SEED PRODUCTION OF GAMBA GRASS (*ANDROPOGON GAYANUS* KUNTH) UNDER VARYING LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM

BY

VINEETHA. L. J.

THESIS
Submitted in partial fulfilment of
the requirement for the degree
Master of Science in Agriculture
Faculty of Agriculture
Kerala Agricultural University.

Department of Agronomy
College of Agriculture,
Vellayani, Trivandrum.

1995.

DECLARATION

I hereby declare that the thesis, entitled "Seed production of Gamba grass (*Andropogon gayanus* Kunth) under varying levels of nitrogen, phosphorus and potassium" 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.

Vellayani, VINEETHA. L. J.

[illegible] 1995.

CERTIFICATE

Certified that this thesis, entitled "Seed production of Gamba grass (*Andropogan gayanus* Kunth) under varying levels of nitrogen, phosphorus and potassium" is a record of research work done independently by Smt. Vineetha, L. J. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani,

14.9.1995.

(Dr. G. Raghavan Pillai)
Chairman,
Advisory Committee,
Professor of Agronomy.

Approved by:

Chairman

Dr. G. Raghavan Pillai

Members:

1. Prof. P. Chandrasekharan.

2. Prof. Abdul Hameed.

3. Dr. P. Saraswathi.

External Examiner:

ACKNOWLEDGEMENT

It is a matter of great privilege and pleasure to record my deep sense of gratitude and heart-felt thanks to Dr. G. Raghavan Pillai, Professor of Agronomy and Chairman of Advisory committee for his personal attention, keen interest, constant inspiration and valuable guidance during the course of this work and preparation of the thesis. My sincere heart felt gratitude ever remains with him.

I extend my sincere thanks to Sri. P. Chandrasekharan, Professor and Head, Department of Agronomy, College of Agriculture, Vellayani, and member of advisory committee for extending his help and assistance during this study.

My profound gratitude is due to Shri. Abdul Hameed, Professor, Dept. of Soil science and Agricultural Chemistry, College of Agriculture, Vellayani and member of advisory committee for his timely help and valuable suggestions at every stage of this investigation and preparation of the thesis.

It is with great pleasure, I thank Nathanya Softwares, Voltas lane, Vazhuthacaud, Thiruvananthapuram-14, for their prompt and neat execution of the type setting work.

I wish to record my appreciation of the co-operation and encouragement given by my friends, parents, husband and relatives during my studies.

Last but not least, I bow my head before the Almighty whose blessings enabled me to complete this venture successfully.

VINEETHA. L. J.

I am extremely grateful to Dr. P. Saraswathi, Professer and Head, Department of Agricultural Statistics, College of Agriculture, and member of advisory committee for her sincere help and guidance in the formulation of data for statistical analysis which contributed much towards the completion of the work.

I am very much idebted and grateful to all the staff members of the Department of Agronomy for their sincere and whole hearted co-operation throughout.

I express my heart felt thanks to Sri. H. Gopinathan, Farm Assistant, Department of Agronomy, for his valuable help during the course of this study.

It is with immense pleasure that I thank Sri. K. Krishnan, Asst. Manager, K.L.D Board, Dhoni, Palakkad who has put in a helping hand in this venture.

My profound sense of gratitude is due to Sri. C. E Ajithkumar, Junior programmer of the Department of Agricultural statistics for his help in carrying out the statistical analysis.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

kg -	Kilogram
g -	Grammes
ha -	Hectare
N -	Nitrogen
P -	Phosphorus
K -	Potassium
m -	Metre
cm -	Centimetre
m^2 -	Square metre
t -	Tonnes

LIST OF APPENDICES

INTRODUCTION

1. INTRODUCTION

The contributions from livestock sector to Kerala's economy is significant. The livestock sector accounts for about 10 per cent of the state's domestic product. The milk production in Kerala increased during the last two decades and the principal factor that contributed to this increase in milk production has been the improvement in the genetic quality of the stock through cross breeding. Today more than 60 per cent of the cattle in the state are cross breds with a significant increase in the productivity of milch animals. But the full potential of milk production from the hybrid cattle cannot be achieved unless sufficient quantity of quality feed is supplied to them. Our state lacks in the production of sufficient feeds and fodder. The gap between the availability and requirement is estimated to be 27.6 lakh tonnes in terms of dry matter (Status paper, 1989). Moreover the cost of milk production in the state tends to be high due to scarcity of quality feeds and fodder which account for nearly 60 to 70 per cent of the total cost.

The primary factor which comes in the way of popularisation of fodder crops is the nonavailability of good quality seed of high yielding varieties. The productivity and availability of seeds are very important because the crops have been bred substantially for vegetative purpose and as such they are shy seeders with very low seed productivity. Secondly the crops are not allowed to come to maturity and they are cut at the vegetative stage. So the opportunity of producing seed is limited. However recently progress has been made in improving the crop husbandry of tropical forages to give higher seed yield and better seed quality. Loch (1991) reported that herbage seed production in the tropics has shorter history and is at an earlier and less sophisticated stage of development.

Most of the tropical forage crops were developed in the last 30 years and are new to agriculture and retain wild characteristics that interfere with commercial seed production. Australia has the largest history of forage production in the tropics and produces the greatest diversity of herbage seeds, particularly legumes. Other major producing countries include Brazil, Thailand, India, Kenya and Zimbabwe. A concerted effort is needed to augment the seed production of cultivated fodder crops, range grasses and pastures. The studies conducted over the last 25 years under the AICRP on forage crops indicated the possibility of enhancing the seed productivity of different crops in their specific agroclimatic locations which were identified through research works. It was also understood that the appropriate crop and soil management aspects including crop fertilization with macro and micro nutrients help in seed production.

Gamba grass (*Andropogon gayanus*) is commonly known as Sadabahar in India. This is a tufted perennial and it grows 1-2 m high. The inflorescence is a large spathate panicle. The name 'sadabahar' was given by Chatterjee (1964), who reported a yield of 700 q/ha with 5.5 per cent crude protein, 1.2 per cent P_2O_5, 0.65 per cent CaO and 32.6 per cent crude fibre. The crude protein percentage in the grass is as high as that of the Napier grass.

Gamba grass is easily established, highly productive, and drought resistant. It remains green during the driest months of the year. 'Sadabahar' is broad leaved, palatable and is avidly eaten by animals. When the plants are spaced at (2' x 3') it may grow as high as 10 feet. The species is adapted to wide range of soil types from light sandy to clay loams and prefers well drained soils. It is not adapted to heavy clay soils which is susceptible to water logging during the wet season. A range of legumes have been grown successfully with this grass. These include *Stylosanthes hamata* Cv. Verano, *S. scabra* Cv. seca, *S. guianensis* Cv. Cook, Endeavour, Graham, *Centrosema pubesense, Macroptilium atropurpureum* and *Calapogonium mucunoids*. Choice of legume would depend on location and expected use of the pasture. Establishment of this grass is effected by sowing as little as 1 kg/ha of clean, seed of high viability. Rates as high as 40 kg/ha may be required if seeds are uncleaned (Ford et al. (1981) and Harrison (1981)). *Andropogon gayanus* is a short day plant and will not flower if the day length is more than 12-14 hrs. Tillers formed early in the season make the greatest contribution to final seed yield and management for seed production should aim at stimulating early better production through fertilizer and husbandry. Bogdan (1977) reported that yields of uncleaned seed range from 20-100 kg/ha/yr and that annual seed yields of upto 90 kg/ha/ yr in India and Brazil. In the Indian trial, the uncleaned seed contained only 5-10 per cent caryopsis. As this being cultivated as a good forage grass in our conditions, there is much need to popularise it among our farmers. The Kerala Livestock Development Board, which is the principal agency for production of fodder seeds in the state is not able to cater to the needs of the state. Also technical information regarding the production of seeds under the agroclimatic conditions of the state is lacking. With this background, the present study was taken up with the following objectives

1. to find out the effect of treatments on fodder production potential of the grass.

2. to find out the effect of treatments on seed production potential of the grass.

3. to work out the economics of cultivation.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

An experiment was conducted at the college of Agriculture, Vellayani during the period from July 1993 to February, 1994 with the object to find out the effect of nitrogen, phosphorus and potassium on seed production of Gamba grass (*Andropogon gayanus*). The treatment consisted of combinations of 3 levels of nitrogen, phosphorus and potassium. In this chapter, the literature available on the topic is reviewed. Wherever sufficient research data on the specific crop was not obtained, the available literature on related crops are cited.

