			1.476	1.481	1.471	1.477	1.482	1.485	1.479
Stylosanthes (i_1)			1.486	1.490	1.480	1.487	1.493	1.493	1.488
Phosphorus levels (kg/ha)									
0 (p_o)					1.473	1.480	1.486	1.487	1.481
60 (p_1)					1.477	1.485	1.490	1.491	1.485
Mean					1.475	1.482	1.488	1.489	1.483

Control: Guinea grass (v_1) - 1.462
Setaria grass (v_2) - 1.463

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P	0.0009	0.0026
N^*; VI^*; VP^*	0.0013	0.0037
VN; PN; IN	0.0018	--

*Significant

Table 43. Potash content of grass in coconut garden (%).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylo-santhes	0	60	50	100	150	200	
	(i_0)	(i_1)	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
<u>Grasses</u>									
Guinea (v_1)	1.488	1.501	1.492	1.497	1.487	1.492	1.498	1.501	1.495
Setaria (v_2)	1.491	1.501	1.495	1.496	1.486	1.495	1.501	1.502	1.496
<u>Intercropping</u>									
None (i_0)			1.488	1.491	1.482	1.488	1.493	1.495	1.490
Stylo-santhes (i_1)			1.500	1.502	1.491	1.498	1.506	1.508	1.501
<u>Phosphorus levels (kg/ha)</u>									
0 (p_0)					1.486	1.491	1.498	1.500	1.494
60 (p_1)					1.487	1.496	1.501	1.503	1.497
Mean					1.486	1.493	1.500	1.501	1.495

Control: Guinea grass (v_1) - 1.470

Setaria grass (v_2) - 1.460

<u>Type of pair comparison of means</u>	<u>S.E.</u>	<u>C.D. (0.05)</u>
V; I*; P*	0.0012	0.0024
N*; VI; VP; IP	0.0017	0.0034
VN; IN; PN	0.0024	--

*Significant

significant in open area only. But the effects due to intercropping, phosphorus application and nitrogen levels were significant under both situations. However interaction effect of V x I and V x P were significant in open area only.

Guinea grass recorded a significantly lower potassium content than setaria grass in open area. Under shade also the same trend was observed. The drymatter production was more for guinea grass as seen in Table 17. Therefore the available potassium absorbed might have been distributed uniformly and as such the percentage content of potassium was lesser in guinea grass.

Intercropping with stylosanthes significantly increased the potassium content of grasses in both open area and in partial shade. Potassium content was found more in the intercropped treatments in both situations.

Phosphorus application significantly increased the potassium content of grasses in both the situations. It has resulted in increased drymatter production (Tables 17 and 18), which might have increased potassium absorption from the soil thereby increasing the potassium content of grasses. Similar instances of increased potassium content of grasses due to phosphorus application were reported by Hendrikson (1960).

Significant and progressive increase in potassium content was observed due to different levels of nitrogen in both situations. In this study nitrogen levels might have helped to increase the potassium absorption of grasses with increase in nitrogen dose. Lorsen (1966) obtained similar increases in potassium content in cocksfoot and timothy grasses due to nitrogen application. Abraham et al. (1980) also reported similar results in dinanath grass at Vellayani.

The interaction effect of V x I was significant in open area only. This may be mainly due to the varietal influence of setaria grass.

The interaction effect V x P was significant in open area. As already stated this may also be due to the varietal effect of setaria grass.

It was also observed that in both the situations the difference between the potassium contents of two grasses grown under control was significant. In open area the potassium content of guinea was lower than setaria while in shade guinea recorded higher potassium content. The treatment means obtained in both the situations were higher than the potassium contents of both the grasses grown under control.

Comparison of the data in Tables 42 and 43 revealed that the potassium content was more in coconut shade than in open area. Increases in potassium content of grasses by shading has been reported by Myhr and Saebo (1969).

4.7.12. <u>Potassium content of stylosanthes</u>.

The mean potassium content of stylo are presented in Tables 44 and 45 for open area and coconut garden respectively.

The difference between grasses and the effect due to phosphorus application were significant in open as well as in partial shade. The effect of nitrogen levels and interaction effect of P x N were significant in partial shade only.

The potassium content of stylo was significantly lesser in guinea grass plots in both the situations. When the grass and legume are grown together, the grass always takes more potassium, especially so in a high yielding grass like guinea (Bogdan, 1977). This greater affinity of grasses for mono valent cations as quoted by Tisdale and Nelson (1973) results in a reduced availability of potassium for legumes. For the same reason in setaria plots, where the drymatter production was lesser than for guinea, comparatively

Table 44. Potassium content of stylosanthes in open area (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	1.49	1.48	1.50	1.48	1.48	1.48	1.48
Setaria (v_2)	1.50	1.49	1.49	1.49	1.50	1.49	1.49
Phosphorus levels (kg/ha)							
0 (p_o)			1.50	1.50	1.50	1.49	1.50
60 (p_1)			1.49	1.48	1.48	1.48	1.48
Mean			1.49	1.49	1.49	1.49	1.49

$. Indicates potash content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0029	0.0062
N; VP	0.0041	--
VN; PN	0.0058	--

*Significant

Table 45. Potassium content of stylosanthes in coconut garden (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	1.51	1.59	1.55	1.56	1.55	1.54	1.55
Setaria (v_2)	1.53	1.60	1.56	1.58	1.57	1.55	1.56
Phosphorus levels (kg/ha)							
0 (p_o)			1.52	1.54	1.52	1.51	1.52
60 (p_1)			1.59	1.60	1.60	1.59	1.59
Mean			1.55	1.57	1.56	1.55	1.55

$. Indicates potash content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.001	0.002
N*; VP	0.001	0.003
VN; PN*	0.002	0.004

*Significant

more potassium would have been left in the soil which was absorbed by stylo (Table 74 and 75). This is justified from the Tables on potassium content of the soil which clearly showed a significantly lesser potassium content in soil grown with guinea grass.

The potassium content in open area showed a significant decrease with phosphorus application. This finding is in agreement with the findings of Falade (1973). While under shade condition phosphorus application significantly increased the potassium content. As in the case of grasses the potassium content of stylo also increased under shade condition.

The effect of nitrogen levels was significant in coconut shade only. This shows that under shade situations the increased growth of stylo under 100 kg N/ha has correspondingly resulted in the higher content of potassium while in open eventhough the increase in drymatter production was noted this has not resulted in any change in potassium content. This shows that the requirement of potassium was also more for legumes under shade.

The interaction effect P x N was significant in partial shade. Wherever phosphorus was applied there was a significant increase in potassium content for all the levels of nitrogen. This shows that when drymatter production is to be increased under shade condition by phosphorus fertilization or otherwise, the requirement for potassium by the plant is much more critical than under open condition. In the open situation eventhough the drymatter production was increased by nitrogen application as well as by phosphorus application the requirement of potassium has not at all increased. It is thus made clear from this investigation that if a grass/legume mixture is to be cultivated under partial shade in coconut garden adequate levels of potassium fertilization has to be ensured both for the grass and the legumes. Otherwise it is likely to become a critical factor. Further investigations are required to find out the exact requirement of potassium by grass/legume mixtures in coconut gardens.

Comparison of the Tables 44 and 45 showed that potassium content of stylo grown in shade was more than that grown in open area. Just as in the case of grass, for stylo also the potassium requirement was more under shade situation.

4.7.13. Calcium content of grasses.

The mean calcium content of grasses are given in

Table 46. Calcium content of grass in open area (%).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	0.525	0.535	0.528	0.531	0.529	0.530	0.530	0.530	0.530
Setaria (v_2)	0.522	0.528	0.526	0.524	0.524	0.524	0.526	0.526	0.525
Intercropping									
None (i_o)			0.523	0.524	0.522	0.523	0.524	0.524	0.523
Stylo-santhes (i_1)			0.531	0.531	0.530	0.531	0.532	0.532	0.531
Phosphorus levels (kg/ha)									
0 (p_o)					0.526	0.526	0.528	0.529	0.527
60 (p_1)					0.527	0.528	0.528	0.527	0.527
Mean					0.526	0.527	0.528	0.528	0.527

Control: Guinea grass (v_1) - 0.524

Setaria grass (v_2) - 0.512

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P	0.0005	0.0010
N^*; VI^*; VP^*; IP	0.0007	0.0014
VN; IN; PN	0.0010	--

*Significant

Table 47. Calcium content of grass in coconut garden (%).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	0.550	0.559	0.553	0.556	0.553	0.555	0.556	0.555	0.555
Setaria (v_2)	0.545	0.549	0.548	0.547	0.546	0.547	0.549	0.547	0.547
Intercropping									
None (i_o)			0.547	0.548	0.546	0.547	0.549	0.547	0.547
Stylo-santhes (i_1)			0.554	0.556	0.553	0.555	0.556	0.554	0.555
Phosphorus levels (kg/ha)									
0 (p_o)					0.5487	0.5506	0.5521	0.5505	0.5505
60 (p_1)					0.5501	0.5515	0.5527	0.5512	0.5504
Mean					0.5494	0.5510	0.5524	0.5508	0.5504

Control: Guinea grass (v_1) - 0.548
Setaria grass (v_2) - 0.538

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P	0.0004	0.0009
N^*; VI^*; VP^*; IP	0.0006	0.0012
VN; IN; PN	0.0009	--

*Significant

Table 46 for open area and in Table 47 for coconut garden respectively. The difference between the two grasses and the effect of intercropping with stylosanthes and effect due to nitrogen levels were significant in influencing the calcium content of grasses in open as well as in partial shade. The interaction effects of V x I and V x P were also significant in both situations. However phosphorus application revealed no significant influence on the calcium content of grass.

The calcium content of guinea grass was significantly more than that of setaria under both situations. The higher content of calcium may be attributed to the higher genetic potential of guinea grass.

The calcium content of grasses was significantly increased due to intercropping with *Stylosanthes gracilis* in both the situations. Increase in calcium content due to stylo intercropping has been reported by Chandini and Raghavan Pillai (1980) in guinea and setaria grasses in open area. Similar increases in calcium content of grasses when intercropped with legumes were also reported by Julen (1976) and by Patel et al. (1966).

The different doses of nitrogen significantly increased the calcium content of grasses. The effect was more pronounced in coconut garden than in open area. In the case of coconut shade the significant increase in calcium content was noted upto 100 kg/ha only. The data on dry-matter production of grass also showed a significant increase upto 100 kg/ha while in the open the effect was pronounced upto 150 kg/ha.

The interaction V x I was significant in both the situations which may be due to the effect of intercropping. The V x P interaction also increased the calcium content significantly in both the situations. This is mainly due to the species effect wherein guinea grass always recorded a higher calcium content.

It was also noticed that under control in both situations guinea recorded significantly higher calcium content than setaria.

The treatment means in both situations (0.527 percent in open area and 0.550 percent in coconut garden) were significantly higher than the calcium contents of grasses recorded under the respective controls.

Comparison of the data in open and in partial shade revealed that in partial shade the calcium content was more. This may be due to the reason already explained that when the production of stylo is more the CEC will also be more which would have resulted in a higher content of calcium in the associated crop as suggested by Ludlow et al. (1974) and Ramos et al. (1977).

4.7.14. Calcium content of stylosanthes.

The mean calcium content of stylo are presented in Table 48 and 49 for open area and coconut garden respectively.

The difference in calcium content on account of association with two different grasses was not significant under either situation. However, the effects of phosphorus application and nitrogen levels and the interaction effect P x N were significant in both situations.

Phosphorus application significantly increased the calcium content of stylo in both situations. The direct effect of phosphorus on the uptake of calcium by forage legumes has been noted by several workers like Omueti and Oyenuga (1970) and Govindaswamy (1978). In addition to this the application of phosphorus would have stimulated the activities of micro-organisms resulting in higher CEC in the

Table 48. Calcium content of stylosanthes in open area (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0	60	50	100	150	200	
	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
$. Grasses							
Guinea (v_1)	1.271	1.347	1.297	1.332	1.315	1.292	1.309
Setaria (v_2)	1.266	1.357	1.302	1.320	1.320	1.305	1.311
Phosphorus levels (kg/ha)							
0 (p_0)			1.260	1.292	1.267	1.255	1.268
60 (p_1)			1.340	1.360	1.367	1.342	1.352
Mean			1.300	1.326	1.317	1.298	1.310

$. Indicates calcium content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.0046	0.0098
N*; VP	0.0065	0.0139
VN; PN*	0.0092	0.0196

*Significant

Table 49. Calcium content of stylosanthes in coconut garden (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	1.272	1.358	1.317	1.335	1.317	1.292	1.315
Setaria (v_2)	1.267	1.358	1.310	1.325	1.320	1.297	1.313
Phosphorus levels (kg/ha)							
0 (p_o)			1.270	1.292	1.272	1.245	1.270
60 (p_1)			1.357	1.367	1.365	1.345	1.358
Mean			1.313	1.330	1.318	1.295	1.314

$. Indicates calcium content of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.0027	0.0057
N*; VP	0.0038	0.0080
VN; PN*	0.0054	0.0114

*Significant

rhizosphere which would have promoted the uptake of calcium by stylosanthes (De Geus, 1977).

Nitrogen significantly increased the calcium content in both the situations. This has followed exactly the same trend as that of drymatter yield of stylo. The calcium content might have also similarly fluctuated due to the CEC changes as already mentioned.

The P x N interaction was significant in both the situations. The phosphorus addition has increased the drymatter production in stylo and has followed the same trend of the main effect of phosphorus.

Comparison of the data in Tables 48 and 49 revealed that a high content of calcium was always recorded by stylo in partial shade for any treatment combination. This may be due to the comparatively high drymatter production of stylo under partial shade. The reason for the high calcium content in accordance with or in relation with the high drymatter production of stylo has already been explained.

4.7.15. Magnesium content of grasses.

The mean magnesium content of grass are given in Tables 50 and 51 for open area and for coconut garden

Table 50. Magnesium content of grass in open area (%).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	0.557	0.558	0.557	0.557	0.557	0.557	0.557	0.558	0.557
Setaria (v_2)	0.558	0.559	0.558	0.558	0.558	0.558	0.558	0.558	0.558
Intercropping									
None (i_o)			0.557	0.557	0.557	0.557	0.557	0.557	0.557
Stylo-santhes (i_1)			0.558	0.558	0.558	0.558	0.559	0.559	0.558
Phosphorus levels (kg/ha)									
0 (p_o)					0.557	0.558	0.558	0.558	0.558
60 (p_1)					0.558	0.557	0.558	0.558	0.558
Mean					0.557	0.557	0.557	0.558	0.558

Control: Guinea grass (v_1) - 0.556
Setaria grass (v_2) - 0.557

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P	0.0002	0.0005
N; VI; VP; IP	0.0003	--
VN; IN; PN	0.0005	--

*Significant

Table 51. Magnesium content of grass in coconut garden (%).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	0.562	0.563	0.563	0.562	0.562	0.562	0.563	0.563	0.563
Setaria (v_2)	0.563	0.564	0.564	0.563	0.563	0.563	0.564	0.564	0.564
Intercropping									
None (i_o)			0.563	0.563	0.563	0.563	0.564	0.564	0.563
Stylo-santhes (i_1)			0.564	0.563	0.562	0.563	0.563	0.564	0.564
Phosphorus levels (kg/ha)									
0 (p_o)					0.562	0.563	0.563	0.563	0.563
60 (p_1)					0.563	0.564	0.564	0.564	0.563
Mean					0.563	0.563	0.563	0.564	0.563

Control: Guinea grass (v_1) - 0.561

Setaria grass (v_2) - 0.562

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.00005	0.00011
N^*; VI; VP; IP	0.00008	0.00015
VN; IN; PN	0.00011	--

*Significant

respectively. The difference between grasses and the effect due to intercropping were found to be significant under both situations. But the effect of phosphorus and nitrogen levels were significant only in partial shade.

Among the two grasses studied it is seen that guinea grass recorded significantly lower magnesium content under both situations. It may be seen from the data on potassium and calcium contents of grasses (Tables 42, 43, 46 and 47) that these two nutrients were present in more quantities in guinea grass than in setaria. Therefore a comparatively higher content of calcium and potassium would have reduced the magnesium content in guinea grass. Calcium ions usually stimulate the uptake of potassium and the uptake of calcium is markedly influenced by even small amounts of potassium ions (Andrew and Robins, 1969 b; Whelan and Edwards, 1975). So in the present study also the contents of potassium and calcium were higher in guinea grass and naturally the magnesium content was lesser.