2.1. Effect of treatments on growth characters

2.1.1. Effect of treatments on plant height

Bokde (1968) working with two varieties of fodder oats (*Avena sativa*, Linn) found that nitrogen application markedly increased plant height. Culm length was increased in Setaria grass (*Setaria sphacelata*) Cv. Nandi by nitrogen application as reported by Boonman (1972) from Kenya. An increase in plant height upto 120 kg N/ha was seen in Bajra (*Pennisetum typhoides*) from trials conducted at Rahuri (Annual Report, 1976). Influence of nitrogen in increasing plant height was noticed in fodder sorghum (*Sorghum bicolor* (L) Moench) by Rathore and Vijayakumar (1977). Trials conducted on dinanath grass (*Pennisetum pedicellatum*) at Vellayani with 0,50,100 and 150 kg N/ha recorded a linear increase in plant height. (Annual Report, 1978). Similar response was noted by Abraham (1978) in dinanath grass (*Pennisetum pedicellatum*). Thomas (1978) found that nitrogen had highly significant effect on plant height of hybrid napier grass. Application of 60 and 120 kg N/ha in addition to inter cropping enhanced plant height significantly in hybrid napier grass. (Balbatti, 1980). Rai and Sankaranarayanan (1981) found that plant height increased with nitrogen application in Giant Anjan grass (*Cenchrus ciliaris*) and also noticed maximum plant height with the application of 40 kg N/ha. Krishnan (1993) reported that plant height was significantly increased due to nitrogen fertilizer application in guinea grass (*Panicum maximum*) and the maximum increase of about 1.1 times obtained at 100 kg N/ha itself.

Thangamuthu et al. (1974) reported a lack of response on plant height in guinea grass (*Panicum maximum*) upto the level of 50 kg N/ha.

In general the plant height increased with nitrogen application in most of the important fodder grasses as well as in cereal fodders.

2.1.2. Effect of phosphorus on plant height

Rai and Sankaranarayanan (1981) working on giant anjan (*Cenchrus ciliaris*), reported that plant height was not affected due to the addition of phosphorus either as soil application or as foliar spray.

2.1.3. Effect of potassium on plant height

Thakuria (1993) working on teosinte (*Euchlaena maxicana*) reported that application of potash did not give any significant response to growth or height of plants.

2.2.1. Effect of nitrogen on number of tillers

Boonman (1972) working on setaria grass (*Setaria sphacelata*) reported that application of nitrogen increased tiller numbers. Rathore and Vijayakumar (1977) got increased number of tillers with increase in nitrogen fertilization in dinanath grass (*Pennisetum pedicellatum*) and fodder sorghum (*Sorghum bicolor*). Mears and Humphreys (1974) got increased density of tillers at 336 kg N/ha in Kikiyu grass (*Pennisetum clandestinum*). Thomas (1978) working on hybrid napier reported a significant increase in tiller number with nitrogen doses upto 250 kg/ha. They further reported that vegetative tiller number was not significantly increased by higher levels of applied nitrogen (300 kg N/ha). In giant anjan grass (*Cenchrus ciliaris*), tiller number increased with increasing levels of nitrogen. (Rai and Sankaranarayanan, 1981). Taneja et al. (1981) also reported that the application of nitrogen produced more number of tillers per square metre in barley and oats. In the case of *Brachiaria humidicola* nitrogen application significantly increased the total number of tillers/m^2 (Mecelis and Oliveira, 1984). Dwivedi and Kanodia (1986) working on setaria grass (*Setaria sphacelata*) reported from IGFRI, Jhansi, that application of nitrogen increased tiller numbers. Sangakkara (1988) found that increasing nitrogen rates increased the number of tillers/plant in guinea grass (*Panicum maximum* Jacq). Krishnan (1993) reported that in the case of guinea grass a number of tillers per hill at 30 days after first fodder cut was significantly influenced by nitrogen fertilizers applied at the rate of 100 kg N/ha, the increase being about 1.23 times. The higher dose of 200 kg N/ha eventhough helped to increase the number of tillers, the increase was not significant. In switch grass (*Panicum virgatum*) application of nitrogen after cutting increased the total tiller number (Brejda, et al. 1994).

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. Studies conducted at Rahuri (Annual Report, 1976) indicated lack of influence of nitrogen on tiller production in dinanath grass (*Pennisetum pedicellatum*) and fodder sorghum (*Sorghum bicolor*). Lack of response to nitrogen in guinea grass (*Panicum maximum*) Cv Likoni was also reported by Perez et al. (1984). The tiller production showed an increasing trend with application of nitrogen in majority of the experiments so far conducted.

2.2.2. Effect of phosphorus on number of tillers

Rai and Sankaranarayanan (1981) reported that there was no significant increase in the number of tillers due to application of phosphorus in giant anjan grass (*Cenchrus* *ciliaris*). Krishnan (1993) working on guinea grass also reported that phosphorus fertilizers did not influence tiller production.

2.2.3. Effect of potassium on number of tillers

Krishnan (1993) reported that potassic fertilizers did not influence tiller production in guinea grass.

2.3.1. Effect of nitrogen on green matter yield

Mukerji and Chatterji (1955), Bose (1965), Tiwari (1965) and Relwani and Bagga (1968) conducted research under different agro-climatic conditions and reported that nitrogen application was very essential for higher green fodder production of dinanath grass (*Pennisetum pedicellatum*). Lotero et al. (1967) observed an increase in forage yield of elephant grass (*Pennisetum purpureum*) upto 200 kg N/ha. Kritayanavach (1968) applied nitrogen to napier and hybrid napier grasses ranging from 0 to 780 kg/ha, and recorded increased fresh weight of fodder upto the maximum level tried. Forage research at Pant Nagar on hybrid napier, revealed a significant increase in forage yield with increased application of nitrogen upto 150 kg/ha. (Annual Report, 1977). Narwal et al. (1977) reported a significant increase in green fodder yield with nitrogen application. Experiments at Vellayani gave an increase in green matter yield of dinanath grass with increased nitrogen application (Annual Report, 1978). Walmsley et al. (1978) got response to nitrogen application in elephant grass (*Pennisetum purpureum*) upto 340 kg/ha in the third year of application. Boruah and Mathur (1979) reported that nitrogen application to fodder maize significantly increased green matter yield. Overwhelming effect of nitrogen on promoting lushy growth and higher green matter production of fodder maize was observed by Lakshminarasimhan et al. (1979). Dwivedi et al. (1991b) working on thin napier grass (*Pennisetum polystachyon*) found that herbage production increases with increasing nitrogen rates. In teosinte (*Euchlaena maxicana*) increasing levels of nitrogen upto 90 kg/ha significantly increased the green fodder yields upto 93.7 per cent over control. (Thakuria, 1993).

Nitrogen application in general, significantly favoured higher green fodder yield in all the grass crops and cereals tried.

2.3.2. Effect of nitrogen on dry matter yield.

Little et al. (1959) got 40 per cent increase in dry matter yield of napier grass (*Pennisetum purpureum*) with 800 lbs N/acre (907 kg/ha) under irrigated conditions. According to Haggar, (1966) in the case of gamba grass (*Andropogon gayanus*) the application of higher quantities of nitrogen, upto the equivalent of 100 lbs N/acre (113.37 kg/ha) resulted in a linear increase in dry matter production. Faroda (1970) reported an increase in dry matter yield upto 40 kg N/ha in black anjan (*Cenchrus ciliaris*). On alluvial soils of Costa-Rica, dry matter production was linearly increased with increase in the rate of applied nitrogen. An increased dry matter production by nitrogen application upto 250 kg/ha was observed in dinanath grass (*Pennisetum pedicellatum*) (Annual Report, 1972). Boonman (1972) reported that in setaria grass, (*Setaria sphacelata*), the highest yields of dry matter at seed harvesting time were recorded at the top nitrogen levels. Response of dry matter yield to nitrogen rates on rye grass (*Lolium perenne*) was almost linear between 0 and 336 kg/ha (Reid 1972). Shankaranarayan et al. (1973) also reported significant increase in the dry matter yield and linear response upto 40 kg N/ha in favourable years. Ganguli et al.(1976) reported that the dry matter yield increased significantly with increase in levels of nitrogen in fodder oats. In black anjan (*Cenchrus ciliaris*) the dry matter yield increased with increase in levels of nitrogen and the differences were significant except between 0 and 30 kg N/ ha (Ravikumar et al., 1979). Working on spear grass (*Heteropogon contortus*) he reported an increase in dry matter yield with increase in levels of nitrogen. He also reported that the differences were significant except between 60 and 90 kg N/ha. The nitrogen levels of 60 and 90 kg/ha were statistically on par. Nitrogen exerted a significant effect on the dry matter yield of barley and oats and there was a linear response to nitrogen upto 120 kg N/ha (Taneja et al., 1981). Dwivedi and Kanodia (1986) also reported significant effect of nitrogen on dry matter yield in setaria grass, (*Setaria sphacelata,* Schumach). The maximum dry matter yield was recorded with the application of 120 kg N/ha and minimum in the control treatment. Similar trend was reported by Rai and Kanodia (1981). Pamo (1991) working on congo signal (*Brachiaria ruziziensis*) reported that dry matter yield increased significantly with increasing nitrogen rate upto 80 kg/ha. Tripathi and Singh (1991) reported that increasing levels of nitrogen increased the dry fodder yields in dinanath grass, but the effect was significant only upto 90 kg N/ha. Carvalho et al. (1992) reported that forage dry matter yield increased with nitrogen rates in *Brachiaria* species. Increasing levels of nitrogen upto 90 kg/ha significantly increased the dry matter yields in teosinte wherein the increase was 116.6 per cent over control by application of 90 kg N/ha (Thakuria 1993).

Dry fodder yield also showed the same trend as that of green fodder yield recording higher rate of production due to higher levels of N application.

2.3.3. Effect of phosphorus on green matter yield

Grasses generally show great response to nitrogen. But much studies have not been carried out on phosphorus fertilization of grasses. Blunt and Humphreys (1970) reported increased fodder yields of setaria grass (*Setaria sphacelata*) when it was fertilised with phosphorus. Javier et al. (1977) showed that herbage yield of guinea grass Cv Common was found to increase significantly with 100-150 kg P_2O_5 ha. In the case of thin napier grass (*Pennisetum polystachyon*) herbage yields increased with increase in phosphorus rates (Dwivedi et al., 1991b).

In dinanath grass, phosphorus application showed no definite trend. In the first year, application of 60 kg P_2O_5/ha produced significantly higher green fodder production over control, but the difference between 0 and 30 kg P_2O_5 /ha and 30 and 60 kg P_2O_5 /ha were not appreciable. However in the second year, there was significant increase in green fodder yield with increasing levels of phosphorus (Narwal et al., 1977).

An increasing trend in fodder production due to phosphorus application was seen in grasses in most of the cases.

2.3.4. Effect of phosphorus on dry matter yield

Haggar (1966) reported that phosphorus increased dry matter yields in gamba grass (*Andropogon gayanus*). A significant increase in dry matter yield of maize by phosphorus application was reported by Bhandari and Virmani (1972). In black anjan (*Cenchrus ciliaris*), the dry matter yield was increased significantly with increase in levels of P_2O_5 in the first year, but in the following years, the results were not significant (Ravikumar et al., 1979). CIAT (1982) reported that in gamba grass (*Andropogon gayanus*) application of 260 ppm phosphorus increased dry matter yield 10 fold compared with no phosphorus application. Shoot dry matter production increased with increasing phosphorus rate in gamba grass, (*Andropogon gayanus*) (Paulino and Malavotta, 1989). Similar results were obtained by Paulino et al. (1989).

Faroda (1970) did not find significant effect of phosphorus alone on dry matter yield in black anjan (*Cenchrus ciliaris*). He has reported that the application of phosphorus did not show any significant effect on dry matter yield of spear grass (*Heteropogon contortus*). No significant difference in dry matter yield during first year due to different levels of phosphorus was reported by Narwal et al. (1977) in dinanath grass (*Pennisetum pedicellatum*). However in the second year, there was significant increase in dry fodder yield with increasing levels of phosphorus.

Varying results were reported on the effect of phosphorus on dry fodder yield of forage grasses.

2.3.5. Effect of potassium on fodder yield

The yield of fodder maize was increased with increasing levels of exchangeable potassium in the soil.

(Mengel and Braunschwieg, 1972). Patel et al. (1985) reported that maize hybrid Ganga safed gave highest yields (5.13 t/ha) with 120 kg K_2O and irrigation at 25 per cent depletion of available soil moisture.

But Smith (1979) working on switch grass (*Panicum virgatum*) reported that the vegetative growth was favoured by nitrogen fertilization, but not by potassium. Similarly Thakuria (1993) working on teosinte (*Euchlaena maxicana*) also reported that application of potash did not give any significant response to fodder yields.

2.3.6. Effect of nitrogen and phosphorus on dry fodder yield

In sorghum Var. M. P. Chari, the maximum yield of green fodder was 1.98 q/kg of nitrogen and 4.33 q/kg of phosphorus applied at the most profitable levels of 85.91 kg N/ha and 24.09 kg P_2O_5/ha respectively (Datta and Prakash, 1974).

2.3.7. Effect of nitrogen, phosphorus and potassium on fodder yield

Fodder yield of maize was significantly increased by application of nitrogen, phosphorus and potassium, more so when nitrogen and phosphorus were applied in three splits. (Kuznetsov, 1970). Satjipanon et al. (1989) reported that in congosignal grass (*Brachiaria ruziziensis*) maximum dry matter yield was obtained at application of 12 + 24 + 12 kg N + P + K/ha.

Berroteran (1989) working on dry matter production in gamba grass (*Andropogon gayanus*) and *Digitaria swazilandensis* reported that gamba grass (*Andropogon gayanus*) did not respond to fertilizer application.

2.4.1. Effect of treatments on nitrogen content in fodder

Narwal et al. (1977) working on dinanath grass (*Pennisetum pedicellatum*) reported that there was significant increase in the percentage content of crude protein and mineral matter with increasing levels of nitrogen and phosphorus. Rathore and Vijayakumar (1978) reported a higher nitrogen concentration at 160 kg N/ha in dinanath grass (*Pennisetum pedicellatum*). Tripathi and Singh (1991) working on dinanath grass (*Pennisetum pedicellatum*) reported that crude protein yield increased with nitrogen levels upto

120 kg N/ha, although the magnitude of increase was lower beyond 90 kg N/ha. Phosphorus application significantly increased crude protein content and yield over 0 and 20 kg P_2O_5 /ha. Application of potassium could not influence the crude protein yield, but the crude protein content increased with increasing levels of potash upto 40 kg K_2O /ha (Thakuria, 1993).

Thangamuthu et al. (1974) observed no influence of nitrogen on protein content of guinea grass upto 150 kg/ha. Walmsley et al. (1978) observed that in hybrid napier grass, crude protein content was not affected by the levels of nitrogen upto 340 kg/ha.

Monteiro and Werner (1977) working on guinea grass (*Panicum maximum*) suggested that application of phosphorus promoted protein production. Chadhokar (1978) reported that mean nitrogen content increased substantially with increase in nitrogen applied in para grass (*Brachiaria mutica*). Ravikumar et al. (1979) working on black anjan (Cenchrus ciliaris) and spear grass (*Heteropogon contortus*) reported that crude protein content of both the grasses increased considerably with levels of nitrogen. Highest protein content was recorded in spear grass (*Heteropogon contortus*) with application of 90 kg N/ha.

Bahl et al. (1970) observed that phosphorus application did not influence the crude protein content in black anjan (*Cenchrus ciliaris*). Andrew and Robins (1974) reported that phosphorus application decreased the nitrogen content of grasses. Walmsley et al. (1978) reported that crude protein content was not affected by phosphorus application in elephant grass, (*Pennisetum purpureum*). Ravikumar et al. (1979) working on black anjan (*Cenchrus ciliaris*) reported a decrease in the crude protein content with increase in levels of phosphorus from 0 to 60 kg/ha.

2.4.2. Effect of treatments on phosphorus content in fodder

Bahl et al. (1970) working on black anjan (*Cenchrus ciliaris*) reported appreciable increase in phosphorus content of hay due to application of nitrogen, while phosphate application slightly increased phosphorus content in hay.

Falade (1975) in his trials gave a complete nutrient solution containing 0-180 mg P/plot to (a) gamba grass (*Andropogon gayanus*) (b) Guinea grass (*Panicum maximum*)

(c) green colored *Pennisetum purpureum* (d) Purple coloured *Pennisetum purpureum* and (e) Pilzer giant star grass (*Cynodon plectostachyum*). In gamba grass (*Andropogon gayanus*) phosphorus content increased with incremental doses of phosphorus application upto 15 and 60 mg/plot while it decreased with further increase in phosphorus rate. Application of phosphorus increased the phosphorus content of fodder in dinanath grass (*Pennisetum pedicellatum*) (Rathore and Vijayakumar, 1978).

Krishnan (1968) reported that different levels of potassium exerted no significant influence in the phosphorus content of grain and straw in rice. Loganathan and Raj (1972) reported that nitrogen levels had little effect upon phosphorus absorption by straw in rice.

Rathore and Vijayakumar (1977) working on dinanath grass (*Pennisetum pedicellatum*) reported that phosphorus content declined due to nitrogen application. Ravikumar et al. (1979) working on spear grass (*Heteropogon contortus*) and black anjan (*Cenchrus ciliaris*) reported that in black anjan (*Cenchrus ciliaris*) the P_2O_5 content decreased with increase in levels of nitrogen. They also reported that the application. The interaction effect of nitrogen with phosphorus and potassium with phosphorus on the content of nitrogen in grain was significant.

2.4.5. Effect of treatments on uptake of nitrogen

Dwivedi and Kanodia (1986) studied the effect of nitrogen levels on different varieties of setaria grass (*Setaria sphacelata* Schumach) and reported that crude protein yield increased due to application of nitrogen. There was a linear increase in uptake of nitrogen upto 120 kg N/ha.

Misra et al. (1982) reported that in 2-row barley (*Hordeum vulgare*) increasing levels of nitrogen significantly increased the nitrogen uptake in grain, straw and total plant produce in both the years. Application of phosphorus too significantly raised the nitrogen uptake in grains but only upto 25 kg P_2O_5 /ha, while application of 25 and 50 kg P_2O_5 /ha significantly raised the nitrogen uptake in straw.