Intercropping also has increased the magnesium content of grass in both the situations. The stylo intercropping has resulted in significantly higher magnesium content which may be attributed to the higher CEC of legume roots and higher absorption in such plots.

In partial shade while phosphorus application significantly reduced the magnesium content, the nitrogen levels significantly increased the magnesium content.

It was further noticed that in the case of grasses grown under absolute control there was no significant difference with respect to magnesium content. But the treatment means were higher than the magnesium contents of grasses grown under control in both the situations.

Comparison of the data from the open and partial shade revealed that magnesium content was more under partial shade. This may also be attributed to the increased growth of stylo in partial shade.

4.7.16. Magnesium content of stylosanthes.

The mean magnesium content of stylosanthes are presented in Tables 52 and 53 for open area and for coconut garden respectively.

The effect of intercropping with grasses was significant in both the situations. Under open conditions effect of guinea grass was significantly inferior to setaria grass, while under shade guinea was significantly superior

Table 52. Magnesium content of stylosanthes in open area (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	1.41	1.51	1.52	1.49	1.49	1.50	1.50
Setaria (v_2)	1.49	1.52	1.51	1.50	1.51	1.51	1.51
Phosphorus levels (kg/ha)							
0 (p_o)			1.51	1.48	1.48	1.49	1.49
60 (p_1)			1.52	1.51	1.51	1.52	1.51
Mean			1.51	1.50	1.50	1.50	1.50

$. Indicates magnesium content in stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0030	0.0064
N*; VP*	0.0043	0.0092
VN*; PN*	0.0060	0.0131

*Significant

Table 53. Magnesium content of stylosanthes in coconut garden (%).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0	60	50	100	150	200	
	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
$. Grasses							
Guinea (v_1)	1.47	1.52	1.49	1.48	1.50	1.50	1.49
Setaria (v_2)	1.45	1.49	1.47	1.46	1.49	1.46	1.47
Phosphorus levels (kg/ha)							
0 (p_o)			1.48	1.45	1.47	1.46	1.46
60 (p_1)			1.49	1.50	1.52	1.50	1.50
Mean			1.48	1.47	1.50	1.48	1.48

$. Indicates magnesium content in stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0046	0.0097
N*; VP	0.0065	0.0137
VN; PN*	0.0091	0.0193

*Significant

to setaria. This may be due to the varietal effect of grasses, under different light intensities.

Similarly the effect due to phosphorus application was significant in both the situations. Applied phosphorus has resulted in higher magnesium content. Phosphorus has the capacity to increase the activity of root nodule bacteria and other organisms present in the rhizosphere which would have resulted in an increase in magnesium content (Andrew and Robins, 1969 b).

The effect of nitrogen levels was significant in both situations.

Under open condition the highest magnesium content was recorded with 50 kg nitrogen while all the higher levels were on par and significantly lower than the 50 kg nitrogen level. However, the trend seemed to be erratic under shaded situations though significant.

The interactions V x N, P x N and V x P were also significant under both situations which may be due to the main treatment effects as explained early.

4.7.17. K: (Ca + Mg) ratio of grasses.

The mean K: (Ca + Mg) ratio of grasses in open area

Table 54. K: (Ca + Mg) ratio of grass in open area.

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
<u>Grasses</u>									
Guinea (v_1)	1.351	1.356	1.351	1.356	1.350	1.353	1.357	1.355	1.354
Setaria (v_2)	1.381	1.375	1.376	1.380	1.378	1.375	1.377	1.383	1.378
<u>Intercropping</u>									
None (i_o)			1.365	1.368	1.364	1.363	1.368	1.370	1.367
Stylosanthes (i_1)			1.363	1.368	1.363	1.365	1.366	1.368	1.366
<u>Phosphorus levels (kg/ha)</u>									
0 (p_o)					1.362	1.362	1.366	1.365	1.364
60 (p_1)					1.365	1.366	1.368	1.372	1.368
Mean					1.364	1.364	1.367	1.369	1.366

Control: Guinea grass (v_1) - 1.341

Setaria grass (v_2) - 1.355

<u>Type of pair comparison of means</u>	<u>S.E.</u>	<u>C.D. (0.05)</u>
V^*; I; P^*	0.0018	0.0037
N; VI^*; VP; IP	0.0026	0.0052
VN; IN; PN	0.0037	--

*Significant

Table 55. K: (Ca + Mg) ratio of grass in coconut garden.

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	1.338	1.336	1.336	1.337	1.331	1.333	1.338	1.345	1.337
Setaria (v_2)	1.345	1.348	1.346	1.347	1.338	1.345	1.349	1.353	1.346
Intercropping									
None (i_o)			1.340	1.342	1.334	1.338	1.343	1.350	1.341
Stylosanthes (i_1)			1.342	1.342	1.336	1.340	1.344	1.348	1.342
Phosphorus levels (kg/ha)									
0 (p_o)					1.337	1.337	1.343	1.347	1.341
60 (p_1)					1.333	1.341	1.345	1.350	1.342
Mean					1.335	1.339	1.344	1.349	1.341

Control: Guinea grass (v_1) - 1.320
Setaria grass (v_2) - 1.387

Type of pair comparison of means	S.E.	C.D. (0.05)
V; I; P	0.0051	--
N; VI; VP; IP	0.0072	--
VN; IN; PN	0.0102	--

*Significant

are presented in Table 54 and that of coconut garden are given in Table 55.

It is seen that none of the treatment effects nor their interaction was significant in partial shade. However in the open area, the difference between the grasses, levels of phosphorus and interaction V x I were significant. Guinea grass recorded a significantly lower ratio than setaria grass. Application of phosphorus significantly increased the ratio in grasses. However, the effect due to nitrogen application was not significant.

The interaction V x I was significant which may be due to the influence of the main treatment effect of grasses.

The K: (Ca + Mg) ratio is important from the point of view of fodder quality. Precaution is to be taken to see that the ratio is within the safer limit of 2.2 as suggested by Hendrikson (1960) and Thill and George (1975) so as to avoid the risk of grass tetany in animals. In the present investigation it is seen that the ratio was less than 1.38 and no increase was noticed due to treatment effects on this character.

It was also noticed that in the case of grasses grown under control significant difference was noticed with respect to this ratio. In both the situations setaria recorded higher K: (Ca + Mg) ratio than guinea grass. The treatment mean (1.366) recorded in open area was significantly higher than the ratios noticed under control, while in coconut garden this was not significant. It may be further noticed from the comparison of the two tables that under shade, the ratio was lower. Mullakoya (1982) also reported that under varying intensities of shade this ratio was well below the safe limits. This shows that it is safer to grow fodder crops under shaded condition if this ratio is taken as an index of safety.

4.7.18. K: (Ca + Mg) ratio of stylosanthes.

The mean K: (Ca + Mg) ratio of stylosanthes are presented in Tables 56 and 57 for open and for coconut garden respectively.

The effect due to intercropping with grass was significant in partial shade only. Stylo when intercropped in guinea grass plots registered a significantly lesser ratio than intercropped in setaria plots.

Application of phosphorus significantly reduced the K: (Ca + Mg) ratio of stylo in open area only. The other

Table 56. K: (Ca + Mg) ratio of stylosanthes in open area.

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. **Grasses**							
Guinea (v_1)	0.539	0.517	0.531	0.525	0.526	0.531	0.528
Setaria (v_2)	0.543	0.515	0.531	0.528	0.529	0.529	0.529
Phosphorus levels (kg/ha)							
0 (p_o)			0.542	0.539	0.540	0.542	0.541
60 (p_1)			0.520	0.513	0.514	0.518	0.516
Mean			0.531	0.526	0.527	0.530	0.528

$. Indicates K: (Ca + Mg) ratio of stylosanthes when inter-cropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.0015	0.0032
N; VP	0.0021	--
VN; PN	0.0030	--

*Significant

Table 57. K: (Ca + Mg) ratio of stylosanthes in coconut garden.

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	0.551	0.550	0.553	0.554	0.548	0.547	0.550
Setaria (v_2)	0.559	0.561	0.559	0.564	0.555	0.562	0.560
Phosphorus levels (kg/ha)							
0 (p_o)			0.553	0.562	0.554	0.551	0.555
60 (p_1)			0.559	0.556	0.549	0.557	0.555
Mean			0.556	0.559	0.551	0.554	0.555

$. Indicates K: (Ca + Mg) ratio of stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P	0.0019	0.0040
N; VP	0.0027	--
VN; PN	0.0038	--

*Significant

treatments or their interaction effects were not significant in either of the two situations.

It may be seen that this ratio of stylosanthes fodder was much lesser than that of the grasses and the highest value recorded was only 0.364. In legumes this ratio is not likely to go above the values reported in this study, because the uptake of potassium will be lesser when compared to calcium and magnesium.

4.8. Uptake studies

4.8.1. Uptake of nitrogen by grasses.

The total uptake of nitrogen by the grasses for two years are presented in Table 58 and 59 for open area and coconut garden.

It is seen from the table that the effects of two grasses, phosphorus application, and levels of nitrogen were significant in both the situations, while the effect of intercropping was significant only in coconut garden. The interaction effect V x P was significant in both the situations. But V x I, I x P, V x N, I x N and P x N were significant in coconut garden only.

Between the two grasses guinea recorded a signi-

Table 58. Uptake of nitrogen by grass in open area (kg/ha).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylo-santhes	0	60	50	100	150	200	
	(i_0)	(i_1)	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	100.69	101.15	97.18	104.66	87.36	102.11	105.67	108.53	100.92
Setaria (v_2)	94.43	93.76	93.39	94.80	82.59	92.07	99.84	101.88	94.09
Intercropping									
None (i_0)			95.45	99.66	86.38	96.99	101.91	104.95	97.56
Stylo-santhes (i_1)			95.12	99.79	83.57	97.19	103.60	105.46	97.45
Phosphorus levels (kg/ha)									
0 (p_0)					78.88	96.39	101.09	104.79	95.29
60 (p_1)					91.07	97.80	104.43	105.62	99.73
Mean					84.98	97.09	102.76	105.21	97.50

Control: Guinea grass (v_1) - 57.06; Setaria grass (v_2) - 69.09

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I; P^*	1.111	2.250
N^*; VI; VP^*; IP	1.571	3.181
VN; IN; PN	2.222	4.498

*Significant

Table 59. Uptake of nitrogen by grass in coconut garden (kg/ha).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylo-santhes	0	60	50	100	150	200	
	(i_o)	(i_1)	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	93.87	96.41	89.45	100.84	86.14	99.12	100.05	95.25	95.14
Setaria (v_2)	77.07	84.27	78.18	83.16	75.76	78.79	82.35	85.79	80.67
Intercropping									
None (i_o)			84.45	86.49	80.56	87.69	85.88	87.76	85.47
Stylo-santhes (i_1)			83.18	97.51	81.34	90.22	96.52	93.28	90.34
Phosphorus levels (kg/ha)									
0 (p_o)					80.06	84.60	87.06	83.53	83.81
60 (p_1)					81.84	93.31	95.33	97.51	91.99
Mean					80.95	83.95	91.20	90.52	87.90

Control: Guinea grass (v_1) - 62.88
Setaria grass (v_2) - 51.85

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I*; P*	1.081	2.190
N*; VI*; VP*; IP*	1.529	3.100
VN*; IN*; PN*	2.162	4.379

*Significant

ficantly higher uptake than setaria in both the situations. The drymatter yield (Tables 17 and 18) showed significantly higher yield in guinea grass. The crude protein content (Tables 23 and 24) was also higher in guinea grass than setaria. Both these factors together might have contributed for the higher uptake of nitrogen by guinea.

Intercropping with stylo has significantly influenced the nitrogen uptake by grasses in coconut garden. The dry-matter yield of grass intercropped with stylo in coconut garden was also higher than under no intercropping, probably due to the beneficial effect of the legume in partial shade. Similar findings were also reported by Kitamura et al. (1975) in the case of setaria grass and desmodium.

Phosphorus application significantly increased the nitrogen uptake of grasses in both the situations. The drymatter yield and crude protein contents were also higher due to phosphorus addition, which might be the reason for the higher uptake of nitrogen by grasses. Dwivedi et al. (1980) also noted higher uptake of nitrogen due to phosphorus treatment in the case of Chrysopogon fulvus (spreng).

Significant increase in nitrogen uptake by grasses was recorded in both the situations. In open area the uptake significantly increased with increase in the level of nitrogen upto 150 kg N/ha beyond which the increase was not significant. In coconut garden also the uptake increased upto 150 kg only and then decreased at 200 kg but 50 kg and 100 kg were on par and 150 kg and 200 kg were also on par. The drymatter yield and crude protein also showed more or less a similar trend.

The significant interaction effects may be due to their main treatment effects.

In the case of control plots guinea grass showed its superiority over setaria with respect to nitrogen uptake. The treatment average (87.90 kg N/ha) was also significantly higher than the uptake by grasses in absolute controls.

Comparison of the nitrogen uptake under both situations showed that corresponding to the difference in drymatter yield and crude protein contents, the nitrogen uptake was higher in open area.

4.8.2. <u>Uptake of nitrogen by stylosanthes.</u>

The total uptake of nitrogen by stylosanthes for two years are presented in Tables 60 and 61 for open area and

Table 60. Uptake of nitrogen by stylosanthes in open area (kg/ha).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_0)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	159.78	218.94	184.94	206.17	183.36	182.98	189.36
Setaria (v_2)	160.38	216.56	182.13	206.82	184.83	180.10	188.47
Phosphorus levels (kg/ha)							
0 (p_0)			158.68	167.65	157.87	156.12	160.08
60 (p_1)			208.39	245.34	210.32	206.96	217.75
Mean			183.54	206.49	184.09	181.54	188.91

$. Indicates the uptake of nitrogen by stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.7516	2.2532
N*; VP	1.0628	3.1862
VN; PN*	1.5029	4.5056

*Significant

Table 61. Uptake of nitrogen by stylosanthes in coconut garden (kg/ha).

Treatments	Phosphorus levels (kg/ha) 0 (p_o)	60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	Mean
$. Grasses							
Guinea (v_1)	169.52	230.30	194.46	217.73	195.13	192.32	199.91
Setaria (v_2)	169.05	227.06	192.23	216.55	192.88	190.57	198.05
Phosphorus levels (kg/ha)							
0 (p_o)			166.85	176.80	167.96	165.53	169.28
60 (p_1)			219.84	257.49	220.05	217.36	228.68
Mean			193.34	217.14	194.00	191.44	198.98

$.Indicates the uptake of nitrogen by stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; P^*	0.3202	0.9599
N^*; VP^*	0.4528	1.3574
VN; PN^*	0.6403	1.9196

*Significant

coconut garden.

Perusal of the tables showed that the effect due to two grasses was significant only in coconut garden. The effect due to phosphorus and nitrogen levels and interaction P x N were significant in both the situations. The interaction V x P was significant only in coconut garden.

Though the difference was not significant in open area, the uptake of nitrogen by stylo grown with guinea grass was higher than setaria in both the situations. The data on drymatter yield (Tables 19 and 20) and crude protein (Tables 25 and 26) also showed similar trends which were exhibited in the case of nitrogen uptake also.

The uptake of nitrogen was significantly higher due to phosphorus application under both the situations. The reason for the increase in nitrogen uptake by legumes due to phosphorus application is well known (Bogdan, 1977).

The interaction P x N in both the situations, and V x P in coconut garden were significant which may be due to their main treatment effects.

Comparison of the data in open area and coconut garden showed that the uptake was more in the later which may also be attributed due to the higher drymatter yield recorded in shade by stylosanthes.

4.8.3. Uptake of phosphorus by grasses.

The uptake of phosphorus by grasses for two years is presented in Tables 62 and 63 for open area and coconut garden.

Perusal of the tables showed that the difference between the two grasses, phosphorus levels and nitrogen levels were significant in both the situations. The effect due to stylosanthes intercropping was significant only in coconut garden. The interaction effects V x P and P x N were significant in both the situations and I x P, V x N and I x N were significant in coconut garden only.