Rathore and Vijayakumar (1978) reported that phosphorus application brought about a progressively higher uptake of nitrogen, which is probably owing to root proliferation in dinanath grass (*Pennisetum pedicellatum*).

phosphorus content did not show any definite trend with phosphorus.

2.4.3. Effect of treatments on potassium content of fodder

Sadayappan and Kolandaiswamy (1974) noticed an increase in the potassium content with increase in the nitrogen levels upto 100 kg/ha in rice.

Thandapani and Rao (1974) found that phosphorus had no effect on potassium content in plants and grains of rice. In elephant grass (*Pennisetum purpureum*), addition of potash did not have any effect on potassium concentration in the oven dry forage. Johnkutty (1981) working on ragi reported that the potassium content of straw in ragi was influenced by application of potash significantly. Similar result was obtained by Subramanian (1969) also. Tiwari and Vanadana Nigam (1985) investigated the response of important legumes, oil seeds, cereals and fodder crops to potassic fertilizers and reported that potassium application markedly enhanced potassium uptake and concentration.

Andrew and Robins (1974) reported that phosphorus application decreased the nitrogen and potash content of grasses.

2.4.4. Effect of treatments on nitrogen, phosphorus and potassium content of fodder

Glogov (1969) found that the content and uptake of nitrogen, phosphorus and potassium were more at higher rates of fertilizers. Working on rice, Ajithkumar (1984) reported that the nitrogen and potassium contents of the plants was significantly influenced by the nutrient levels. The phosphorus content of the plant was not significantly influenced by the levels of NPK.

Ganguli et al. (1976) working on fodder oats (*Avena sativa*) reported that application of nitrogen, phosphorus and zinc sulfate did not significantly influence the contents of the nutrients in the forage. Joshi and Tandon (1984) studied the effect of NPK fertilization on the content of these elements in grain and straw in ragi (*Eleusine corocana*) and reported that the application of neither nitrogen nor phosphorus nor potash had effected the percentage contents of any of the three elements in grain or straw consistently. But there were indications of some effect on potassium content in grain by nitrogen application and potassium in straw by potash

Uptake of nitrogen by the shoot increased by higher potassium supply in rice (Mengel et al., 1976). Agarwal (1978) also revealed that the increase in uptake of nitrogen was highest with application of potassium.

Reddy et al. (1978) reported that nitrogen uptake increased with increase in rates of nitrogen + phosphorus + potassium from 100 + 50 + 50 to 200 + 100 + 100 kg / ha, in rice. Working on winter maize, Singh et al. (1991) reported that higher rates of nitrogen, phosphorus and potassium increased total nitrogen uptake in maize (being maximum under 150 per cent NPK) due to greater uptake by plants under higher nitrogen application and also better growth.

Working on 2 - row barley (*Hordeum vulgare*) Misra et al. (1982) reported that potassium application failed to show any notable impact on nitrogen uptake in straw upto a level of 100 kg K_2O /ha.

2.4.6. Effect of treatments on uptake of phosphorus

Working on 2 - row barley (*Hordeum vulgare*), Misra et al. (1982) reported that nitrogen application significantly increased the phosphorus uptake in grain, straw and total plant produce.

Rathore and Vijayakumar (1978) working on teosinte (*Euchleana maxicana*) reported that the uptake of phosphorus increased with an increase in the level of phosphorus and prominently so with the higher dose. Studies on the uptake of phosphorus by rice under graded levels of phosphorus revealed that there was a significant increase in phosphorus absorption with increasing rates of fertilizer at all stages of growth. (Suseelan et al., 1978). Misra et al. (1982) also reported an increased uptake of phosphorus due to phosphorus application in 2 - row barley.

Mohanty and Patnaik, (1974) reported an increased uptake of phosphorus due to potassium application in rice. Loganathan and Raj (1972) working on rice noticed that the uptake of phosphorus in the variety Co-32 was enhanced by the application of potassium at 40 and 80 kg /ha.

Singh et al. (1991) reported that under higher dose of NPK, the uptake of phosphorus was more in winter maize.

Alexander et al. (1974b) revealed that various rates of phosphorus had no significant effect on the uptake of phosphorus in rice. In 2 - row barley (*Hordeum vulgare*) potassium application failed to show any significant contribution in phosphorus uptake in grain and straw in any of the seasons (Misra et al., 1982).

2.4.7. Effect of treatments on uptake of potassium

Applied nitrogen was found to increase potassium uptake in rice in experiments conducted by Esakkimuthu et al. (1975). A consistent rise in the uptake of potassium in dinanath grass (*Pennisetum pedicellatum*), due to nitrogen application was noticed by Rathore and Vijayakumar (1978). Singh and Modgal (1978) observed that uptake of potassium was enhanced by application of nitrogen upto 120 kg /ha in rice.

Ramaswami and Raj (1974) observed that nitrogen and phosphorus increased potassium uptake in rice. Misra et al. (1982) reported that there was a significant increase in potassium uptake due to nitrogen application from 0 to 50 kg N/ha in 2 - row barley. Like nitrogen, application of phosphorus too raised the potassium uptake in barley.

Singh et al. (1976) noticed the highest rate of uptake and translocation of potassium by the application of 160 kg K/ha in rice. From their trials Singh and Jaiprakash (1979) revealed that potassium application increased potassium uptake in rice.

Loganathan and Raj (1972) noticed that the uptake of potassium was little affected by the different combinations of phosphorus and nitrogen in rice. In 2 - row barley, there was no significant increase in potassium uptake due to potash supply in first year, while the results of second year did not indicate any definite trend (Misra et al., 1982).

2.4.8. Effect of treatments on nitrogen, phosphorus and potassium uptake

Glogov (1969) reported that in grasses, the uptake of nitrogen, phosphorus and potassium was more at the higher dose of fertilizers. Ajithkumar (1984) working on rice variety Mashuri reported that the uptake of nitrogen and phosphorus increased significantly with increase in nutrient levels. Highest level of NPK (70:45:45) gave the highest nitrogen, phosphorus and potassium uptake values though there was no significant difference in the uptake of potassium.

Sarkar et al. (1989) also reported that organic manure applied in conjunction with optimal NPK dose resulted in higher NPK uptake in grain and fodder crops. In fodder sorghum, nitrogen, phosphorus and potassium uptake was higher at 100 per cent recommended dose (60 kg N + 13 kg P/ha) of inorganic fertilizer (Gangwar and Niranjan, 1991).

2.4.9. Effect of treatments on crude fibre

Tiwana and Puri (1976) reported a decrease in fibre content of fodder oats with each increment of nitrogen from 0 to 120 kg/ha. This confirms the result obtained by Tiwana et al. (1975) in hybrid napier. Thomas (1978) reported that in hybrid napier, crude fibre content was significantly reduced with increased nitrogen application upto 250 kg/ha. Similar reduction in crude fibre content with enhanced nitrogen application was also reported by Abraham (1978) in dinanath grass (*Pennisetum pedicellatum*).

Nooruddin and Roy (1977) studied the chemical composition, digestability and nutritive value of gamba grass (*Andropogon gayanus*) at flowering stage and reported that the crude fibre content was 25.38 per cent. Caceres et al. (1986) in their trial applied 60 kg N/ha to guinea grass

(*Panicum maximum* Cv. comun, *Panicum maximum* Cv. Likoni and gamba grass (*Andropogon gayanus*) and reported that crude fibre ranged from 37.1 to 38.0 percentage (DM basis), in the cut forage and from 38.1 to 40.5 per cent on the 4th day in gamba grass (*Andropogon gayanus*) and guinea grass (*Panicum maximum* Cv. comun) respectively.

2.5. Effect of treatments on days to 50 per cent flowering

Studies conducted by Sharma (1973) revealed that increasing the rates of applied nitrogen decreased the days to silking.

Nair et al. (1966) working on maize reported that earliness to cobbing was not significantly influenced by the various nitrogen treatments. Similarly George et al. (1990) reported that mean anthesis date was not affected by nitrogen fertilization in switch grass (*Panicum virgatum*).

2.6. Effect of treatments on number of panicles / plant

2.6.1. Effect of nitrogen on number of panicles / plant or number of fertile tillers / plant

In gamba grass (*Andropogon gayanus*) the application of 60 lbs N/acre (68 kg/ha) approximately doubled the number of inflorescences per unit area, while the equivalent of 100 lbs N/acre (113 kg/ha) almost trebled inflorescence numbers. There was no further response to nitrogen beyond 100 lbs N/acre (113 kg/ha) (Haggar, 1966). Boonman (1972) reported that in setaria grass (*Setaria sphacelata*), nitrogen increased the head numbers and percentage of heading tillers. Bahnisch and Humphreys (1977) reported that urea application increased tillering and tiller fertility in massey setaria grass (*Setaria anceps*). In a field study, Bilbao et al. (1979) applied different levels of nitrogen at 0, 10 and 20 days after cutting of black anjan (*Cenchrus ciliaris* L. Cv. Bioloela) and reported that panicle production /ha increased with nitrogen rates. Mecelis and Oliveira (1984) working on *Brachiaria humidicola* reported that nitrogen application significantly increased the number of fertile tillers / m^2. Park et al. (1985) working on tall fescue (*Festuca arundinaceae*) reported that the number of panicles per m^2 increased with increased nitrogen levels.

Sangakkara (1988) reported that increasing nitrogen rates increased the percentage of effective tillers in guinea grass (*Panicum maximum* Jacq). An increase in the number of seed heads / m^2 with nitrogen application was reported by Dwivedi et al. (1991a) in Guinea grass, (*Panicum maximum*). Krishnan (1993) also working on the same grass reported that nitrogen fertilizer application significantly increased number of panicles per hill during the first and second seed harvest.

Brejda et al. (1994) reported that in switch grass (*Panicum virgatum*), application of nitrogen after cutting increased reproductive tiller density.

Hampton et al. (1983) reported that increasing nitrogen levels did not significantly affect fertile tiller number at final harvest in 1979 and 1980, but in 1981 fertile tiller number in rye grass (*Lolium perenne*) at 160 kg nitrogen /ha was significantly greater than those of the control.

But Hebblethwaite (1977) working on S.23 rye grass reported that increasing the nitrogen from 80-160 kg/ha significantly decreased number of fertile tillers.

Nordestgaard (1988) working on Westerworld rye grass, (*Lolium multiflorum*), reported that increasing nitrogen rate from 50-150 kg/ha had no effect on number of fertile tillers.

It can be seen that in general, nitrogen application increases the number of panicles in grasses.

2.6.2. Effect of phosphorus on number of panicles / plant

In gamba grass (*Andropogon gayanus*), phosphate had a variable effect of inflorescence numbers at the highest levels of nitrogen application (N_{200}). The 300 lbs P_2O_5 per acre (339 kg/ha) treatment resulted in more inflorescences than the higher phosphate application (Haggar, 1966).

Alexander et al. (1974a) could not obtain any influence of phosphorus on the number of fertile tillers in rice. Sadanandan and Sasidhar (1975) noticed that increasing rate of phosphorus holds no significant effect on number of productive tillers in rice. Similarly Krishnan (1993) noticed no significant effect of phosphorus on the number of productive tillers in guinea grass (*Panicum maximum*).

2.6.3. Effect of potassium on number of panicles / plant

Padmaja (1976) observed that the number of productive tillers in rice and consequently panicle production was increased by application of potassium.

Uexkull (1982) found that the number of panicles per hill in rice was decreased by potassium application.

Rao et al. (1974) observed that the number of productive tillers was not significantly influenced by the application of potash even up to 80 kg/ha in rice. In the case of guinea grass (*Panicum maximum*), Krishnan (1993) reported that potassium did not have any influence on number of panicles per hill.

2.7. Effect of treatments on number of seeds / panicle

2.7.1. Effect of nitrogen on number of seeds / panicle

According to Subbiah et al. (1975) grain number per panicle in rice increased with increasing the nitrogen doses from 0 to 100 kg per hectare. Dixit and Singh (1979) observed a significant increase in the number of grains per panicle with 80 kg nitrogen /ha as compared to absolute control.

Sangakkara (1988), working on the relationship between nitrogen fertilizer, defoliation frequency and seed productivity of guinea grass (*Panicum maximum* Jacq) reported that the defoliation and nitrogen treatment had no significant effect on number of seeds per raceme.

There was a tendency for applied nitrogen to decrease the number of seeds / spike in perennial rye grass (*Lolium perenne*) (Hebblethwaite and Mc Laren, 1979).

2.7.2. Effect of phosphorus on number of seeds/panicle

Majumdar (1971) revealed that number of grains per panicle was significantly increased by application of 59.7 kg phosphorus per hectare in rice. Krishnan (1993) working on guinea grass also observed a similar trend.

Sadanandan and Sasidhar (1976) could not find any effect of phosphorus on number of grains/panicle in rice. In rice, the number of filled grains/panicle was unaffected by the rate of phosphorus application (Suseelan et al., 1978).

2.7.3. Effect of potassium on number of seeds/panicle

Bavappa and Rao (1956) reported that in rice, the number of grains per panicle was increased with potassium application. Kalyanikutty and Morachan (1974) reported that the number of grains per panicle was not affected by the rates of application of potassium. Ajithkumar (1984) could not find significant difference between the different levels of fertilizers in this respect in rice.

2.8. Effect of treatments on filled grains

Studying the effect of levels of nitrogen on yield components, Ramanujam and Rao (1971) found that the percentage of filled grains was not altered beyond 60 kg N/ ha. Sobhana (1983) reported that in rice, treatments receiving higher nitrogen produced more unfilled grains, thereby resulting in a higher sterility percentage.

Sasanki and Wada (1975) reported that low levels of phosphorus increased the percentage of sterile grains and can be altered by the level of applied phosphorus. Sadanandan and Sasidhar (1976) also working on rice found no significant effect on the number of filled grains / panicle with increased rates of applied phosphorus. Uexkull (1976) propounded that phosphorus increases the percentage of filled grains.

According to Rao et al. (1974), application of potash even up to 80 kg K_2O /ha did not influence the number of filled grains and chaff per panicle.

2.9. Effect of treatments on seed yield

2.9.1. Effect of nitrogen on seed yield

Preliminary investigation by Foster (1956) demonstrated that nitrogen was the most important nutrient for increasing seed yields of Rhode's grass, (*Chloris gayanas*). He found that seed yield could be increased significantly from 246 lb/acre (278 kg/ha) were no nitrogen was used to 306 lbs/acre (345.8 kg/ha) where 100 lb/acre of sulfate of ammonia was applied.

In gamba grass (*Andropogon gayanus*), seed yields per acre were increased considerably by the high levels of nitrogen. The 200 lbs N/acre (226 kg/ha) treatment trebled seed yields compared with the control (Haggar, 1966). In setaria grass (*Setaria sphacelata*) Cv. Nandi II, in the absence of nitrogen, yield of pure germinating seeds dropped to an average of less than 2.5 kg. A seven fold increase resulted from an additional 100 kg nitrogen. (Boonman, 1972).

Chadhokar and Humphreys (1973) studied the influence of time and level of urea application on seed production of paspalum and opined that response of nitrogen was much less in the year of establishment and higher in the succeeding years. In grasses like anguton grass (*Dicanthium aristatum*), gamba grass (*Andropogon gayanus*), setaria grass (*Setaria sphacelata*), and thin napier grass (*Pennisetum polystachyon*), application of nitrogen significantly increased seed yields. Above 200 kg, N/ha responses diminished rapidly (Javier et al., 1975). In another study by Cameron and Humphreys (1976) seed yield of *Paspalum plicatum* averaged 60, 301 and 361 kg/ha when fertilized with 0,100 and 400 kg nitrogen per hectare respectively. In seed crops of perennial rye grass, nitrogen application in excess of 120 kg/ha does not usually increase seed yield significantly over that of recommended rates. (Hebblethwaite and Ivins, 1977; Nordestgaard, 1980), because of increased lodging, production of secondary vegetative tillers and lower seed set (Hebblethwaite and Ivins, 1977). In field trials it was revealed that application of 30, 60, 120 or 150 kg nitrogen/ ha as Urea increased the seed yield of guinea grass (*Panicum maximum*) (Meja et al., 1978).

Park and Lee (1979) studied the effect of nitrogen fertilizer levels on seed production of *Dactylis glomerata* and reported that average yields of seed for 1977-78 were 309 kg/ha with 60 kg N/ha. Trials conducted with teosinte (*Euchlaena maxicana*) revealed that nitrogen increased seed yield significantly in both the years of the trial (1973 and 1974). The increase in seed yield due to per kg nitrogen application was 7.6 kg and 9.2 kg with application of 60 and 120 kg N/ha respectively. (Mukerjee et al., 1981). In another trial Rai and Sankaranarayanan (1981) found that in pusa giant anjan (*Cenchrus ciliaris*), seed yields increased significantly with application of nitrogen. There was significant increase of seed yield by 19.6 kg/ha with an increase in nitrogen from 20 to 40 kg/ha. Shingareva (1981) working on perennial rye grass (*Lolium perenne*) reported that application of 90 kg nitrogen/ha gave high seed yields in the first year and a good yield in the second year. Report from CIAT (1982) showed that in gamba grass (*Andropogon gayanus*) application of 100 kg N/ha as urea increased pure seed yield by an average of 40 per cent compared with plots given no nitrogen. Mecelis and Oliveira (1984) working on *Brachiaria humidicola* reported that nitrogen application significantly increased seed production. Monteiro et al.