The phosphorus uptake of guinea was significantly more than setaria in both the situations. The phosphorus content of guinea (Tables 38 and 39) was also significantly higher than setaria in both the situations. Since the drymatter yield was also more (Tables 17 and 18) the uptake of phosphorus by guinea was also higher than setaria in open and shade.

Intercropping grasses with stylo recorded significantly higher phosphorus uptake in coconut garden. The

Table 62. Uptake of phosphorus by grass in open area (kg/ha).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylosan-thes	0	60	50	100	150	200	
	(i_o)	(i_1)	(p_o)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	16.99	16.18	16.41	18.15	15.38	17.47	18.03	18.23	17.28
Setaria (v_2)	16.18	16.15	15.90	16.42	16.12	15.92	15.92	17.50	16.16
Intercropping									
None (i_o)			16.06	17.11	14.66	16.51	17.35	17.83	16.58
Stylo-santhes (i_1)			16.25	17.46	14.86	16.87	17.80	17.90	16.86
Phosphorus levels (kg/ha)									
0 (p_o)					13.41	16.40	17.01	17.80	16.15
60 (p_1)					16.11	16.98	18.13	17.93	17.29
Mean					14.76	16.69	17.57	17.86	16.72

Control: Guinea grass (v_1) - 9.88

Setaria grass (v_2) -11.09

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I; P^*	0.217	0.440
N^*; VI; VP^*; IP	0.307	0.622
VN; IN; PN^*	0.434	0.880

*Significant

Table 63. Uptake of phosphorus by grass in coconut garden (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	15.98	16.81	15.27	17.52	14.78	17.16	17.28	16.35	16.39
Setaria (v_2)	13.69	14.88	13.73	14.85	13.44	14.04	14.55	15.12	14.29
Intercropping									
None (i_o)			14.50	15.18	13.94	15.25	14.94	15.22	14.84
Stylo-santhes (i_1)			14.50	17.19	14.28	15.96	16.89	16.24	15.84
Phosphorus levels (kg/ha)									
0 (p_o)					13.89	14.67	14.98	14.46	14.50
60 (p_1)					14.33	16.54	16.85	17.01	16.18
Mean					14.11	15.60	15.92	15.73	15.34

Control: Guinea grass (v_1) - 10.81; Setaria grass (v_2) - 9.61

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I*; P*	0.192	0.389
N*; VI; VP*; IP*	0.271	0.553
VN*; IN*; PN*	0.384	0.944

*Significant

drymatter yield of grass due to intercropping was higher and hence the phosphorus uptake was also significantly high.

Significant increase in phosphorus uptake by grasses due to application of 60 kg phosphorus was noticed in both the situations which may be attributed due to higher drymatter yield (Tables 17 and 18) and phosphorus content (Tables 38 and 39) as already mentioned.

Significant increase in phosphorus uptake was noted due to nitrogen levels in both the situations. In open area the uptake increased significantly with increase in nitrogen levels upto 150 kg and levels 150 kg and 200 kg N/ha were on par. In coconut garden significant increase in uptake was noticed upto 100 kg and 200 kg N/ha were on par. The increase in phosphorus uptake noticed may be attributed to the higher drymatter yield and phosphorus content obtained due to these respective nitrogen levels.

The significant interaction effects V x P and P x N noticed in both the situations and interaction effects of I x P, V x N and I x N noticed in coconut shade may be attributed due to their main treatment effects.

The uptake of phosphorus by grasses due to treatments (16.72 kg/ha in open area and 15.34 kg/ha in coconut garden) were also significantly higher than the average uptake noted by the two grasses under absolute control in both the situations.

Comparison of the total uptake in open area and shade showed that higher uptake was noticed in the former, probably due to the higher drymatter yield recorded there.

4.8.4. Uptake of phosphorus by stylosanthes.

The uptake of phosphorus by stylosanthes for two years are presented in Tables 64 and 65 for open area and coconut garden respectively.

The effects of two grasses, phosphorus application, and levels of nitrogen and the interactions V x P and P x N were significant in both the situations.

Perusal of the tables showed that uptake of phosphorus by stylo, intercropped with guinea grass was significantly higher than stylo intercropped with setaria grass in both the situations. It has already been discussed under drymatter yield (Tables 19 and 20) and phosphorus content (Tables 40 and 41) of stylo that between the grasses,

Table 64. Uptake of phosphorus by stylosanthes in open area (kg/ha).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_o)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	21.683	28.845	24.352	27.577	24.717	24.410	25.264
Setaria (v_2)	21.677	28.506	24.202	27.607	24.427	24.130	25.091
Phosphorus levels (kg/ha)							
0 (p_o)			21.295	22.800	21.395	21.232	21.680
60 (p_1)			27.260	32.385	27.750	27.307	28.675
Mean			24.277	27.592	24.572	24.27	25.179

$. Indicates the uptake of phosphorus by stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.04908	0.1471
N*; VP*	0.06940	0.2080
VN; PN*	0.09813	0.2941

*Significant

Table 65. Uptake of phosphorus by stylosanthes in coconut garden (kg/ha).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0 (p_0)	60 (p_1)	50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	
$. Grasses							
Guinea (v_1)	21.241	27.833	23.897	26.680	24.035	23.537	24.537
Setaria (v_2)	21.133	27.410	23.655	26.577	23.632	23.222	24.271
Phosphorus levels (kg/ha)							
0 (p_0)			21.040	22.215	21.005	20.490	21.187
60 (p_1)			26.512	31.042	26.662	26.270	27.621
Mean			23.776	26.628	23.833	23.380	24.404

$. Indicates the uptake of phosphorus by stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; P*	0.0381	0.1142
N*; VP*	0.0539	0.1615
VN; PN*	0.0762	0.2284

*Significant

guinea provides a favourable effect for the growth of stylo intercropped with that. This may be the reason for recording a higher uptake of phosphorus by stylosanthes under this situation.

Phosphorus level @ 60 kg/ha significantly increased the uptake of this nutrient over zero phosphorus in both the situations. The higher drymatter yield and phosphorus content of stylo fodder have resulted in the higher uptake of phosphorus also as reported by Dwivedi et al. (1980).

The effect of nitrogen levels was significant in phosphorus uptake, under both the situation, where the uptake increased upto 100 kg N/ha and then decreased correspondingly under higher levels.

The significant interaction effects of V x P and P x N noted in both the situations may be due to their main treatment effects.

Comparison of the data from the two situations showed that in open area the uptake of phosphorus was higher than in coconut garden.

4.8.5. <u>Uptake of potassium by grasses</u>.

The uptake of potassium grasses for two years are

Table 66. Uptake of potassium by grass in open area (kg/ha).

Treatments	Intercropping		Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	None	Stylo-santhes	0	60	50	100	150	200	
	(i_0)	(i_1)	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
Grasses									
Guinea (v_1)	110.74	111.63	107.12	115.24	95.84	112.42	116.64	119.82	111.18
Setaria (v_2)	109.86	108.44	108.55	109.76	95.45	106.87	116.11	118.17	109.15
Intercropping									
None (i_0)			107.86	112.74	97.29	109.44	115.43	119.04	110.30
Stylo-santhes (i_1)			107.82	112.25	93.99	109.85	117.33	118.95	110.03
Phosphorus levels (kg/ha)									
0 (p_0)					89.05	108.88	114.59	118.84	107.83
60 (p_1)					102.24	110.42	118.17	119.16	112.50
Mean					95.64	109.65	116.38	118.99	110.16

Control: Guinea grass (v_1) - 65.17
Setaria grass (v_2) - 75.65

Type of pair comparison of means	S.E.	C.D. (0.05)
V; I; P*	1.294	2.620
N*; VI; VP*; IP	1.829	3.705
IN; PN*	2.587	5.238

*Significant

Table 67. Uptake of potassium by grass in coconut garden (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylo-santhes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
<u>Grasses</u>									
Guinea (v_1)	101.79	103.49	96.95	108.33	92.85	107.17	108.05	102.49	102.64
Setaria (v_2)	89.67	96.32	90.71	95.29	84.41	90.99	95.16	98.44	92.99
<u>Intercropping</u>									
None (i_o)			95.04	96.43	90.16	98.40	96.28	98.09	95.73
Stylo-santhes (i_1)			92.62	107.19	90.11	99.76	106.93	102.83	99.91
<u>Phosphorus levels (kg/ha)</u>									
0 (p_o)					89.55	94.68	97.81	93.28	93.83
60 (p_1)					90.72	103.48	105.40	107.64	101.81
Mean					90.13	99.08	101.61	100.61	97.82

Control: Guinea grass (v_1) - 70.18
Setaria grass (v_2) - 62.26

<u>Type of pair comparison of means</u>	<u>S.E.</u>	<u>C.D. (0.05)</u>
V^*; I^*; P^*	1.289	2.610
N^*; VI; VP^*; IP^*	1.822	3.691
VN^*; IN^*; PN^*	2.577	5.218

*Significant

presented in Tables 66 and 67 for open area and coconut garden respectively.

From the table it was noted that effects due to grasses and intercropping in coconut garden and effects due to phosphorus and nitrogen in both the situations were significant. The interaction effects V x P and P x N were significant in both the situations while I x P, V x N and I x N were significant only in coconut garden.

The uptake of potassium by guinea grass was significantly higher than setaria in coconut garden which can be attributed to the higher drymatter produced by guinea grass (Table 18).

Intercropping with stylosanthes has enhanced the potassium uptake by grasses significantly compared to monoculture. The higher nutrient uptake by the grass may be due to the higher drymatter production as well as the indirect effect of legume on the growth of grass.

Application of phosphorus has helped better drymatter production which has resulted in higher potassium uptake in both the situations.

Perusal of the tables on the effect of nitrogen levels also indicated that in coconut garden beyond 100 kg and in open area beyond 150 kg N/ha, there was no significant influence on the uptake of potassium.

Significant interactions V x P, P x N (in both the situations) and I x P, V x N and I x N (in coconut garden) clearly showed the influence of the main treatment effect in the concerned situations.

Comparing the absolute controls with the treatment averages showed the similar trend as in the case of nitrogen and phosphorus, viz. the absolute controls recorded lower potassium uptake compared to that by the concerned treatment effects in both the situations.

As in the case of nitrogen and phosphorus higher uptake of potassium was noted in the open area than in coconut garden.

4.8.6. Uptake of potassium by stylosanthes.

The uptake of potassium for two years by stylosanthes are presented in Tables 68 and 69 for open area and coconut garden respectively.

The potassium uptake of stylo was significantly

Table 68. Uptake of potassium by stylosanthes in open area (kg/ha).

Treatments	Phosphorus levels (kg/ha)		Nitrogen levels (kg/ha)				Mean
	0	60	50	100	150	200	
	(p_0)	(p_1)	(n_1)	(n_2)	(n_3)	(n_4)	
$. Grasses							
Guinea (v_1)	105.24	132.58	116.27	129.09	115.57	114.72	118.91
Setaria (v_2)	105.60	131.99	115.14	129.80	116.03	114.24	118.80
Phosphorus levels (kg/ha)							
0 (p_0)			104.23	110.59	103.99	102.88	105.42
60 (p_1)			127.18	148.30	127.61	126.08	132.29
Mean			115.71	129.45	115.80	114.48	118.85

$. Indicates the uptake of potassium by stylosanthes when intercropped with grasses.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.1857	0.5567
N*; VP	0.2626	0.7872
VN; PN*	0.3713	1.1131

*Significant

Table 69. Uptake of potassium by stylosanthes in coconut garden (kg/ha).

Treatments	Phosphorus levels (kg/ha) 0 (p_o)	60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	100 (n_2)	150 (n_3)	200 (n_4)	Mean
$. Grasses							
Guinea (v_1)	109.44	144.82	123.91	139.09	123.91	121.62	127.13
Setaria (v_2)	109.39	143.58	122.20	139.50	123.20	121.05	126.49
Phosphorus levels (kg/ha)							
0 (p_1)			107.83	115.93	108.40	105.51	109.42
60 (p_2)			138.28	162.66	138.71	137.15	144.20
Mean			123.05	139.29	123.55	121.33	126.81

$. Indicates the uptake of potassium by stylosanthes when intercropped with stylosanthes.

Type of pair comparison of means	S.E.	C.D. (0.05)
V; P*	0.26	0.77
N*; VP	0.36	1.09
VN; PN*	0.52	1.55

*Significant

influenced by phosphorus, nitrogen levels and interaction effect P x N in both the situations.

Application of 60 kg P_2O_5 significantly increased the potassium uptake both in the open and shade situations. Perusal of the tables on drymatter yield of stylo (Tables 19 and 20) as well as potassium content (Tables 44 and 45) will support this finding.

In both the situations increase of nitrogen from 50 to 100 kg/ha significantly increased the potassium uptake beyond which it showed a depressing effect indicating that higher levels of nitrogen applied to stylosanthes depressed potassium uptake.

The interaction P x N was only significant in both the situations which may be attributed to the combined effect of the main treatment nitrogen and phosphorus.

Comparison of the data of the two situations showed that the uptake of potassium by stylosanthes was more in coconut garden.

4.9. Soil Analysis

4.9.1. Nitrogen content of soil.

The mean nitrogen content of soil after the experiment

Table 70. Nitrogen content of soil after the experiment in open area (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	1263.68	1264.97	1265.08	1263.57	1253.46	1262.13	1269.34	1272.37	1264.33
Setaria (v_2)	1148.50	1149.00	1148.66	1148.84	1141.69	1146.04	1150.06	1157.21	1148.75
Intercropping									
None (i_o)			1205.95	1206.23	1192.48	1203.22	1211.26	1217.40	1206.09
Stylosanthes (i_1)			1207.79	1206.18	1202.67	1204.95	1208.14	1212.17	1206.98
Phosphorus levels (kg/ha)									
0 (p_o)					1197.44	1204.31	1210.26	1215.47	1206.87
60 (p_1)					1197.72	1203.86	1209.14	1214.11	1206.20
Mean					1197.58	1204.08	1209.70	1214.79	1206.53

Control: Guinea grass (v_1) - 996.87
Setaria grass (v_2) - 981.62

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.160	0.322
N^*; VI^*; VP^*; IP^*	0.226	0.456
VN^*; IN^*; PN^*	0.320	0.645

*Significant

Table 71. Nitrogen content of soil after the experiment in coconut garden (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	1304.51	1306.06	1306.08	1304.48	1294.47	1303.15	1310.35	1313.17	1305.28
Setaria (v_2)	1190.62	1190.38	1189.70	1191.30	1185.30	1187.03	1190.82	1198.86	1190.50
Intercropping									
None (i_o)			1246.87	1248.25	1236.09	1244.22	1251.76	1258.18	1247.56
Stylosanthes (i_1)			1248.91	1247.53	1243.68	1245.96	1249.40	1253.84	1248.22
Phosphorus levels (kg/ha)									
0 (p_o)					1238.55	1245.31	1251.26	1256.47	1247.89
60 (p_1)					1241.22	1244.87	1249.91	1255.56	1247.89
Mean					1239.89	1245.09	1250.58	1256.01	1247.89

Control: Guinea grass (v_1) - 998.81

Setaria grass (v_2) - 987.50

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.354	0.714
N^*; VI^*; VP; IP^*	0.501	1.009
VN^*; IN^*; PN^*	0.707	1.428

*Significant

are presented in Tables 70 and 71 for open area and for coconut garden respectively.

It is seen that the difference between the two grasses was significant under both the situations. Guinea grass plots recorded a significantly higher soil nitrogen content than setaria plots in both the situations. The effect due to intercropping with stylosanthes was also significant. Intercropped plots recorded a significantly higher nitrogen content than non-intercropped plots. The effect of phosphorus application was significant only in open area. The different levels of nitrogen significantly increased the soil nitrogen content in open area and in partial shade. The interaction effects V x I, I x P, V x N, P x N and I x N were significant in both the situations while V x P was significant in open area only.

The soil nitrogen content in guinea grass plots was higher than in setaria plots in both the situations. According to Neyra and Dobereiner (1977) grasses also fix nitrogen in association with bacteria. Hence, this may probably be due to the higher nitrogen fixing capacity of guinea than setaria. Table on drymatter production of stylo showed that the yield of stylo was more when grown as intercrop in guinea grass plots (Tables 19 and 20). The nitrogen contribution of stylo is directly reflected in the nitrogen content of soil in these plots as reported by Singh and Chatterjee (1968) wherein they have reported that nitrogen accumulated wherever legumes grew well. Intercropping significantly increased the total nitrogen content of the soil. This may be due to the contribution by stylosanthes. Nitrogen content of soil increased under grass legume pasture as observed by Singh and Chatterjee (1968) and Lal (1979) in stylosanthes.

In phosphorus applied plots (P_{60}) the drymatter production was higher (Tables 17 and 18) as compared to P_0 plots and for higher drymatter production more nitrogen was absorbed from the soil and hence significant reduction in soil nitrogen content was noticed.

The effect of nitrogen was significant under both the situations. The plots which received the highest level of nitrogen has resulted in maximum nitrogen content in both the situations. Similar increases in soil nitrogen content was also reported by Balbatti (1980) in a trial with hybrid napier.

The interaction V x I was significant in both open area as well as in partial shade. This may be attributed to the increase in nitrogen content due to intercropping. The varietal effect in this respect has already been discussed.

The interaction effect of I x P was significant in both the situations which may be due to the main effect of intercropping. The interaction effect of V x N was also significant indicating main effect of nitrogen as well as that of variety. The interaction I x N was significant. The main effects of intercropping and nitrogen are reflected here also. The interaction P x N was significant where the main effect of nitrogen was more pronounced than the effect of phosphorus.

In both the situations in plots where guinea was grown under control significantly higher nitrogen content than setaria plots was recorded. The treatment means were also higher than the nitrogen contents of control plots.

It is seen that in partial shade the nitrogen content of the soil was higher than in the open area. This is attributed to the higher stylo production. This shows that in coconut garden growing stylosanthes in combination with grasses enriches the soil nitrogen content which can be recommended safely from the point of view of soil fertility.

4.9.2. Phosphorus content of soil.

The mean phosphorus content of the soil after the experiment are given in Tables 72 and 73 for open and for coconut garden respectively.

The difference between the two grasses were significant in both the situations. Guinea grass plots recorded significantly lesser phosphorus content than setaria plots. Perusal of the Tables 62 and 63 on the uptake of phosphorus by grasses in both the situations and Tables 64 and 65 on the uptake of phosphorus by stylo in both the situations showed that the total uptake of phosphorus was more in the guinea grass plots than in setaria plots which may be the reason for the lower phosphorus content in guinea grass plots.

The phosphorus content of soil was enriched by phosphorus fertilization in both the situations. Nihal Singh and Khatri (1972) observed appreciable increase in phosphorus with increasing doses of phosphorus.

Intercropping treatment showed that the phosphorus

Table 72. Available phosphorus content of soil after the experiment in open area (kg/ha).

Treatments	Intercropping None (i_0)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_0)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	99.28	99.20	98.47	100.01	100.18	99.04	98.75	98.99	99.24
Setaria (v_2)	103.43	102.57	102.49	103.51	102.98	102.76	103.26	103.00	103.00
Intercropping									
None (i_0)			100.13	102.58	101.66	100.86	101.63	101.28	101.36
Stylosanthes (i_1)			100.83	100.94	101.50	100.95	100.38	100.71	100.88
Phosphorus levels (kg/ha)									
0 (p_0)					101.02	100.18	100.37	100.35	100.48
60 (p_1)					102.14	101.63	101.64	101.63	101.76
Mean					101.58	100.90	101.01	100.99	101.12

Control: Guinea grass (v_1) - 89.03
Setaria grass (v_2) - 91.73

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.090	0.181
N^*; VI^*; VP^*; IP^*	0.127	0.356
VN^*; IN^*; PN	0.180	0.363

*Significant

Table 73. Available phosphorus content of soil after the experiment in coconut garden (kg/ha).

Treatments	Intercropping: None (i_o)	Intercropping: Stylosanthes (i_1)	Phosphorus levels (kg/ha): 0 (p_o)	Phosphorus levels (kg/ha): 60 (p_1)	Nitrogen levels (kg/ha): 50 (n_1)	Nitrogen levels (kg/ha): 100 (n_2)	Nitrogen levels (kg/ha): 150 (n_3)	Nitrogen levels (kg/ha): 200 (n_4)	Mean
Grasses									
Guinea (v_1)	99.88	99.69	99.09	100.49	100.62	99.16	99.57	99.81	99.79
Setaria (v_2)	104.12	102.84	103.11	103.85	103.21	103.40	103.44	103.87	103.48
Intercropping									
None (i_o)			100.91	103.10	102.23	101.47	102.12	102.20	102.00
Stylosanthes (i_1)			101.29	101.25	101.60	101.09	100.89	101.49	101.27
Phosphorus levels (kg/ha)									
0 (p_o)					101.34	100.91	100.84	101.30	101.10
60 (p_1)					102.49	101.65	102.17	102.38	102.17
Mean					101.92	101.28	101.50	102.84	101.63

Control: Guinea grass (v_1) - 89.31

Setaria grass (v_2) - 92.50

Type of pair comparison of means	S.E.	C.D. (0.05)
V^*; I^*; P^*	0.086	0.174
N^*; VI^*; VP^*; IP^*	0.122	0.246
VN^*; IN^*; PN	0.173	0.348

*Significant

content of the stylo intercropped plots was significantly lower than the non-intercropped plots indicating the excess removal of phosphorus by the legume. This may be attributed to the increased phosphorus requirement for the drymatter production of grasses and legume which showed more or less a similar trend.

A significant reduction in the phosphorus content of the soil was noted when the nitrogen level was increased from 50 to 100 kg/ha beyond which the difference was not significant.

The interactions V x I, V x P, I x P and V x N were significant which may be attributed due to their main treatment effects.

In both the situations where setaria was grown under control, the available phosphorus content of soil was significantly higher than in guinea grass plots. The treatment means were also higher than the phosphorus contents of the soil under absolute control

Comparison of the data from the open and coconut garden showed that in general a reasonably higher phosphorus residue is left in the soil in coconut garden than under open area. This may be due to the lesser mineralisation of phosphorus taking place in coconut garden compared to open area.

4.9.3. Potassium content of soil.

The mean potassium content of the soil after the experiment are given in Tables 74 and 75 for open area and for coconut garden respectively.

The difference between the two grasses was significant in area and in partial shade. The effect due to intercropping was not significant in both the situations. The effect of phosphorus application was significant only in open area. The effect of nitrogen levels, I x P and V x I interactions were also significant in open area only.

Guinea grass recorded significantly lesser potassium content in both the situations. This may be attributed to the higher drymatter production of this grass.

Phosphorus application significantly increased the potassium content in open area, but in partial shade the effect was not significant but same trend was noted. In both situations the potassium uptake was more in phosphorus applied plots than under p_0 plots as revealed from Tables

Table 74. Potassium content of soil after the experiment in open area (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	29.29	29.05	29.12	29.22	29.06	29.08	29.23	29.30	29.17
Setaria (v_2)	30.18	30.39	30.20	30.37	30.22	30.26	30.30	30.35	30.28
Intercropping									
None (i_o)			29.73	29.74	29.62	29.64	29.80	29.87	29.73
Stylosanthes (i_1)			29.58	29.86	29.66	29.70	29.74	29.78	29.72
Phosphorus levels (kg/ha)									
0 (p_o)					29.59	29.61	29.70	29.73	29.66
60 (p_1)					29.70	29.73	29.84	29.92	29.80
Mean					29.64	29.67	29.77	29.83	29.72

Control: Guinea grass (v_1) - 27.96
Setaria grass (v_2) - 28.84

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P*	0.045	0.091
N*; VI*; VP; IP*	0.063	0.129
VN; IN; PN	0.090	--

*Significant

Table 75. Potassium content of soil after the experiment in coconut garden (kg/ha).

Treatments	Intercropping None (i_o)	Intercropping Stylosanthes (i_1)	Phosphorus levels (kg/ha) 0 (p_o)	Phosphorus levels (kg/ha) 60 (p_1)	Nitrogen levels (kg/ha) 50 (n_1)	Nitrogen levels (kg/ha) 100 (n_2)	Nitrogen levels (kg/ha) 150 (n_3)	Nitrogen levels (kg/ha) 200 (n_4)	Mean
Grasses									
Guinea (v_1)	28.56	28.53	28.41	28.68	28.56	28.51	28.50	28.61	28.54
Setaria (v_2)	29.85	29.84	29.89	29.80	29.87	29.89	29.81	29.81	29.84
Intercropping									
None (i_o)			29.24	29.17	29.20	29.20	29.21	29.21	29.21
Stylosanthes (i_1)			29.05	29.32	29.23	29.20	29.09	29.21	29.18
Phosphorus levels (kg/ha)									
0 (p_o)					29.27	29.01	29.07	29.24	29.15
60 (p_1)					29.16	29.39	29.23	29.18	29.24
Mean					29.21	29.20	29.15	29.21	29.19

Control: Guinea grass (v_1) - 27.65
Setaria grass (v_2) - 28.40

Type of pair comparison of means	S.E.	C.D. (0.05)
V*; I; P	0.056	0.114
N; VI; VP; IP	0.080	--
VN; IN; PN	0.113	--

*Significant

62 and 63.

The effect due to nitrogen levels was significant only under open condition. The highest levels of nitrogen resulted in a significant increase in potassium content in open area. In open area the absorption of potassium was related to the drymatter production of grasses and hence the difference was significant.

The interaction effect of V x I and I x P were significant in open area. This may be mainly due to the main treatment effect of the grasses and phosphorus.

In soil where setaria was grown under control in both the situations, the available potassium content was significantly higher than in guinea grass plots. The treatment averages were also higher than the potassium content in control plots in both the locations.

Comparison of the data in Tables 74 and 75 showed that in partial shaded situation, there was a uniform reduction noticed in potassium content of soil. Under shade condition the requirement of potassium was more, as was clearly seen in the potassium content of both grass and stylo (Tables 42, 43, 44 and 45). This may be attributed the luxury consumption of potassium in shade (Henderson, 1960; Heiberg and Leaf, 1960).

4.10. Economics of fodder production

The economics of total fodder production/ha of grass + stylosanthes under both situations is presented in Table 76.

Perusal of the table revealed that among the two grasses tried, guinea recorded the highest net profit in open area (Rs.4688) and in coconut garden (Rs.4195). Guinea grass also recorded the highest cost benefit ratio in both the situations. Both the grasses registered higher cost benefit ratio than the respective grasses in absolute control in open area as well as in coconut garden.

Intercropping with stylosanthes recorded the maximum net profit under both situations. The increase in net profit due to intercropping was 91.08 percent in open area and 74.11 percent in partial shade. Cost benefit ratio was also highest due to intercropping stylo in both the situations. The cost benefit ratio due to intercropping revealed that for every rupee spent, it gives an additional income of ninetythree paise over non-intercropping in the open area and Rs.1/06 in coconut garden.

Table 76. Economics of fodder production.

Treatments	Cost of cultivation excluding treatments. Rs.	Addl. expenditure due to treatments. Rs.	Total expenditure Rs.	Open area			Coconut garden		
				Gross return Rs.	Net profit Rs.	Cost benefit ratio	Gross returns Rs.	Net profit Rs.	Cost benefit ratio
Grasses									
Guinea (v_1)	1952	807	2759	7447	4688	2.70	6954	4195	2.52
Setaria (v_2)	1952	807	2759	7247	4488	2.63	6428	3669	2.33
Intercropping									
None (i_o)	2671	-	2671	5823	3152	2.18	5019	2348	1.88
Stylosanthes (i_1)	2671	177	2848	8871	6023	3.11	8364	5516	2.94
Phosphorus levels (kg/ha)									
0 (p_o)	2666	-	2666	7049	4383	2.64	6303	3637	2.36
60 (p_1)	2666	187	2853	7644	4791	2.68	7078	4225	2.48
Nitrogen levels (kg/ha)									
50 (n_1)	2134	250	2384	6568	4184	2.76	6271	3887	2.63
100 (n_2)	2134	500	2634	7473	4839	2.84	6902	4268	2.62
150 (n_3)	2134	750	2884	7615	4731	2.64	6837	3953	2.37
200 (n_4)	2134	1000	3134	7731	4597	2.47	6753	3619	2.15
Control									
Guinea (v_1)	1952	-	1952	3508	1556	1.80	3729	1777	1.91
Setaria (v_2)	1952	-	1952	4043	2091	2.07	3331	1358	1.71

Price of 1 kg nitrogen = Rs.5.00

Price of 1 kg phosphorus= Rs.3.12

Price of 1 tonne of dryfodder = Rs.781.00

Among the levels of nitrogen 100 kg/ha recorded the highest net profit both the situations. The cost benefit ratio was highest for 100 kg nitrogen in open area while the difference in cost benefit ratio between 50 kg and 100 kg nitrogen in coconut garden was negligible.

Similarly phosphorus application @ 60 kg/ha registered higher net profit and cost benefit ratio than zero phosphorus under both the situations.

Comparison of the income from open area and coconut garden revealed that more income from fodder cultivation was obtained from open area than from coconut garden. But it is to be pointed out that in coconut garden the net profit obtained was over and above the income from the main crop of coconut. Thus this finding has considerable practical significance in a state like Kerala, where there is great scope for intercropping fodder in coconut gardens.

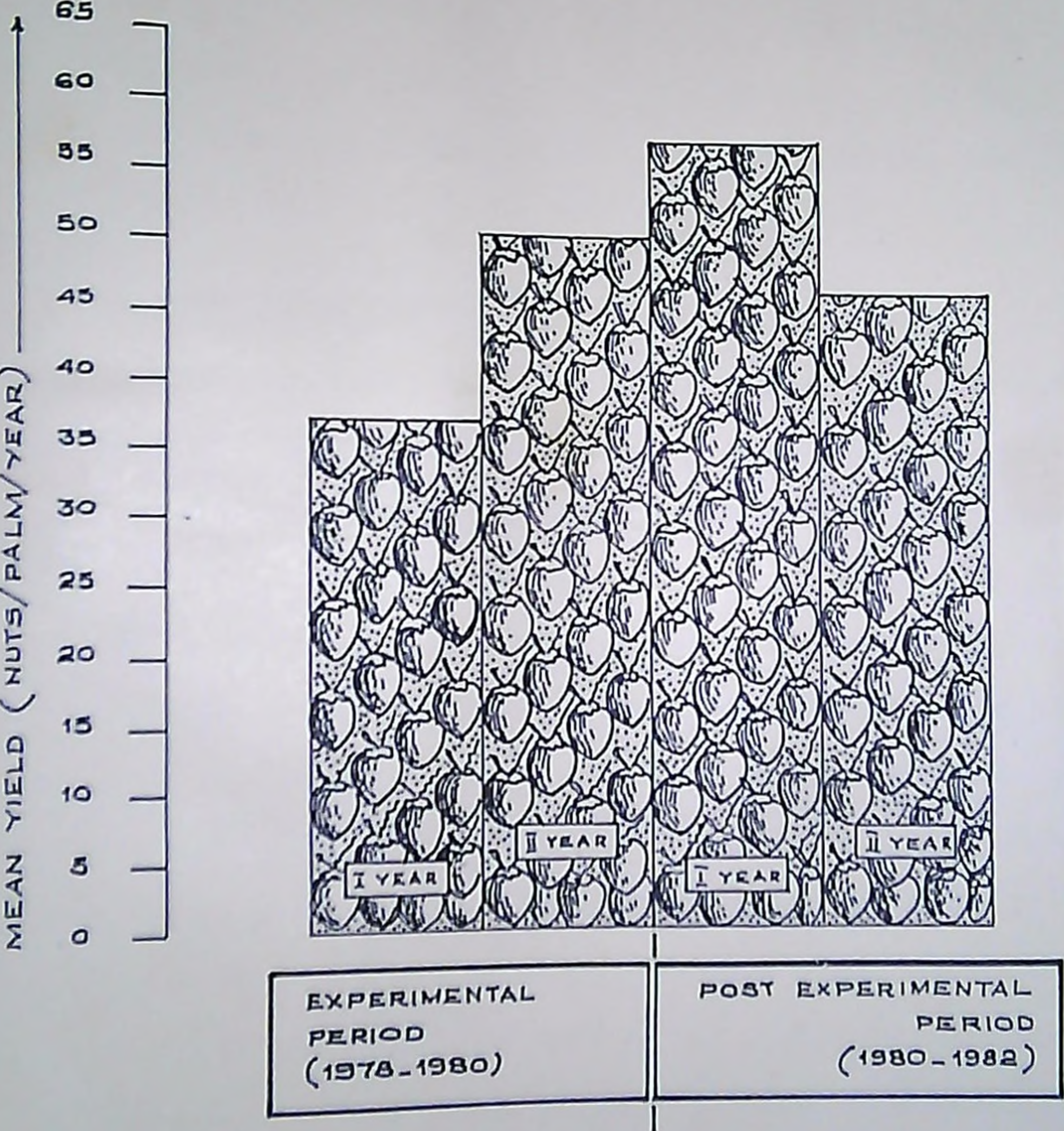
4.11. Influence of fodder intercropping on coconut yield

The data on the yield of coconuts (number of nuts/palm/year) obtained during the experimental period and the subsequent two years after the experiment are presented in Table 77.