(1984) working on guinea grass (*Panicum maximum*) reported that the yield of pure viable seed was highest at 44 kg N/ ha. Working on setaria grass (*Setaria sphacelata*) Junquira et al. (1985) reported that nitrogen application increased clean seed yield from 171 kg without nitrogen to a mean of 277.3 kg/ha with 250 kg/ha. Difference between nitrogen rates were not significant.

In another study in Westerworld rye grass (*Lolium multiflorum*), Nordestgaard (1988) reported that increasing nitrogen rates from 50-100 kg/ha increased average seed yield from 1.42 to 1.49 t/ha; but further increase to 150 kg nitrogen reduced average seed yield to 1.45 t/ha. Trials on guinea grass by Sangakkara (1988) revealed that two defoliation in combination with 150 to 200 kg nitrogen/ha produced approximately two fold increase in seed yields.

Carmo et al. (1988) reported that in signal grass (*Brachiaria decumbens*), increasing nitrogen levels increased yield of crude seed from 96 to 229 kg/ha in March, but had no effect on yield in April, when yields were 57-94 kg/ha. Dwivedi et al. (1991a) working on guinea grass found that seed yield was 63.6 to 89.7 kg when given nitrogen fertilizer and the increased seed production was due to increase in number of seeds/m^2. Working on thin napier grass (*Pennisetum polystachyon*) he also reported that mean seed yield increased with increasing rates of nitrogen up to 60 kg/ ha (Dwivedi et al., 1991b). Brejda et al. (1994) working on switch grass (*Panicum virgatum*) reported that nitrogen application increased seed yield.

Varchenko (1980) reported that application of nitrogen to brome grass (*Bromus inermis*) in Siberia had no effect on seed yield in the first utilisation year. Febles et al. (1982) reported that seed yield of guinea grass was not significantly increased by application of 50 or 100 kg. nitrogen per hectare when compared with the untreated control. He also reported that the highest pure seed yield of 150 kg were given with application of 100 kg N/ha every 20 days after cutting. In the second year, seed production was highest with application of 200 kg N/ha.

2.9.2. Effect of phosphorus on seed yield

In buffel grass (*Cenchrus ciliaris*) seed yields increased from 82.5 to 257.8 kg ha with 0 kg and 120 kg P_2O_5/ha. (Ayerza, 1980). Mukerjee et al. (1981) working on seed production of teosinte (*Euchlaena maxicana*) reported that phosphorus increased the seed yield significantly in 1973 though the increasing trend on seed yield was recorded in 1974. Satjipanon et al. (1989) obtained maximum seed yield 53 kg/ha with application of 16 + 20 + P'max (24 kg P)/ ha in ruzi grass (*Brachiaria ruziziensis*). In thin napier (*Pennisetum polystachyon*) seed yield increased by application of 30 kg P_2O_5 /ha from 177 kg/ha (no phosphorus) to 199 kg/ha (Dwivedi et al., 1991b).

According to Foster (1956) in Rhodes grass (*Chloris gayana*) application of 100 lb/acre of superphosphate did not significantly increase seed yield. Javier et al. (1975) revealed that responses to phosphorus were infrequent in grasses like Anguton grass (*Dicanthium aristatum*), gamba grass (*Andropogon gayanus*), setaria grass (*Setaria sphacelata*) and thin napier (*Pennisetum polystachyon*). In perennial rye grass (*Lolium perenne*) and meadow fescue (*Festuca pratensis*), trials conducted to assess the effect of 0 or 40 kg phosphorus on seed production showed that seed yield varied little between 'P' treatments (Nordestgaard, 1990).

In gamba grass (*Andropogon gayanus*), the influence of phosphate on seed yields did not reach significance, but the results suggested that high level of phosphate depressed seed yields when more than the equivalent of 50 lb N/acre were applied '(Haggar, 1966). Rai and Shankaranarayanan (1981) working on pusa giant anjan (*Cenchrus ciliaris*), reported that the seed yield was not affected by the application of phosphorus. Pooled data clearly showed that the seed yield obtained with the application of 20 kg P_2O_5 /ha as soil application was lower than that under control.

2.9.3. Effect of potassium on seed yield

Singh et al. (1976) observed that application of 120 kg potassium per hectare gave the highest yield of grain in rice. Ramakrishnan and Vadivelu (1981) working on rice applied 3 levels of K_2O at 50, 70 and 100 kg/ha reported that irrespective of the cultivars and their duration, rice responded to application of potash. The growth of the crop improved and the yield of quality seeds increased from 4 to 10 per cent with increasing levels of applied potash.

Shukla (1969) could not get any significant effect of potassium on the grain yield of rice. Trials by Nordestgaard (1990) with perennial rye grass (*Lolium perenne*) to assess the effect of 0 or 100 kg potassium on seed production showed that seed yields varied little between potassium treatments. Krishnan (1993) working on guinea grass (*Panicum maximum*) reported that potassium did not show any influence on seed yield.

2.9.4. Effect of nitrogen and phosphorus on seed yield

Chakravarty et al. (1966) working on buffel grass (*Cenchrus ciliaris*) reported that application of 22.4 kg each of nitrogen and phosphorus favoured seed production. Narwal and Tomer (1973) reported that dinanath grass (*Pennisetum pedicellatum*) when fertilized with 60 kg each of nitrogen and phosphorus recorded increased seed yield of about 600 kg/ha over control. Mukerjee et al. (1981) working on seed production of teosinte, (*Enchleana maxicana*) found that maximum seed yield (18.82 q/ha) was obtained in the treatment $N_{20}P_{60}$. Yadav and Mahendra Singh (1986) working on buffel grass reported higher seed yield with 40 kg nitrogen and 50 kg P_2O_5 /ha under arid conditions.

2.9.5. Effect of nitrogen, phosphorus and potassium on seed yield

According to Skoblin and Perepravo (1979) in cocksfoot (*Chloris barbata*), the highest average seed yields (0.74 t/ha) were obtained by harvesting crops at the wax stage from plots given 180 kg N + 90 kg P_2O_5 + 180 kg K_2O /ha.

Application of NPK fertilizer to congosignal grass showed that the different levels of NPK fertilizer had no significant difference on seed yield, the NPK being 0:0:0, 40:40:40, 60:60:60, 80:80:80. Fertilizer does of 40:40:40 gave maximum seed yield of 310 kg/ha (Research Report, 1987-90).

Nair and George (1973) reported that the levels of nitrogen had no significant effect in increasing the grain yield. Nitrogen supply over 80 kg/ha could not increase yield significantly in rice (Pillai and George, 1973).

Shukla (1969) noticed that paddy yield was unaffected by phosphorus application. Nair and Pisharody (1970) also reported that paddy yields were not increased with 22.4 to 56 kg phosphorus applied alone or with various rates of nitrogen or potassium.

Shukla (1969) and Pandey and Das (1973) could not get any significant effect of potassium on the grain yield of rice.

2.10. Effect of treatments on seed quality

2.10.1. Effect of nitrogen on seed quality

Meeelis and Oliveira (1984) reported that in *Brachiaria humidicola*, nitrogen application significantly increased seed germination. In a trial Monteiro et al. (1984) applied different levels of nitrogen to guinea grass (*Panicum maximum*) and reported that nitrogen rate affected seed purity. The effect of nitrogen fertilizer and date of harvest on seed production and quality in signal grass (*Brachiaria decumbens*) were studied by Carmo et al. (1988) and reported that with increasing nitrogen, germination decreased from 51 to 32 per cent in March and increased from 42-71 per cent in April. Physical purity of crude seed was 20 per cent in March and increased from 30 to 40 per cent with increasing nitrogen levels in April. 100 seed weight was 0.33 g. in March which increased to 0.42 g. with increasing nitrogen levels in April.

Dwivedi et al. (1991a) reported that 1000 seed weight in guinea grass ranged from 1.77 g. in pure stands to 2.13 g. when intercropped with *Stylosanthes hamata* or given 40 kg nitrogen /ha. Percentage germination was not affected by the treatments.

Sangakkara (1988) working on the relationship between nitrogen fertilizer, defoliation frequency and seed productivity of guinea grass (*Panicum maximum* Jacq) reported that the defoliation and nitrogen treatments had no significant effect on 1000 seed weight.

In another trial, nitrogen fertilizer application for seed yield and quality of setaria grass (*Setaria sphacelata* var sericeae Cv. Kazungula) was studied by Cruz et al. (1989) and reported that seed germination in all trials was unaffected by nitrogen rates.

2.10.2. Effect of nitrogen and phosphorus on seed quality

Dwivedi et al. (1991 b) studied the effect of nitrogen and phosphorus levels on seed yield of thin napier grass (*Pennisetum polystachyon*) and reported that seed germination and 1000 seed weight were increased by nitrogen application, but not significantly affected by phosphorus.

2.10.3. Effect of nitrogen, phosphorus and potassium on seed quality

Skoblin and Perepravo (1979) studied the effect of harvest dates and fertilizer rates on the yield and quality of cocksfoot seed and reported that higher fertilizer rates gave higher yields, but did not affect the sowing quality of the seed.