Table 77. Yield of coconuts (Nuts/tree/year) during the period of fodder intercropping and subsequent two years after the experiment.

Sl. No.	Tree Number	Experimental period		After the experiment	
		1978-79	1979-80	1980-81	1981-82
1.	2828	2	27	69	61
2.	2829	91	29	46	42
3.	2830	55	46	99	64
4.	2833	33	27	47	35
5.	2834	32	54	63	23
6.	2837	14	33	49	50
7.	2838	48	56	37	58
8.	2836	51	84	67	33
9.	2835	22	77	62	10
10.	2832	36	11	18	13
11.	2831	37	46	45	15
12.	2888	16	43	31	23
13.	2826	1	39	72	23
14.	2827	37	62	67	23
15.	2825	51	94	76	51
16.	2824	73	86	24	37
17.	2794	12	16	44	17
18.	2823	68	66	73	81
19.	2818	0	18	57	80
20.	2812	56	54	48	64
21.	2810	57	60	79	59
22.	2808	67	93	83	82
23.	2800	73	60	86	56
24.	2887	25	52	64	70
25.	2889	12	46	49	63
26.	2891	2	31	40	56
27.	2892	46	47	59	80
28.	2893	20	34	91	48
29.	2816	55	87	70	66
	Mean	37.7	51.0	59.1	47.7

FIG-8. YIELD OF COCONUTS AS INFLUENCED BY FODDER INTERCROPPING



It may be seen that the mean yield of nuts/palm/year which was 37.7 during the first year of the experimental period increased to 51.0 during the second year. This increasing trend in the yield of coconut was sustained for one more year (59.1) after the experiment was over and then gradually declined (47.7). These sequences are illustrated in Figure 8.

The increase in nut yield in the second year of the experimental period was 35.35 percent more than the first year, while the rate of increase was 57.05 percent and 26.64 percent respectively during first and second year after the experimental period. The average increase in nut yield after two years of experimentation can be computed to be 20.54 percent. This increase in coconut yield may be due to improved fertilization and plant nutrition, weed control and other cultural practices provided for fodder crops grown in coconut garden. Such improved coconut yields following intercropping have been reported by several workers (Kotalawala, 1968; Kuttappan, 1971; Sethi, 1963; Sahasranaman, 1964). Thus it can be concluded that coconut really provides immense scope for a forage intercropping system, provided adequate care and management is given to both the principal as well as the intercrops. This has a remarkable practical utility for the dairy farmers having a coconut based fodder-cum-livestock production system.

SUMMARY

SUMMARY

An experiment was conducted during the period 1978 to 1980 in the Instructional Farm, College of Agriculture, Vellayani to compare the fodder production potential of two grasses under various management practices. The treatments consisted of two grasses viz. guinea and setaria, two systems of cropping viz. with and without a legume (Stylosanthes) intercrop. The fertilizer treatments included four levels of nitrogen viz. 50, 100, 150 and 200 kg N/ha, and two levels of phosphorus viz. 0 and 60 kg P_2O_5/ha. Separate experiments having 32 treatment combinations were carried out, one in an open area and the other in an adjascent coconut garden with 50 percent shade intensity. The data collected for two years from the experiments were statistically analysed, and the results were presented and discussed in the foregoing chapters. Apart from this, the yield of coconut palms existed in the experimental area during the period and two years after the trial, were also recorded and discussed. The findings of this study are summarised below:-

1. Grasses grown in coconut shade were found to be taller than those grown in open area.

2. Guinea grass recorded more number of tillers than setaria in coconut shade. Higher doses of nitrogen as well as full intensity of light increased tiller number in grasses.

3. Leaf stem ratio of guinea was found to be higher than that of setaria in both the situations. Leaf-stem ratio of grasses was found to be lower due to stylo intercropping.

4. In open area leafiness of stylo was enhanced while impartial shade it was decreased due to intercropping with guinea grass.

4. Nitrogen upto 100 kg/ha given in combination with 60 kg P_2O_5/ha in open area was effective in increasing the leafiness of stylo, while levels of nitrogen above 100 kg/ha showed a depressing effect on this quality parameter.

5. Leaf Area Index of guinea grass was higher in both the situations which indicated that the utilization of solar radiation was more by guinea than by setaria grass.

6. Guinea grass recorded higher crop growth rate than setaria in both the situations. A wide range of nitrogen levels from 50 kg to 200 kg was required to

influence the crop growth rate of grasses. It was also revealed that crop growth rate was lesser in coconut shade.

7. The crop growth rate of stylo when grown with guinea grass was higher than when intercropped along with setaria grass. The application of phosphorus significantly resulted in a higher crop growth rate for stylo in both the situations. With regard to nitrogen doses, the crop growth rate increased only upto 100 kg N/ha.

It was further noticed that the growth rate of stylo in partial shade was better than in full sunlight.

8. Guinea grass has given higher drymatter yield than setaria in both the situations. It was also found that drymatter production of grass in open area was more than that in coconut garden. Further it was observed that the drymatter yield was positively correlated with tiller production. This was more significant in open area.

Intercropping with stylosanthes in partial shade has increased the fodder yield of grasses. This was further improved by the application of phosphorus.

Phosphorus applied at 60 kg/ha has significantly increased the fodder yield especially in guinea grass.

Response of pure crop of grasses to nitrogen levels in open area was noticed upto 150 kg/ha and optimum dose was found to be 191 kg/ha, while the response in coconut shade was found to be 156 kg/ha. The drymatter production per unit of nitrogen applied was higher in open area than in partial shade. Between the two grasses grown under shade, guinea showed better production efficiency than setaria especially at moderate levels of nitrogen.

It was noticed that application of nitrogen beyond 150 kg/ha is not necessary for a pure crop of guinea grass especially at reduced light intensity experienced in coconut garden. It was also observed that when intercropped with stylosanthes and supplied with 60 kg P_2O_5/ha the response to N was obtained only upto 100 kg/ha.

9. When intercropped with guinea grass the drymatter yield of stylosanthes was found better than when intercropped with setaria. Phosphorus application also improved the yield of stylo more so in coconut garden. Nitrogen levels upto 100 kg/ha only were effective in increasing the yield of stylo.

In general the fodder yield of stylo was more in coconut garden than in open area.

10. Total drymatter yield of guinea and stylo was more than that of setaria and stylosanthes in open area as well as in coconut garden. Even under shaded situation guinea grass was better than setaria in yield. The decrease in fodder yield due to shade can be made good by intercropping with stylosanthes apart from increasing the quality.

It was further noticed that the percentage increase in drymatter yield due to grass-legume association was more in coconut garden. Phosphorus application increased the total fodder yield in both the situations. Nitrogen levels also increased the total fodder yield and the optimum was found to be 171 kg/ha for open area and 145 kg/ha for coconut garden for grass-legume combination.

11. In quality aspects guinea grass was superior to setaria grass in many respects. Protein content of guinea grass was more than that of setaria. When grown in coconut garden a slight increase in crude protein content of grasses was noticed which was more pronounced in the case of guinea. Stylo intercropping as well as nitrogen and phosphorus application, helped to increase the crude protein content in grass, more so in coconut shade.

12. Phosphorus application increased the protein

content of stylo in open area and in shade. Nitrogen levels showed no effect on protein content of stylo. In general, the protein content of stylo in partial shade was higher than in the open area.

13. The protein yield of guinea grass + stylosanthes combination was higher than that of setaria + stylosanthes. Nitrogen doses upto 100 kg/ha increased the protein yield. Similarly phosphorus dose of 60 kg P_2O_5/ha increased the protein yield of grass + stylo combination.

14. The crude fibre content of setaria grass was higher than that of guinea in both the situations indicating the superiority of guinea grass. The fibre content of grasses decreased with increase in nitrogen doses while the protein content increased with increased nitrogen dose. It was noticed that as protein content increased the fibre content of grass decreased and vice versa.

15. The crude fibre content of grasses decreased due to treatments over control indicating that different management practices improved the quality and palatability of fodder.

It was also noticed that the fibre content was lesser when the grasses were grown in shade. This resulted in the production of more succulent fodder in shade than in the open.

16. The fibre content of stylosanthes increased due to phosphorus application @ 60 kg/ha in both the situations. In shade the fibre content of stylo was lesser and hence more succulent fodder was obtained.

17. Ash content of grasses grown alone, was higher than when grown with intercrops. The ash content was found more in the open area where the growth of stylo was less and the growth of grass was more.

18. Ash content of stylosanthes in both the situations increased due to phosphorus application. Nitrogen levels upto 100 kg/ha increased the ash content of stylo in open area only.

It was further noticed that the ash content of stylo was more in the open area than under shade.

19. Phosphorus content of guinea was more than in setaria under both the situations. Intercropping with stylo, as well as application of phosphorus, enabled the grasses to increase their phosphorus content in the fodder.

The phosphorus content of stylosanthes was higher in open than in shade.

20. In open area and in shade the potassium content of setaria grass was more than in guinea grass.

Intercropping with stylosanthes increased the potassium content of grasses in both the situations. Similarly nitrogen doses as well as phosphorus application helped to improve the potassium content in grass.

It was also revealed that the potassium content of grass grown in shade was more than in the open area.

21. The potassium content of stylo due to intercropping with guinea was less than the potassium content due to setaria intercropping.

22. Under partial shade due to intercropping with setaria the potassium content of stylo was increased. In shade there was increase in potassium content of stylo due to nitrogen application upto 100 kg/ha. In the case of phosphorus application a decrease in the potassium content was noticed in open area only. Raised an intercrop in coconut shade the requirement of potassium by stylo was high, especially when the drymatter production was more.

23. The calcium content of guinea grass was found to be more than that of setaria in both the situations. Intercropping with stylo as well as nitrogen applications upto 100 kg/ha increased the calcium content in grass. When compared to open area the calcium content was higher in coconut garden.

24. The calcium content in stylosanthes increased due to phosphorus and nitrogen applications in both the situations. In partial shade the calcium content was found to be more.

25. The magnesium content of setaria was found to be more than that of guinea in both the situations. Stylo intercropping has increased the magnesium content in both the situations. The magnesium content of grass was found to be more in coconut garden than in open area. But in partial shade magnesium content was reduced due to phosphorus while nitrogen application increased the magnesium content.

26. Stylosanthes grown as intercrop of guinea recorded more magnesium content in shade while in open area stylo intercropped with setaria recorded a higher magnesium content. Phosphorus application resulted in a higher magnesium content in both the situations but higher doses

of nitrogen increased the magnesium content of stylo in open area only.

27. The various treatments and their interactions had no influence on the K: (Ca + Mg) ratio of grasses in shade.

In open area guinea recorded a lower ratio than setaria. Phosphorus application increased the K: (Ca + Mg) ratio of grasses. The treatment mean ratio was less than 2.38 in this study and in shade it was still lower which indicates that intercropping fodder in coconut garden is completely safe as far as this ratio is concerned.

28. Stylosanthes when intercropped in setaria plots registered a higher K: (Ca + Mg) ratio than when inter-cropped in guinea grass plots. Application of phosphorus also reduced this ratio in open area.

29. The total uptake of nitrogen for two years by guinea was more than setaria in both the situations. Phosphorus and nitrogen applications increased the nitrogen uptake of grasses. The uptake of nitrogen due to inter-cropping was significant only in coconut garden. In open area the uptake was more.

When intercropped with guinea grass the uptake of nitrogen by stylosanthes was more than intercropping with setaria. Similarly nitrogen and phosphorus application increased the uptake of nitrogen in both the situations. The nitrogen uptake was more in open area.

30. The total uptake of phosphorus by guinea was more than setaria in both the situations. Phosphorus and nitrogen applications increased the total uptake of phosphorus in both the situations. Intercropping with stylosanthes increased the phosphorus uptake only in coconut garden. The uptake of phosphorus was more in open area.

When intercropped with guinea the uptake of phosphorus by stylosanthes was more than intercropping with setaria. Application of phosphorus and nitrogen increased the phosphorus uptake by stylosanthes in both the situations. In open area the uptake of phosphorus was higher than in coconut garden.

31. The total uptake of potassium by guinea grass for two years was more than setaria in coconut garden. Intercropping with stylosanthes as well as phosphorus application increased the total uptake of potassium in both the situations. In the case of nitrogen levels, the uptake of

potassium by grasses increased upto 100 kg N/ha in coconut garden and upto 150 kg N/ha in open area.

The total uptake of potassium by grasses was more in open area than in coconut garden.

In the case of stylosanthes the total uptake of potassium was more due to phosphorus application in both the situations. The uptake increased upto under 100 kg nitrogen level beyond which it showed a depressing effect.

32. The soil nitrogen content of guinea grass plots was higher than that of setaria plots in both the situations. Intercropping with stylo and application of nitrogen increased the soil nitrogen status. In coconut garden the nitrogen content of soil was found to be higher than in the open area which is attributed to higher production of stylosanthes.

33. The soil phosphorus content of guinea grass plots was lower than that of setaria plots indicating a higher removal of phosphorus by guinea grass. In stylosanthes intercropped plots the phosphorus content was significantly lesser than non-intercropped plots. Phosphorus application increased the soil phosphorus content while nitrogen doses significantly reduced the phosphorus

status of the soil. The phosphorus content in coconut in coconut garden soils was found to be more than in the open area.

34. The soil potassium content of guinea grass plots was lesser than that of the setaria plots in both the situations. Phosphorus and nitrogen levels improved the potassium content of soil in open area only. The potassium content in coconut garden soil was lesser than in the open area which is attributed to the luxury consumption of potassium by grasses in shade.

35. Guinea grass recorded higher net profit than setaria in both the situations. Guinea grass also recorded the highest cost benefit ratio in both the situations. Similarly intercropping with stylosanthes and application of phosphorus increased the net profit. The cost benefit ratio was the highest due to intercropping stylosanthes in both the situations. Among the different levels of nitrogen, 100 kg/ha recorded the maximum net return in both the situations. If fodder alone is taken into account more income was recorded from open area. But in coconut garden the net profit obtained is over and above the income from the main crop of coconut. This aspect has got great practical

significance in the state where the practice of fodder intercropping in coconut garden has got immense scope.

36. The coconut yield increased to the tune of 20.54 percent due to fodder intercropping for a period of two years which may be due to the improved fertilization and plant nutrition, weed control and other cultural practices provided for the fodder crops grown in coconut garden. This finding has a very remarkable practical utility for the dairy farmers of the state where a coconut based fodder-cum-livestock production system is in practice.

Finally it was concluded that in open area, guinea grass intercropped, with stylosanthes and supplied with 60 kg phosphorus plus 150 kg nitrogen, and in coconut garden guinea grass intercropped with stylosanthes and supplied with 60 kg phosphorus plus 100 kg nitrogen was found to be the best management practice for obtaining higher fodder yield and good quality forage. It was also proved that fodder intercropping in the interspaces of coconut palms increases coconut yield.

Future line of work

Coconut being a perennial crop committed to the land for more than a century, a long term intercropping experiment with promising fodder grasses and legumes may be undertaken. The physico-chemical and biological properties of soil due to fodder cropping as well as, impact of fodder intercropping on coconut production may be included in the proposed study.

REFERENCES

REFERENCES

Abraham, C.T., Sreedharan, C. and Raghavan Pillai, G. (1980). Effect of nitrogen and lime on forage quality of dinanath grass. Forage Res. 6: 95-98.

Acharya, N. (1973). Yield and quality of two varieties of grasses as influenced by nitrogen fertilization. Madras agric. J. 60(8): 1017-1018.

*Adepetu, J.A. and Barber, S.A. (1978). Soil P availability of millet roots. Commo. Soil Sci. & Plant Analysis, 1978, 9, 6, 541-50(En) Phosphorus in Agric. 75.

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

Ahlawat, M.R., Saini, S.S. and Jindia, J.R. (1964). Effect of nitrogen on the yields of some early Khariff fodders grown alone or mixed with legumes. J. Res. Punjab Agric. Univ. 1(1): 106-110.

Andrew, C.S. and Robins, M.F. (1969 a). The effect of phosphorus on the growth and chemical composition of some tropical pasture legumes. II. Nitrogen Ca, Mg, K and sodium contents. Australian J. Agric. Res. 20: 675-684.

Andrew, C.S. and Robins, M.F. (1969 b). The effect of potassium on the growth and chemical composition of some tropical and temperate pasture legumes. 2. Potassium, calcium, magnesium, sodium, nitrogen, phosphorus and chloride. Australian J. Agric. Res. 20: 1009.

Andrew, C.S. and Robins, M.F. (1971). Effect of phosphorus on the growth, chemical composition and critical phosphorus percentages of some tropical pasture grasses. Australian J. Agric. Res. 22: 693-706.

Anonymous (1972 a). Progress report of the All India Co-ordinated Project for Research on Forage Crops, ICAR. 1971-72 Pantnagar Centre pp.98.

Anonymous (1972 b). Progress report of the All India Co-ordinated Project for Research on Forage Crops, ICAR. 1971-72 Jabalpur Centre pp.89.

Anonymous (1973). Annual report 1973 of the All India Co-ordinated Project for Research on Forage Crops, Kerala Agric. Univ., College of Agric., Vellayani, Kerala pp.42.

Anonymous (1974). Annual report of All India Co-ordinated Project for Research on Forage Crops. Tamil Nadu Agric. Univ., Coimbatore: 30-31.

Anonymous (1975 a). National Symposium on Forage and Forage seed production, IGFRI, Jhansi (UP): 14-270.

Anonymous (1975 b). Coconut convention Technical Report 9th and 10th October, 1975, Kerala Agric. Univ. pp.59.

Anonymous (1977 a). Annual progress report of the All India Co-ordinated Project for Research on Forage Crops, 1976-77. Main centre - Palampur, Himachal Pradesh Agric. Univ. 37 and 39.

Anonymous (1977 b). Annual progress report of the All India Co-ordinated Project for Research on Forage Crops, 1976-77 MPKV, Rahuri Centre: 10-17.

Anonymous (1977 c). Annual progress report of the All India Co-ordinated Project for Research on Forage Crops, 1976-77. Gujarat Agric. Univ., Anand: 21-22.

Anonymous (1977 d). Status paper on fodder development, Directorate of Agric., Govt. of Kerala, Trivandrum pp.52.

Anonymous (1978 a). Summarised Report of Research work done from 1971-78. All India Co-ordinated Project for Research on Forage Crops, Kerala Agric. Univ., College of Agric., Vellayani pp.60.

Anonymous (1978 b). Annual progress report of the All India Co-ordinated Project for Research on Forage Crops. Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani, West Bengal pp.106.

Anonymous (1978 c). Annual report 1978. All India Co-ordinated Project for Research on Forage Crops, Kerala Agric. Univ., College of Agric., Vellayani, Kerala.

Anonymous (1978 d). Annual report 1978. Tropical Pasture Programme, Centro Internacional de Agricultura Tropical, Quilichao.

Anonymous (1979 a). Annual progress report of All India Co-ordinated Project for Research on Forage Crops, MPKV, Rahuri 1978-79.

Anonymous (1979 b). Annual progress report 1979. All India Co-ordinated Project for Research on Forage Crops, Kerala Agric. Univ., College of Agric., Vellayani pp.34.

Anonymous (1980). Ten years' report of All India Co-ordinated Project for Research on Forage Crops. Kerala Agric. Univ., College of Agric., Vellayani, Kerala pp.88.

A.O.A.C. (1975). Official Methods of Analysis. 12th Ed. Association of Official and Analytical Chemists, Washington, D.C. pp.217.

Appadurai, R.R. (1968). Grassland Farming in Ceylon. T.B.S. Godmunne & Sons Ltd., Kandy, Srilanka pp.135.

Ayyangar, G.N.R. (1942). Mixed cropping in India. Indian Fmg. 3: 255-276.

Bahl, D.B., Bhaid, H.U. and Srivatsava, J.P. (1970). Influence of fertilizer on the yield, botanical composition and quality of pasture in Malwa. First workshop on forage crops at the Haryana Agric. Univ., Hissar pp.12.

Balasko, J.A. (1977). Effects of nitrogen, phosphorus and potassium fertilization on yield and quality of tall fescue forage in winter. Agron. J. 69(3): 425-428.

Balasundaram, C.S., Chandramani, R.J., Krishnamoorthy, K.K. and Balakrishnan, T. (1975). Optimum time of cutting for maximum yield of extractable protein in some fodder grasses. Madras agric. J. 62: 431-434.

Balbatti, M.S. (1980). Effect of nitrogen levels and row spacings on yield and quality of hybrid napier grown with and without legume. M.Sc.(Ag) Thesis, Kerala Agric. Univ. 1980.

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

Bhagwan Das, Arora, S.K., Paroda, P.S., Gill, P.S. and Luthra, Y.P. (1975). Nutritive parameters of summer legume forages in relation to P levels and irrigation regimes. Indian J. Dairy Sci. 28: 190-195.

Black, C.A. (1968). Soil Plant Relationships, John Wiley and Sons, Inc. New York, 2nd Ed: 202-272.

Blunt, C.G. and Humphreys, L.R. (1970). Phosphate response of mixed stands at Mt. Cotton South Eastern Queensland. Aust. J. Exp. Agric. Anim. Husb. 10: 431-441.

Bogdan, A.V. (1966). Glycine javanica under experimental cultivation in Kenya. Trop. Agric. Trin., 43: 99-105.

Bogdan, A.V. (1977). Tropical Pasture and Fodder Plants (Grasses and legumes). Longman, London and New York: 186-299.

Bokade, S. (1968). Effect of different levels of nitrogen application and cutting interval on growth, yield and quality of two varieties of oats. Indian J. Agron. 24: 50-53.

Bruce, R.C. (1976). Tropical Forage Legumes. Food and agriculture Organisation of the United Nations, Rome pp.377.

Bruce, R.C. and Teitzel, J.K. (1978). Nutrition of Stylosanthes guianensis on two sandy soils in a humid tropical low land environment. Trop. Grassl. 12(1): 39-48.

*Bunproma, K. and Mobbayad, B.B. (1978). Effect of plant population, density and nitrogen fertilizer application on sorghum - soybean intercrop. Phillippines J. Crop. Sci. 3(4): 221-227.

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

Burton, J.C. (1959 b). Selection, propagation and practical use of rhizobia culture in the United States. Recent Adv. Bot. 1: 596-600.

*Butterworth, M.H. (1967). The digestibility of tropical grasses. Nutr. Abst. Rev., 37: 349-368.

*Byasov, K.H. (1974). Biological nitrogen cycle and ash content in maize on main soils of Severo - Osetin. USSR. Herb. Abstr. 46: 1033.

Capiel, M. and Ashcroft, G.L. (1972). Effect of irrigation, harvest interval and nitrogen on the yield and nutrient composition of napier grass. Agron. J. 64: 376-378.

*Caro-Costas, R. and Vicente-Chandler, J.J. (1956). Production potentialities of pastures in the tropics and subtropics. J.G. De Geus, Centre D' Etude De L' Azote, Zurich pp.54.

Carter, L.P. and Scholl, J.M. (1972). Effectiveness of inorganic nitrogen as a replacement for legumes grown in association with forage grasses. Agron. J. 64: 396-378.

Chadhokar, P.A. (1978). Effect of rate and frequency of nitrogen application on drymatter yield and nitrogen content of para grass. Herb. Abstr. 49: 173-174.

Chandini, S. and Raghavan Pillai, G. (1980). Economics of herbage production of grass legume mixtures in the humid tropics. Forage Res. 9(1): 91.

Chandramoni, R., Balasundaram, C.S., Krishnamoorthy, K.K. and Balakrishnan, T. (1975). The effect of nitrogen and frequency of cutting in guinea grass. Madras agric. J. 62(3): 155-157.

Chandrasekharan, P., Balasubramonian, M., Shanmugasundaram, V., and Fazlullah Khan, A.K. (1980). Research work on grass, legumes and fodder trees in Tamil Nadu - problems and prospects. Paper presented in the 2nd National Seminar on fodder production at NDDB, Anand. pp.24-32.

*Charles, J.P. (1976). Experience of grass-legume mixtures compared to pasture stands of Switzerland. Herb. Abstr. 48: 1801.

Chauhan, D.S., Mahajan, J.M., Tomer, U.P.S. (1971). Cowpea for forage in Himachal Pradesh. Indian Fmg. 21(8): 39.

Cheng, K.L. and Bray, R.H. (1951). Determination of calcium and magnesium in soil and plant material. Soil Sci., 72: 449-458.

*Chumakovskiy, N.N. and Kefeli, V.I. (1968). "Interaction of natural growth regulators in tall and dwarf pea forms growing in Sakhalis Islands". Proc. U.S.S.R. Acad. Sci., Biol. series (In Russian).

Cochran, W.G. and Cox, G.M. (1965). Experimental Designs. Asia Publication House.

Colman, R.L. and Mears, P.T. (1975). Tropical Grasslands, 9(2): 101-108.

Crespo, G., Rodriguez, T., Peres, J. (1975). Potential response of guinea grass (Panicum maximum Jacq) and pangola grass (Digitaria decumbens, Stent.) to nitrogen fertilization. Cuban J. Agric. Sci. 1975 a (3): 353-362.

Crowder, L.V., Michelin, A. and Bastidas, A. (1964). The response of pangola grass (Digitaria decumbens, Stent) to rate and time of nitrogen application in Columbia. Trop. Agric. Trin. 41: 21-29.

Crowder, L.V. and Chheda, H.R. (1977). Forage and Fodder crops. In "Food Crops of the Lowland Tropics". Edited by Leakey and Wills, Oxford Univ. Press pp.216.

Dabadghao, P.M., Chakravarty, A.K., Das, R.B., Deb Roy, R. and Marwaha, S.P. (1965). Response of some promising desert grasses to fertilizer treatments. Ann Arid zone, 4: 120-135.

Daulay, H.S., Chakravarty, A.K. and Bhati, G.N. (1968). Study on the pasture establishment technique. III Effect of intercropping with different legumes on the growth and forage production of Dhawan (Cenchrus ciliaris) and Sewan (Lasiurus sindicus) Pastures in the establishment year. Ann. Arid zone, 7: 265-269.

Daulay, H.S., Chakravarty, A.K., and Bhati, G.N. (1970). Intercropping of grasses and legumes. Indian Fmg., 19 (10): 12-14.

De Geus, J.G. (1977). Production potentialities of pastures in the tropics and subtropics. CENTRE D'ETUDE DE L'AZOTE, ZURICH pp.27.

Demarquilly, C. (1970). Feeding value of green forages as influenced by nitrogen fertilization. Herb. Abstr. 41: 2645.

Dey, N.R., Ghosh, A.K. and Joshi, H. (1958). Intercropping of sorghum with legumes. Allahabad Farmer 32: 240-241.

*Dobereiner, J. and Aronovich, S. (1965). Effecto da calagen e da temperatura do sola na fixaco de nitrogenuo de Centrosema pubescens benth. em solo com toxidez de manganes. Proc. IX. Int. Grasslds. Congr., 2: 1121-1124.

Drodsov, I.P. and Lepkovich, I.P. (1976). Effect of biological peculiarities of leguminous - graminaceous sward components and the nitrogen fertilizer rates on yield formation. Proc. 12th Intr. Grasslds Congr. Chemicalisation of Grassland farming I. Moscow, U.S.S.R. (1974): 118-128.

Duggar, B.M. (1903). The physiological effects of shading plants. Proc. Soc. Hort. Sci. 15-17.

Duncan, W.G. (1975). Maize. Crop Physiology, Some case histories, Cambridge University Press pp.23-51.

Dus arthur, L. (1971). Competition between grass and legume species on dryland. Agron J. 63(3): 359-362.

Dwivedi, G.K., Kanodia, K.C. and Rai, P. (1980). Effect of nitrogen and phosphorus on quantity and quality of herbage of Chrysopogon fulvus (spreng) Chin. cv. Mhow at Jhansi. Forage Res. 6: 181-186.

*Eliassova, L. (1971). Growth Inhibitors in Populus tremula Physiol. Plantarum, 24: 205.

Eng, P.K., Kerridge, P.C. and Mannetje, L.T. (1978). Effect of phosphorus and stocking rate on pasture and animal production from a guinea grass-legume pasture in Johore, Malaysia, I. Drymatter yields, botanical and chemical composition. Trop. Grass L. 12(3): 188-197.

*Erickson, F.I. (1977). The effect of different light intensities on morphology, yield and nitrogen fixation rates of tropical grasses and legumes. Ph.D. dissertation, University of Hawaii, Honolulu U.S.A. (unpublished).

Falade, J.A. (1973). Effect of phosphorus on the growth and mineral composition of four tropical forage legumes. J. Sci. Food. Agric. Abstr. 24(7): 795-802.

Faroda, A.S. (1970). Effect of different levels of phosphorus with and without nitrogen on the growth and yield of anjan grass Cenchrus ciliaris. First workshop on Forage crops at the Haryana Agric. Univ., Hissar, 17-19 September, 1970.

Faroda, A.S. and Tomer, P.S. (1970). Nutrients uptake by fodder varieties of cowpea under phosphate, nitrogenous and bacterial fertilization. Forage Res. 1: 47-53.

*Filipek, J. and Kasperczyk, M. (1975). Effect of rate of application on yield and quality of sown pastures. Herb. Abstr. 46(7): 2986.

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

Furaya, M. and Galtson, A. (1965). "Flavinoid complexes in Pisum sativum L.J." Phytochrome 4: 285.

Garg, K.P., Sharma, A.K. and Thakur, B.S. (1970). Manuring of cowpea. I. Studies on the effect of different rates of phosphorus and molybdenum on the growth and yield of cowpea fodder and residual effect on wheat. Indian J. Agron. 15: 112-116.

Gervias, P. (1960). Effect of varying levels of phosphorus and potassium applications on productivity and botanical and chemical composition of a ladino clover-timothy association. Soils Fert. 23(6): 2781.

Gill, A.S., Maurya, R.K., Pandey, R.K., Mukhtar Singh, Mannikar, N.D. and Abichandani, C.T. (1972). Effect of different levels of nitrogen and phosphorus on fodder yield and chemical compositions of sorghum and cowpea. Indian J. Agric. Res. 7: 185-190.

Gillard, P. (1977). Establishment of Townsville stylo in native perennial grass pastures. Aust. J. Exp. Agric. Anim. Husb. 17, 784.

Govindaswamy, M. (1978). Studies on comparative performance of different cowpea (*Vigna sinensis*) varieties in relation to yield and fodder value as influenced by phosphorus and molybdenum fertilization. M.Sc.(Ag) Thesis, Tamil nadu Agric. Univ.

Grof, B. and Harding, W.A.T. (1970). Drymatter yields and animal production of guinea grass (*Panicum maximum*) on the humid tropical coast of North Queensland. Trop. Grass L. 4(1): 85-95.

Grumes, D.L., Stout, P.R. and Brownwell, J.R. (1970). Grass tetany of ruminants. Adv. Agron. 22: 332-369.

Guerrero, R., Fassbender, H.W. and Blydenstein, J. (1970). Fertilizer application to elephant grass (*Pennisetum purpureum*) in Costa - Rica. Agron. J. 69: 30-35.

*Gutierres, G.J.M. (1971). Studies on the fertilizing of semi natural grassland communities. III. Relative yield increase and mineral content. Relationship with soil composition. Soils Fert. 35(1): 93.