In a field trial in Thailand, ruzi grass (*Brachiaria ruziziensis*) pasture was given 0-48 kg nitrogen /ha, 0-25 kg phosphorus /ha and 0-15 kg potassium /ha and it was found that fertilizer application had no effect on seed quality parameters like germination, purity and viability (Satjipanon et al., 1989).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study was undertaken to find out the effect of varying levels of nitrogen, phosphorus and potassium on the seed production potential of gamba grass, (*Andropogon gayanus*. Kunth) a tall tussock grass, which is a recent introduction to our state.

3.1 Materials

3.1.1. Experimental site

The experiment was conducted at the instructional farm attached to the College of Agriculture, Vellayani located at 8.5° N latitude and 76.9° longitude at an altitude of 29m above mean sea level.

3.1.2. Soil

The soil of the experimental site was red sandy clay loam (oxisol, Vellayani series). The important physical and chemical properties of the soil are summarised in table 3.1.

Table 3:1 Physical and Chemical properties of soil

A. Mechanical composition.

Constituent	**Content in soil (%)**	**Method used**
Coarse sand	14.70	International Pipette
Fine sand	33.30	method(Piper, 1950)
Silt	26.50	
Clay	25.50	

B. Chemical Composition before the experiment.

Constituent	**Content in Soil**	**Rating**	**Method used**
Available N (kg/ha)	313.60	Medium	Alkaline Permagnate method. (Subbiah and Asija, 1956)
Available P_2O_5 (kg/ha)	59.5	High	Chlorostannous reduced Molybdophosphoric blue colour method. (Jackson, 1958)
Available K_2O (kg/ha)	68.14	Low	Flame Photometric method. (Jackson, 1958)
pH (1:2.5 soil water ratio)	4.8	Acidic	pH meter. (Jackson, 1958)

3.1.3. Season and climate

The experiment was started in the month of July 1993 and continued upto January 1994. The meteorological parameters recorded are rainfall, maximum and minimum temperature and relative humidity. The average weekly values from sowing to harvest were worked out and are presented in appendix I and graphically represented in fig. 3.1.

3.1.4. Cropping History of the field.

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

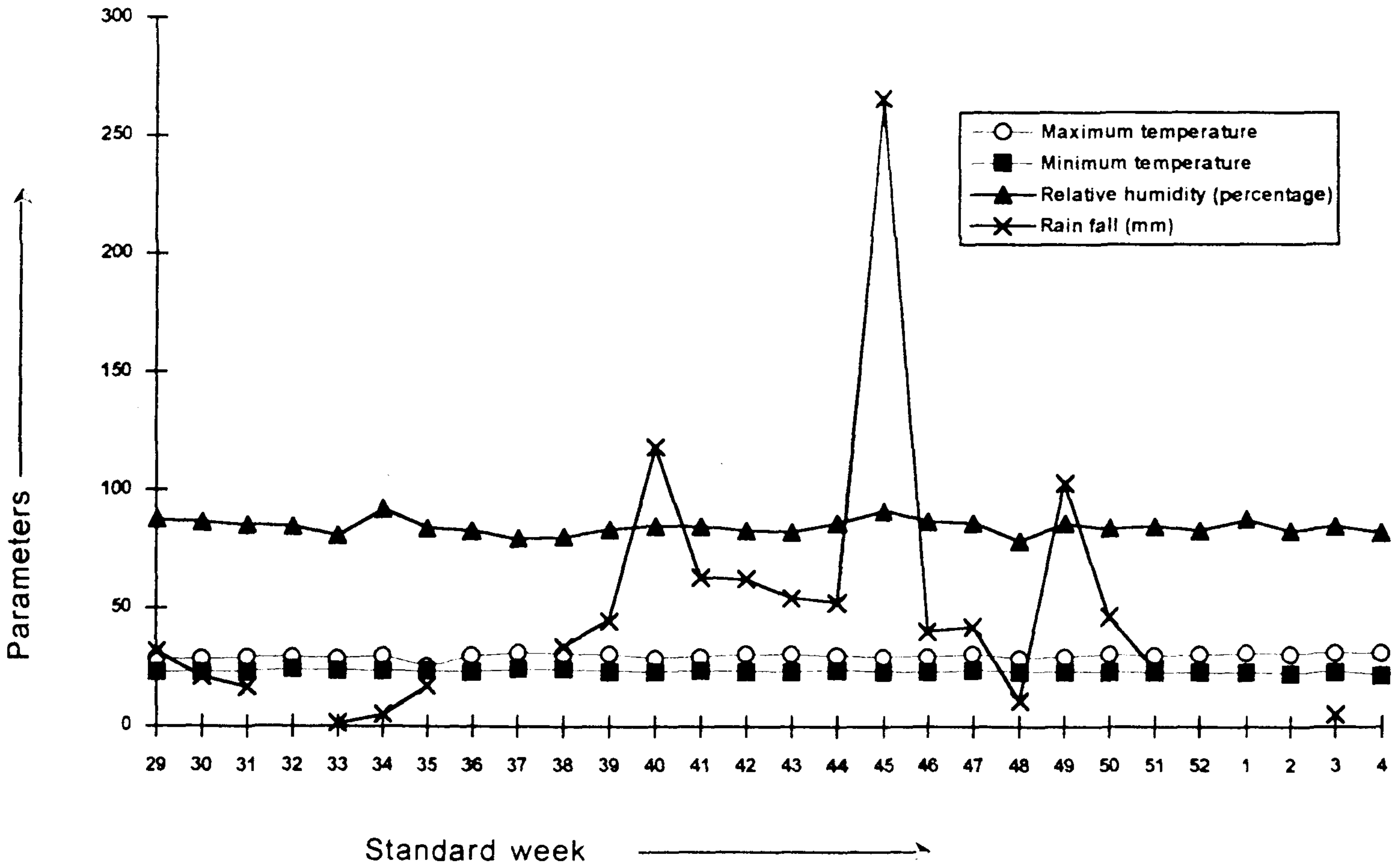
3.1.5. Seed material

Seeds of gamba grass obtained from the Kerala Livestock Development Board, Regional Unit Dhoni were tested for viability and was found satisfactory.

3.1.6. Fertilizers

Urea, mussoorie rock phosphate and muriate of potash, analysing 46 per cent N, 28 per cent P_2O_5 and 60

Fig. 3.1. Weather parameters for the crop period (1993 - 94)



per cent K_2O respectively were used for the experiment.

3.2. Methods

3.2.1. Treatments

The treatments included,

A. 3 levels of Nitrogen

N_1 - 75 kg N/ha.

N_2 - 150 kg N/ha.

N_3 - 225 kg N/ha.

B. 3 levels of Phosphorus

P_1 - 50 kg P_2O_5/ha.

P_2 - 75 kg P_2O_5/ha.

P_3 - 100 kg P_2O_5/ha.

C. 3 levels of Potassium

K_1 - 50 kg K_2O/ha.

K_2 - 75 kg K_2O/ha

K_3 - 100 kg K_2O/ha.

D. Treatment combinations

1. $N_1P_1K_1$ - 75 kg N : 50 kg P_2O_5 : 50 kg K_2O/ha.
2. $N_1P_1K_2$ - 75 kg N : 50 kg P_2O_5 : 75 kg K_2O/ha.
3. $N_1P_1K_3$ - 75 kg N : 50 kg P_2O_5 : 100 kg K_2O/ha.
4. $N_1P_2K_1$ - 75 kg N : 75 kg P_2O_5 : 50 kg K_2O/ha.
5. $N_1P_2K_2$ - 75 kg N : 75 kg P_2O_5 : 75 kg K_2O/ha.
6. $N_1P_2K_3$ - 75 kg N : 75 kg P_2O_5 : 100 kg K_2O/ha.
7. $N_1P_3K_1$ - 75 kg N : 100 kg P_2O_5 : 50 kg K_2O/ha.
8. $N_1P_3K_2$ - 75 kg N : 100 kg P_2O_5 : 75 kg K_2O/ha.
9. $N_1P_3K_3$ - 75 kg N : 100 kg P_2O_5 : 100 kg K_2O/ha.
10. $N_2P_1K_1$ - 150 kg N : 50 kg P_2O_5 : 50 kg K_2O/ha.
11. $N_2P_1K_2$ - 150 kg N : 50 kg P_2O_5 : 75 kg K_2O/ha.
12. $N_2P_1K_3$ - 150 kg N : 50 kg P_2O_5 : 100 kg K_2O/ha.
13. $N_2P_2K_1$ - 150 kg N : 75 kg P_2O_5 : 50 kg K_2O/ha.
14. $N_2P_2K_2$ - 150 kg N : 75 kg P_2O_5 : 75 kg K_2O/ha
15. $N_2P_2K_3$ - 150 kg N : 75 kg P_2O_5 : 100 kg K_2O/ha.
16. $N_2P_3K_1$ - 150 kg N : 100 kg P_2O_5 : 50 kg K_2O/ha.
17. $N_2P_3K_2$ - 150 kg N : 100 kg P_2O_5 : 75 kg K_2O/ha.
18. $N_2P_3K_3$ - 150 kg N : 100 kg P_2O_5 : 100 kg K_2O/ha.
19. $N_3P_1K_1$ - 225 kg N : 50 kg P_2O_5 : 50 kg K_2O/ha.