Hacker, J.B. and Jones, R.J. (1969). The *Setaria sphacelata* complex - A review. Trop. Grassl. 3: 13.

Hadjchristodoulou, A. (1973). Production of forage from cereals, legumes and their mixtures under rainfed conditions in Cyprus. (Agric. Res. Tech. Bul. 14) Forage Res. 9: 105-188.

Haggar, R.J. (1971). The production and management of Stylosanthes gracilis at Shika, Nigeria. II. In Savanna grassland. J. Agric. Sci. Camb. 77: 437.

Heiberg, S.O. and A.L. Leaf (1960). Potassium fertilization of coniferous plantations in New York. Proc. 7th Intern. Congr. Soil Sci. 3: 376.

Henderson, R. (1960). The application of potassic fertilizers to pasture and incidence of hypomagnesemia. Potash Ltd., Tech. Seri. 1: 23.

*Hendrikson, A. (1960). Influence of fertilizer treatment on the mineral content of pastures. Soils Fert. 23(5): 363.

Henzell, E.F. (1962). Nodulation and nitrogen fixation of tropical legume. Adv. Agron. 22: 23-26.

Henzell, E.F. (1968). Tropical Grasslands, 2: 1-17.

Henzell, E.F. (1970). Problems in comparing the nitrogen economics of legume based and nitrogen - fertilized pasture systems. Proc. XI Int. Grasslds. 112-120.

*Hojatti, L. and Gillet, M. (1974). The influence of N fertilizer and optimum management on quality of green forages. Herb. Abstr. 46(4): 1642.

Hojatti, M., Templeton, W.C. Jr. and Taylor, T.H. (1977). Change in chemical composition of Kentucky blue grass and Tall Fescue herbages following N fertilization. Agron. J. 69(2): 264-268.

Humbphreys, L.R. and Robinson, A.R. (1966). Interrelation of leaf area and non-structural carbohydrate status as determinents of the growth of subtropical grasses. Proc. 10th Int. Grasslds. Congr. 113-116.

Humphreys, L.R. (1978). Tropical Pastures and Fodder Crops. Intermediate Tropical Agriculture Series. Longman Group, London pp.197.

Humphreys, L.R. (1981). Environmental adaptation of tropical pasture plants, Scientific and Medical Division. Macmillian Publishers Ltd., London and Basingstoke pp.197.

*Huget, L. and Gillet, M. (1974). The influence of N fertilization and optimum management on quality of green forages. Herb. Abstr. 46: 1642.

Hutton, E.M. (1970). Tropical pastures. Adv. Agron. 22: 2-66.

*Inosaka, M., Ito, K., Numaguchi, H. and Higashi, S. (1975). Studies on the productivity of some tropical grasses Herb. Abstr. 46: 2532.

Jackson, C.M. and Ulrich, A. (1959). Analytical methods for use of plant analysis. Calif, Agric. Expt. Sta. Bull. (766): 26-76.

Jackson, M.L. (1970). Soil Chemical Analysis. Prentice Hall of India Private Ltd. New Delhi 2nd Ed. pp.498.

James, R.L. and Frank, O.R. (1942). Inter-relationship of legumes and grasses grown in association. J. Amer. Soc. Agron. 34: 695-701.

Jarrell, W.M. and Beverly, R.B. (1981). "The dilution effect in plant nutrition studies" Advances in Agronomy 34: 197-222.

*Javier, E.Q., Leon, B.De and Castillo, E. (1977). Fertilizer response to pasture crops on Aborton sandy loams - an infertile coastal plain soil in Palawan. Herb. Abstr. 49(1).

Johnson, W.L., Ordoveza, A.L., Haridson, W.A. and Castillo, L.S. (1967). The nutritive value of guinea grass. I. Yield and chemical composition related to season and herbage growth stage. J. Agric. Sci. Camb. 69: 155-160.

Jones, R.J. (1970). The effect of nitrogen fertilizer applied in spring and autumn on the production and botanical composition of two subtropical grass-legume mixtures. Trop. Grasslds, 4, (1): 97-109.

Jones, R.K. (1968). Initial and residual effects superphosphate on a Townswille lucerne pasture in North East Quennsland. Australian J. Exp. Agric. Anim. Husb. 8: 521-527.

Jones, R.K. (1974). A study of the phosphorus responses of a wide range of accessions from the genus stylosanthes. Australian J. of Agric. Res. 25(6): 847-862.

*Julen, G. (1976). Botanical analysis of grass-legume mixtures by means of chemical analysis. Herb. Abstr. 48(6).

*Jurion, F. and Henry, J. (1969). Can primitive farming be modernised? Publication de I' institute National Pour I' Etude Agronomique du Congo (INEAC).

Kalra, G.S. and Khokhar, J.S. (1979). Effect of nitrogen and potassium on yield and quality of legume plue non-legume fodder mixture. Forage Res. 5(1): 57-62.

Kandaswamy, P., Sundaram, P. and Krishnamurthy, K.K. (1973). Nitrogen and phosphorus application and the age of the crop on the crude protein content in Panicum maximum. L. Madras Agric. J. 60(8): 970-972.

*Kandera, J. (1971). Effect of high rates of phosphorus and potash on yields and forage quality of Medicago sativa. Soils Fert. 35(2): 213.

*Kefeli, V.I. (1978). Natural plant growth inhibitors and phytochromes published by Dr. W. Junk. b.v. publishers. The Magree 1978 pp.110-113.

Kemp, A. and t' Hart, M.L. (1957). Grass tetany in grazing milking cows. Netherland J. Agric. Res. 5: 4-17.

*Kitamura, Y., Nishimura, S. and Tanaka, S. (1975). Studies on mixed cultivation of tropical legume and grass. I. Legume effects in terms of increased drymatter on nitrogen yield in mixed stands of Desmodium intortum and Setaria sphaecelata. Herb. Abstr. 46(9): 3814.

Kitamura, Y., Nishimura, S. and Tanaka, S. (1978). Studies on mixed cultivation of tropical legume and grass. 6. Changes in mixture effect on increasing drymatter production. J. Japanese Soc. Grass L. Sci. 24(2): 123-127.

Khan, D.H. and Ali, M.I. (1969). Mineral balance in grass as influenced by fertility conditions in soil. J. Sci. Fd. Agric.20(11): 671-672.

*Kharkov, G.D., Shekhovtseva, N.S. (1976). Response of red clover and red clover/timothy mixture to applied nitrogen. Trudy, Vsesoyuznyi Institut Udobreniyai, Agropochvovedeniya (1975) No. 25. 335-339 (Ru) Herb. Abstr.6(6): 2539.

Kotalwala, J. (1968). Pineapple cultivation in coconut land in the low-country wet zone. Ceylon coconut planters' review. 5(3): 112-114.

*Koter, Z. (1974). Comparison of chemical composition of grasses and lucerne in pure stands and in mixtures under various conditions of nitrogen fertilization. Herb. Abstr. 47: 1361.

*Kristozov, A. (1964). Concerning the growth and production features of the Ohio C - 92 maize hybrid and certain soya varieties grown as mixed crops. Rast. Nauki 1: 51-58.

*Kritayanavach, P. (1968). Effect of rate and method of nitrogen application on napier and hybrid napier. Herb. Abstr. 42: 716.

Kurup, K.P.P. (1971). Growth analysis and regrowth potential of three cool season grasses in spring. M.Sc. Thesis in Agronomy 1971 Virginia Polytechnic Institute and State University, Blacksburg, Virginia, U.S.A. (Unpublished).

Kuttappan, M. (1971). Banana - beneficial intercrop in coconut gardens. Coconut Bulletin. 1 (2): 2-4.

Lal, M. (1979). P transformation under continuous submergence in rice barley rotation. J. Indian Soc. Soil Sci. 27(4): 375-382.

Leather (1897). Effect of legume and non-legume grown pure and mixed on yield and quality of forage. Indian Agric. 12(1): 62-63.

Little, S., Vicente, J. and Abruna, F. (1959). Yield and protein content of irrigated napier grass and pangola grass as affected by nitrogen fertilization. Agron. J. 51(2): 111-113.

Lokhart, J.A. (1961). "Photoinhibition of stem elongation by full solar radiation". American J. Botany 48: 387-391.

*Lorsen, E.R. (1966). Effect of nitrogen fertilization on yield and chemical composition of corn and certain grass spp. Diss. Abstr. 26(11): 6282.

*Lotero, C.J., Bernal, E.J. and Hezzera, P.G. (1967). Planting distance and nitrogen application with elephant grass. Herb. Abstr. 38: 1773.

Lowe, J. (1970). Comparative efficiency of pastures and crops for animal production. Proc. 11th Int. Grassland Congress Surfers Paradise, Queensland, Australia pp.88.

Ludlow, M.M., Wilson, G.L. and Heatchrurst, M.R. (1974). Studies on productivity of tropical pasture plants. V. Effect of shading on growth, photosynthesis and respiration of 2 grasses and 2 legumes. Australian J. Agri. Res. 25: 425-433.

Madok, M.R. (1940). Association of legumes and non-legumes. J. Agric. Sci. 49: 419-432.

Manitkar, N.D. and Shukla, N.P. (1974). Fodder crops and cropping pattern. Indian Fmg. 24(8): 11-13.

Mayland, H.F., Grumes, D.L., Waggoner, H., Florence, A., Hewes, D.A. and Joo, P.K. (1975). Nitrogen effects on crested wheat grass as related to forage quality indices of grass tetany. Agron. J. 67(3): 411-413.

Mc Allister, J.S.V. (1966). A study of the responses to alternative sources of N in Ireland. 1. Effect of time of application on yield and chemical composition of Italian rye grass. 2. Effects of moderate and heavy dressings on the yield and mineral composition of the grass. Rec. Agric. Res. Nth. Ire. 15(2): 67-110.

Mc Lean, E.O. (1957). Plant growth and uptake of nitrogen. Proc. Soil Sci. Amer. 21: 219-222.

Mears, P.T. and Humphreys, L.R. (1974). Nitrogen response and stocking rate of Pennisetum clandestimum pastures. J. Agric. Sci. Camb. 83: 451-467.

Meerabai, M. and Raghavan Pillai, G. (1981). NPK requirement and possibilities of reducing nitrogen doses for sorghum legume fodder mixtures (Symposium on Fertilizer Management).

Mercy George (1981). Fodder production potential of Maize - legume mixtures in coconut garden. M.Sc.(Ag) Thesis. Kerala Agric. Univ. (Unpublished).

*Miranova, L.S. (1971). Effect of mineral fertilizers on yield and quality of sown pastures. Herb Abstr. 41(2): 817.

Monteiro, F.A. and Werner, J.C. (1977). Effect of N and P fertilizers on the establishment and maintenance of guinea grass. Phosphorus In Agric. 73: 54.

*Moog, F.A., Sena, E.M. and Valenzuela, F.G. (1978). Herbage production of guinea grass grown singly and mixed with Schoefield and Townville stylos. Herb. Abstr. 49(10): 4009.

Moore, A.W. (1962). Nodulation and nitrogen fixation of tropical legumes. Adv. Agron. 22: 23-26.

Moursi, M.A., El-Gawad, A.A.A., El-Din, N.A.N., Ashour, N.I. and Yakout, G.M. (1976). Effect of shading and nitrogen fertilizer on photosynthetic pigments and nitrogen contents of wheat blades. Egyptian J. Agron. 1(2): 171-179.

Mukherjee, A.M., Bhattacharya, K.K., Rana, S.K. and Chatterjee, B.N. (1976). Forage production from Pennisetum pedicellatum Trin. through fertilizer nitrogen. Forage Res. 2: 173-175.

Mukherjee, A.K., Rana, S.K., Banerjee, S., Roquib, M.A. and Chatterjee, B.N. (1981). Effect of fertilizer and spacing on the yield and quality of Dinanath grass (Pennisetum pedicellatum Trin) Forage Res. 7: 39-41.

Mullakoya, P. (1982). Shade tolerance of guinea grass (Panicum maximum) under different levels potassium. M.Sc. (Ag) Thesis, Kerala Agric. Univ. (Unpublished).

Mumford, F., Deway, H., Smith, J. and Castle, J. (1961). "An inhibitor of IAA Oxidase from Pea tips". Plant physiol. 36: 752.

*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.

Narayanan, T.R. and Dhabadghao, P.M. (1972). Forage crops of India. I.C.A.R., New Delhi 1st Ed. 220-221.

Narwal, S.S., Tomer, P.S. and Faroda, A.S. (1977). Effect of nitrogen and phosphorus levels with varying seed rates on fodder yield and quality of dinanath grass. Forage Res. 3: 61-62.

Nelliat, E.V., Bavappa, K.V.A. and Nair, P.K.R. (1974). Multi-storeyed cropping a new dimension in multiple cropping for coconuts. World Crops 26: 262-266.

Neyra, Carlos, A. and Dobereiner, J. (1977). Nitrogen fertilization in grasses. Adv. Agron. 29: 1-38.

Nihal Singh and Khatri, P.B. (1972). Effect of phosphate fertilization of legumes on soil fertility. Indian J. Agron. 17: 49-53.

Nuthall, P.L. and Whiteman, P.C. (1972). J. Australian Inst. Agric. Sci. 38: 100.

*Ogwang, B.K. and Mugerwa, J.A. (1976). Yield response to nitrogen application and in vitro drymatter digestibility of elephant grass x bulrush millet hybrid. Herb. Abstr. 49: 420.

*Olsen, F.J. and Moe, P.G. (1971). The effect of phosphate and lime on the establishment, productivity, nodulation and persistence of Desmodium intortum, Medicago sativa and Stylosanthes gracilis. East African For. J. 37(1): 29-37.

Omueti, J.O. and Oyenuga, V.A. (1970). Effect of phosphorus fertilizer on the protein and essential components of the ash of groundnuts and cowpeas. West African J. Biol. Appl. Chem. 13: 14-19.

Oyenuga, V.A. and Olubajo, F.O. (1969). Pasture productivity in Nigeria. J. Agric. Sci. Camb. 85: 1-10.

Oyenuga, V.A. Olubajo, F.O. (1975). Drymatter production and chemical composition of herbage. J. Agric. Sci. Camb. 85: 1-10.

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.

Panicker, S.N., Sarojini, 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.

*Papanicolaou, E.P. (1977). A study of placement methods of P. fertilizer labelled with P32 in the cultivation of beans. Agrochimica, 1977, 21, 6, 451-60 (En, fr, de, es, it). Phosphorus in Agric. (74) pp.45.

Patel, B.M., Shukla, P.C. and Patel, B.J. (1966). Composition and yield of fodder when guinea grass alone is grown and when lucerne is grown between its rows. Indian J. Agric. Sci. 38(1): 17-21.

Patel, R.M., Talpada, P.M. and Shukla, P.C. (1973). Effect of intercropping lucerne on the fodder and nutrient production of guinea grass. Indian J. Agric. Sci. 43: 737-739.

Pears, P.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.

*Pereira, J.R. and D' Olivera, L.O.B. (1976). Effect of two nitrogen sources on drymatter yield and crude protein content in elephant grass. Herb. Abstr. 48: 3067.

Plucknett, Donald, L. (1979). Managing Pastures and Cattle under Coconuts. Westview Tropical Agriculture series No. 2. Westview Press, Inc. USA.

*Portieles, J.M. (1978). Effect of P and liming on pangola grass. Agroteenia de cuba, 1978, 10, 2, 97 - 9 (En, es) (Abstr. Trop. Agric., 1980, 30633).

Rai, P., Kanodia, K.C., Shankaranarayan, K.A., Velayudhan, K.C. and Rajiv Agrawal (1979). Effect of various sources and levels of nitrogen on the botanical composition, drymatter production and forage quality of Sehima - Heteropogon grassland. Forage Res. 5: 37-48.

Ramanagowda (1981). Production potential of fodder cowpea varieties in coconut garden at different levels of nitrogen and lime. Ph.D. Thesis. Kerala Agric. Univ. (Unpublished).

*Ramos, G.M., Brage, J.M., Nascimento Junior, D.Do., Garvia, R. (1977). Determination of C.E.C. of roots of forage plants and its relationship with levels of K, Ca and Mg in the above ground parts. Revista Ceres (1977) 24 (135): 515-520.

*Randhava, S.S. and Gill, S.S. (1977). Effect of different levels of nitrogen application on the nutritive value of hybrid napier (NB - 21) when fed on hay. Herb. Abstr. 49: 1733.

Rathore, D.N. and Vijayakumar (1977 a). Forage potential of dinanath grass and sorghum as influenced by nitrogen and phosphorus fertilizer. Indian J. Agric. Sci. 47(3): 153-156.

Rathore, D.N. and Vijayakumar (1977 b). Quality components of dinanath grass and sorghum forage as affected by nitrogen and phosphorus fertilization. Indian J. Agric. Sci. 47(8): 401-404.

Ravikumar, Shankaranarayanan, K.A. and Rai, P. (1979). Effect of nitrogen and phosphorus on the dry forage yield and quality in Cenchrus ciliaris L. and Heteropogon contortus (L.) Beauv. Forage Res. 5: 69-74.

Ravikumar and Shankaranarayan, K.A. (1980). Response to fertilizers in the natural grassland of Sehima nervosum (Rottl.) Stapf. Forage Res. 6: 20-25.

Rehm, G.M., Nicholas, J.T., Sorensen, R.C. and Moline, W.J. (1975). Yield and botanical composition of an irrigated grass-legume pasture as influenced by fertilization. Agron. J. 67(1): 64-68.

Reid, D. (1972). The effect of long term application of wide range of nitrogen rates on the yields from perennial rye grass swards with and without white clover. J. Agric. Sci. Camb. 79: 291-301.

Reid, R.L., Odhuba, E.K. and Jung, G.A. (1967). Evaluation of Tall Fescue under different fertilization treatments, Agron. J. 59(3): 265-271.

*Rinne, K. (1976). The chemical composition of pasture herbage affected by different levels of nitrogenous fertilizers. J. Sci. agric. Soc. Finland 48(4): 305-316.

Rhykerd, C.L., Ruble, L. and Mott, G.O. (1959). Influence of light on foliar growth of alfalfa, red clover and birds'foot trefoil. Agron. J. 51: 199-201.

Robinson, P.J. and Jones, R.K. (1972). The effect of phosphorus and sulphur fertilization on the growth and distribution of drymatter, N,P,S in Townsville stylo (Stylosanthes humilis) Aust. J. Agric. Res. 23(4): 633-40.

Roberts, R.H. and Struckmeyer, B.E. (1939). Further studies on the effect of temperature and other environmental factors upon the photoperiodic response of plants. J. agric. Res. 59: 699-709.

Russel, E.W. (1973). Soil conditions and plant growth. Longman Group Ltd., London. 10th Ed. pp.387.

Ryle, G.J.A., Powell, C.E. and Gordon, A.J. (1979). Respiratory costs of nitrogen fixation in soybean, cowpea and white clover. I. N fixation and the respiration of the nodulated roots. J. Exp. Bot. 30(114): 135-144.

*Sachs, J. (1972). "Uber den Einfluss der Lufttemperatur Und des Tageslichts auf die stundlicher und taglichen Anderungen des Lungeberustum (Sreeking) der Internodien". Arb. Botan. Inst. Wurtzburg 172, 1: 99-192.

Sachs, R.M. (1965). Stem elongation. Ann. Rev. Pl. Physiol. 16: 73-96.

Sahasranaman, K.N. (1964). It pays to grow groundnut in coconut gardens. Coconut Bulletin 18(4): 123-130.

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

*Salcedo, B.M. (1969). Comparative study on the green forage yield and chemical composition of two grasses, a legume and grass-legume mixture. Trop. Abstr. 27(3).

*Sanchez, S. (1979). The influence of lime, P and K on the yield of napier grass grown in the Oxisol in the Llanos Orientales, Columbia, Rev. Inst. Colomb. Agropeon., 1979, 14, 2, 63 - 72 (Es, en) (T.V.A. Fert. Abstr., 1981, 696).

Shankaranarayan, K.A., Dabadghao, P.M., Rai, R., Upadhyaya, V.S. and Maurya, R.K. (1973). Fertilization of grasslands of Heteropogon contortus in Jhansi. Indian J. Agric. Sci. 43: 562-66.

Santhirasegarem, K. (1966). Some Problems of Pasture Production Under Coconuts, Working Paper, FAO Technical Working Party on coconut production, protection and processing, Colombo, Ceylon, 1964, FAO, Regional Office for Asia and the Far East, Bangkok, Thailand. p.371-380.

*Savova, N.P. (1976). The effect of increasing rates of applied nitrogen on the yields of lucerne grown under irrigation. Rasteniev dni Nanki (1974) 11(7) 82-83 (Bg, ru, en, 12 ref) Institut po Genetika i Selektsiya na Rasteniyata, Sofia Bulgaria. Herb. Abstr. 1976. 46(2): 511.

Sethi, B.L. (1963). Intercropping sea island cotton in coconut gardens. Coconut Bulletin 17(5): 129-131.

*Schollеs (1978). Residual effect of application of P fertilizer on yield, level of P in tissue of tropical fodder plants and in available soil P. Agronomia Sulriograndense, 1978, 14, 2, 303-10 (Pt, en) Soils and Fert.,1980, 5878).

*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.

Shankaranarayanan, K.A., Dabadghao, P.M., Rai, P., Upadhyay, V.S. and Maurya, R.K. (1973). Fertilizer for the grasslands of Heteropogon contortus (L.) Beauv. ex. Roem. and Schult. in Jhansi. Ind. J. agric. Sci., 42: 562-566.

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.

Sidhu (1980). Performance of guinea grass in Punjab. Paper presented in the 2nd National Seminar on fodder production at NDDB, Anand (16 - 18 January, 1980).

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, C.M. and Guleria, W.S. (1979). Effect of intercropping and fertility levels on growth, development and yield of maize (Zea mays L.) Food Fmg. Agric. 10(7): 242-245.

Sing, H.N. and Sing, A.P. (1975). Physico-chemical properties of soil under phosphate application in Stylosanthes humilis. Ind. J. Agron. June 1975 20(2): 197.

Singh, R.D. and Chatterjee, B.N. (1968). Growth analysis of perennial grasses in tropical India. II. Herbage growth in mixed grass-legume swards. Exp. Agric. 4: 127-134.

Singh, S.D., Misra, D.K., Vyas, D.L. and Daulay, H.S. (1971). Fodder production of sorghum in association with different legumes under different levels of nitrogen. Indian J. agric. Sci. 41: 172-176.

Skerman, P.J. (1977). Tropical Forage Legumes. Food and Agriculture Organisation of the United Nations, Rome. pp.609.

*Solomko, I. and Rudin, I. (1977). Fertilization of lucerne (Medicago spp) Kornia (1976) No. 3, 42-43 (Ru) stavropol skii Institut Sel' skogo khozyaistva, stavropol' U.S.S.R. Herb. Abstr. 1977, 47(2): 408.

Sreedharan, C. (1975). Studies on the influence of climatological factors on rice under different water management practices. Ph.D. Thesis, Orissa University of Agriculture and Technology, Bhubaneswar (1975).

Stansel, J.W. (1966). Rice and light. Rice J. 69(8): 30-32.

Steel, R.J.H. and Humphreys, L.R. (1974). Growth and 'P' response of some pasture legumes sown under coconuts in Bali. Trop. Grasslds. 8(3): 171-178.

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

Suttie, J.M. (1970). The effect of single superphosphate on the yield and chemical composition of a grazed grass-legume pasture at Kerale, Kenya. Soils Fert. 34(2): 1721.

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

*Thairu, D.M. (1972). The contribution of Desmodium uncinatum to the yield of Setaria sphaecelata. Trop. Abstr. 28(2): 1219.

Thangamuthu, G.S., Sundaram, A. and Kandaswamy, P. (1974). Performance of guinea grass under different levels of nitrogen and phosphorus manuring. Madras Agric. J. 61(9): 584-587.

Thangamuthu, G.S. and Sundaram, J.P. (1974). Performance of fodder sorghum varieties under different nitrogen levels. Madras Agric. J. 61(9): 719-721.

Thill, James, L. and George, J.R. (1975). Cation concentrations and K to Ca + Mg ratio of nine cool season grasses and implications with hypermagnesaemia. Agron. J. 6(1): 89-91.

Thomas, J. (1978). Comparative performance of guinea grass and hybrid napier under varying nitrogen levels and cutting intervals. M.Sc. (Ag) Thesis (1978), Kerala Agric. Univ. (Unpublished).

Thompson, L. (1958). Sorghum versus sorghum - guar mixture for forage and protein production. Field Crop Abstr. 12.

Tisdale Samuel, L. and Nelson Werner, L. (1973). Soil Fertility and Fertilizers. Macmillan Inc. New York. 3rd Ed. pp.694.

*Tiwana, M.S. and Puri, K.P. (1976). Response of three varieties of oats to N application. Herb. Abstr. 49: 1397.

Tiwana, M.S., Bains, D.S. and Gill, S.S. (1975). Effect of various levels of nitrogen and phosphorus under different spacings on fodder of napier - bajra hybrid. J. Res. Punjab Agric. Univ. 12(4): 345-350.

Valasquiz, E.R. and Bryan, W.B. (1974). Grass-legume associations. IRI Research Institute, INC.

Vicente-Chandler, J., Silva, S. and Figarella, J.J. (1959). Agric. Univ. R.R. 43. 4. Production potentialities of pastures in the tropics and subtropics. J.G. De Geus. Centre D' Etude De L' Azote, Zurich (1977).

Vicente-Chandler, J., Figarella, J. and Silva, S.J. (1961). Agric. Univ. R.R. 45, 1.p. 37-45 (1961). Production potentialities of pastures in the tropics and subtropics. J.G. De Geus. Centre D' Etude De L' Azote, Zurich 1977.

Viswanath, D.P. (1975). Effect of repeated application of heavy doses of fertilizers on physical and chemical properties of soils and uptake of nutrients by hybrid maize. Mysore J. Agric. Sci. 9: 713-714.

Warmsley, D., Sargeant, V.A.L. and Dookeran (1978). Effect of fertilizers on the growth and composition of elephant grass (Pennisetum purpureum) in Tobago, West Indies. Trop. Agric. 55(4): 329-334.

*Washburn, K.L. Jr., Donohue, S.J., Rhykerd, C.L., Noller, C.H., Holt, D.A. and Bula, R.J. (1976). Influence of N fertilization on drymatter yield and N concentration of Medicago sativa, L. Proc. 12th Int. Congr. Chemicalisation of Grassland Farming. 2. Moscow U.S.S.R. (1974). 633-638 (En, Ru, 7 ref). Department of Agronomy, Purdue University, Indiana, U.S.A. Herb. Abstr. 46(2): 512.

* Weightman, B.L. (1977). Pasture research and development in the New Hebrides. Proceedings Regional Seminar Pasture Research, Ministry of Agriculture and Lands, Honiara, Solomon Islands: 252-257.

Wendt, W.B. (1970). Responses of pasture species in eastern Uganda to P, S and K. East African For. J. 36(2): 211-219.

Whelan, B.R. and Edwards, D.G. (1975). Uptake of potassium by Setaria anceps and Macroptilium atropurpureum from the same standard solution culture. Australian J. Agric. Res. 26, 819.

White, E.M., Kruerger, C.R. and Moore, R.A. (1976). Changes in total N, organic matter, available P and bulk densities of cultivated soil 8 years after tame pastures were established. Agron. J. 68(4): 581-583.

Whitney, A.S., Kanehiro, Y. and Sherman, G.D. (1967 a). Nitrogen relationship of three tropical forage legumes in pure stands and in grass mixtures. Agron. J. 59: 47-50.

Whitney, A.S. and Kanehiro, Y. and Sherman, G.D. (1967 b). Pathways of nitrogen transfer in some tropical grass-legume association. Agron. J. 59: 85-88.

Whitney, A.S. and Green, R.E. (1969). Nitrogen contributions to yield and composition of Desmodium sps. Pangola grass mixtures. Agron. J. 61: 741-745.

Whyte, R.O. (1964). The grassland and fodder resources of India. Indian Council of Agricultural Research, New Delhi. pp.1-540.

Wong, C.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. Australian J. Agric. Res. 31: 269-285.

Yadava, B.S., Chokhey Singh (1978). Nitrogen balance in soil and nutrient status of green gram in relation to plant population and fertility levels. Madras Agric. J. 65(4): 367-371.

*Original not seen.

APPENDICES

Appendix 1.

Climatic parameters during the crop period.

A weekly interval 0	Maximum temperature °C	Minimum temperature °C	Relative humidity %	Total Rainfall mm
1	29.8	23.2	92.4	2
2	30.0	23.3	90.7	0
3	29.5	22.9	93.5	766
4	30.8	21.6	89.8	56
5	31.0	22.6	91.2	65
6	31.7	22.2	91.6	0
7	31.4	23.2	91.2	115
8	32.2	23.4	90.8	24
9	33.1	29.9	91.2	49
10	31.7	23.4	87.7	97
11	30.4	23.5	88.8	291
12	29.2	22.9	91.6	213
13	29.5	22.7	93.2	126
14	30.5	22.8	91.7	191
15	29.9	22.8	90.8	44
16	29.1	22.3	95.3	325
17	30.5	21.5	94.3	80
18	30.9	20.9	90.0	3
19	31.5	20.0	84.2	0
20	31.4	20.3	84.2	0

Appendix 2.

Climatic parameters (average values) for the past 24 years (1956-1980).

Month	R.F.(mm)	Temperature °C		Relative Humidity (%)
		Maximum	Minimum	
January	34.62	30.93	22.46	79.88
February	36.0	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	197.7	31.75	24.92	85.07
June	292.2	30.42	23.95	85.13
July	220.9	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	29.7	23.76	87.41
November	208.05	29.91	23.81	86.97
December	71.85	30.66	23.26	84.78

PRODUCTION POTENTIAL OF TWO FODDER GRASSES UNDER DIFFERENT MANAGEMENT PRACTICES

By

G. RAGHAVAN PILLAI

ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE

Doctor of Philosophy

FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1986

ABSTRACT

An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani during the period from July, 1978 to February, 1980 to compare the production potential of two fodder grasses under different management practices and also to investigate the effect of fodder intercropping on the yield of coconut palms. The treatments consisted of two grasses (Guinea and Setaria), two systems of cropping (with and without stylosanthes intercropping), four levels of nitrogen (50, 100, 150 and 200 kg/ha) and two levels of phosphorus (0 and 60 kg/ha) laid out in a 4×2^3 confounded factorial design. Two separate experiments having 32 treatment combinations were simultaneously carried out, one in open area and the other in an adjascent coconut garden.

Twelve cuts of grasses were taken from individual net plots during the course of two years coinciding with abundant growth or 50 percent flowering. In the case of stylosanthes also twelve cuts were taken along with grasses. Biometric observations from the grasses and stylosanthes at each harvest and the yield of coconuts

during the experimental period and subsequent two years were collected.

Results from the investigation revealed that the crop growth rate of guinea was more than setaria grass in both the situations. It was also noticed that the crop growth rate of grasses in full sunlight was higher than in coconut shade while the crop growth rate of stylosanthes was higher in shade than in full sunlight.

The drymatter yield of guinea was higher than setaria grass in both the situations. Similarly the total drymatter yield of guinea plus stylosanthes combination was also higher than setaria plus stylosanthes combination. The total fodder yield in open area was more than the yield in shade. Between the two grasses, fodder production potential of guinea was better than setaria in both the situations.

Intercropping grasses with stylosanthes increased the yield and quality of fodder.

Phosphorus applied @ 60 kg/ha was beneficial in increasing the yield and quality of both grasses and legumes.

Response of pure crop of grasses was found to be upto 150 kg N/ha in open area and 100 kg N/ha in coconut garden, while for grass plus stylosanthes combination the response was obtained upto 100 kg N/ha only in both the situations.

The crude protein yield of guinea plus stylosanthes combination was higher than setaria plus stylosanthes combination in both the situations. In the case of quality aspects like crude protein, crude fibre, ash content, phosphorus, calcium and K: (Ca + Mg) ratio, guinea grass was found superior to setaria.

The cost benefit ratio due to guinea grass cultivation was the highest in both the situations. Similarly inter-cropping grasses with stylosanthes also recorded highest cost benefit ratio in both the situations.

The yield of coconuts increased to the tune of 2.54 percent due to fodder intercropping in coconut garden.