20. $N_3P_1K_2$ - 225 kg N : 50 kg P_2O_5 : 75 kg K_2O/ha.

21. $N_3P_1K_3$ - 225 kg N : 50 kg P_2O_5 : 100 kg K_2O/ha.

22. $N_3P_2K_1$ - 225 kg N : 75 kg P_2O_5 : 50 kg K_2O/ha.

23. $N_3P_2K_2$ - 225 kg N : 75 kg P_2O_5 : 75 kg K_2O/ha.

24. $N_3P_2K_3$ - 225 kg N : 75 kg P_2O_5 : 100 kg K_2O/ha.

25. $N_3P_3K_1$ - 225 kg N : 100 kg P_2O_5 : 50 kg K_2O/ha.

26. $N_3P_3K_2$ - 225 kg N : 100 kg P_2O_5 : 75 kg K_2O/ha.

27. $N_3P_3K_3$ - 225 kg N : 100 kg P_2O_5 : 100 kg K_2O/ha.

3.2.2. Layout and Design

The experiment was laid out as a partially confounded factorial randomised block design with 2 replications, confounding NPK in replication 1 and NP^2K^2 in replication 2.

The layout plan is given in fig. 3.2.

Replications - 2

Treatment combinations - 27

Total number of plots - 54

Gross Plot size - 5 x 3 m

Net Plot size - 3 x 1.8 m

Fig. 3.2 Layout of The Experiment

N

T19	T20	T4
T1	T6	T15
T11	T27	T22
T5	T10	T21
T16	T13	T8
T7	T14	T26
T25	T2	T17
T18	T23	T9
T3	T12	T24

R_1 R_2

T4	T7	T24
T3	T2	T1
T5	T25	T15
T23	T19	T21
T11	T22	T26
T20	T14	T27
T6	T13	T17
T18	T8	T12
T16	T10	T9

Treatment combinations

1. $N_1P_1K_1$ - 75kg N : 50 kg P_2O_5 : 50 kg K_2O/ha.
2. $N_1P_1K_2$ - 75kg N : 50 kg P_2O_5 : 75 kg K_2O/ha.
3. $N_1P_1K_3$ - 75kg N : 50 kg P_2O_5 : 100 kg K_2O/ha
4. $N_1P_2K_1$ - 75kg N : 75 kg P_2O_5 : 50 kg K_2O/ha.
5. $N_1P_2K_2$ - 75kg N : 75 kg P_2O_5 : 75 kg K_2O/ha.
6. $N_1P_2K_3$ - 75kg N : 75 kg P_2O_5 : 100 kg K_2O/ha.
7. $N_1P_3K_2$ - 75kg N : 100 kg P_2O_5 : 50 kg K_2O/ha.
8. $N_1P_3K_2$ - 75kg N : 100 kg P_2O_5 : 75 kg K_2O/ha.
9. $N_1P_3K_3$ - 75kg N : 100 kg P_2O_5 : 100 kg K_2O/ha.
10. $N_2P_1K_1$ - 150kg N : 50 kg P_2O_5 : 50 kg K_2O/ha.
11. $N_2P_1K_2$ - 150kg N : 50 kg P_2O_5 : 75 kg K_2O/ha.
12. $N_2P_2K_3$ - 150kg N : 50 kg P_2O_5 : 100 kg K_2O/ha.
13. $N_2P_2K_3$ - 150kg N : 75 kg P_2O_5 : 50 kg K_2O/ha.
14. $N_2P_2K_2$ - 150kg N : 75 kg P_2O_5 : 75 kg K_2O/ha.
15. $N_2P_2K_3$ - 150kg N : 75 kg P_2O_5 : 100 kg K_2O/ha.
16. $N_2P_3K_1$ - 150kg N : 100 kg P_2O_5 : 50 kg K_2O/ha.
17. $N_2P_3K_2$ - 150kg N : 100 kg P_2O_5 : 75 kg K_2O/ha.
18. $N_2P_3K_3$ - 150kg N : 100 kg P_2O_5 : 100 kg K_2O/ha
19. $N_3P_1K_1$ - 225kg N : 50 kg P_2O_5 : 50 kg K_2O/ha.
20. $N_3P_1K_2$ - 225kg N : 50 kg P_2O_5 : 75 kg K_2O/ha.
21. $N_3P_1K_2$ - 225kg N : 50 kg P_2O_5 : 100 kg K_2O/ha.
22. $N_3P_2K_1$ - 225kg N : 75 kg P_2O_5 : 50 kg K_2O/ha.
23. $N_3P_2K_2$ - 225kg N : 75 kg P_2O_5 : 75 kg K_2O/ha.
24. $N_3P_2K_3$ - 225kg N : 75 kg P_2O_5 : 100 kg K_2O/ha.
25. $N_3P_3K_1$ - 225kg N : 100 kg P_2O_5 : 50 kg K_2O/ha.
26. $N_3P_3K_2$ - 225kg N : 100 kg P_2O_5 : 75 kg K_2O/ha.
27. $N_3P_3K_3$ - 225kg N : 100 kg P_2O_5 : 100 kg K_2O/ha.

Net area of a plot - 5.4 m^2

Spacing - 50 x 30 cm

Two rows of plants all around were left as border rows.

3.2.3. Details of cultivation

3.2.3.1. Nursery preparation

The area selected for the nursery was dug well and levelled. The seeds were sown in beds of size 2 m^2 and 4 such beds were raised. Sowing was done on 24.6.1993.

3.2.3.2. Main field preparation

With the onset of monsoon, the experimental area was cleared, dug twice, stubbles removed, clods broken and the field laid out into blocks and plots. The plots were again thoroughly dug and levelled.

3.2.3.3. Fertilizer application

The entire doze of phosphorus and potassium and one forth of nitrogen as per treatment were applied to the experimental plots as basal. Remaining three fourth of nitrogen was applied in 2 equal split doses.

3.2.3.4. Transplanting

One month old healthy seedling from the nursery were used for planting in the main field. The nursery was given one irrigation so as to enable uprooting of the seedlings without any damage to the root system. The seedlings were transplanted along with a ball of earth to avoid transplanting shock. Seedlings were planted in rows 50 cm apart and the plant to plant spacing was 30 cm. Transplanting was done on 27, 28 and 29^{th} July, 1993. Gap filling was done 20 days after transplanting and uniform plant population was maintained.

3.2.3.5. Weeding and intercultivation

Weeding was first carried out 20 days after planting on 18.8.1993 and two months later a uniform cut was given on 5.10.1993. Half of the remaining three fourth of nitrogen was applied after weeding. A light digging was also done One month afterwards on 8.11.1993 the remaining dose of nitrogen was given.

3.2.3.6. Seed harvest

The seeds were collected at weekly intervals, when the colour of the seed turned white from green. The first seed harvest was done 28 days after the first flower appeared and continued for a period of 35 days at weekly intervals. The details of seed harvest are furnished below

1st Seed Harvest - 15.12.93

2nd Seed Harvest - 22.12.93

3rd Seed Harvest - 29.12.93

4th Seed Harvest - 05.12.93

5th Seed Harvest - 12.01.94

6th Seed Harvest - 19.01.94

The seed harvests were done in the morning hours by collecting the mature seeds plotwise. The shattered seeds from the ground were also collected carefully plotwise without any contamination. The seeds were then dried and stored.

3.2.4. Observations recorded

Growth characters

For assessing the periodical growth, 4 plants were randomly selected from each plot and the following growth characters were recorded.

(a) Height

Height of the plant was measured in centimetres from the base of the plant to the tip of the tallest leaf in all observation hills and the means worked out.

(b) Number of tillers

The number of tillers from each clump was counted and the means worked out

(c) Number of leaves

The number of leaves in each clump was counted and mean number of leaves was worked out.

(d) Green matter yield

Harvest of green fodder was done on 5.10.1993 and 19.1.1994. After each harvest of green fodder, the yield from each net plot was recorded and converted to per hectare yield in tonnes.

(e) Dry matter yield

At the final harvest of green fodder, the sample plants were cut into small pieces, weighed and first dried in shade and then dried to constant weight in an air oven. Dry matter content for each treatment was computed and the dry matter yields calculated from the respective green matter yields.

(f) Days to 50 per cent flowering

The number of days taken for more than half of the population in each plot for flowering was counted as the days to 50 per cent flowering. The day of transplanting was counted as the first day of the crop period.

(g) Number of seeds per panicle

From the four sample plants 1 panicle each was selected and the number of seeds present in each panicle was counted.

(h) Seed weight per plot

The seeds separated from the harvested crop and the shed seeds were thoroughly cleaned, mixed, dried and final weights recorded.

(i) Thousand seed weight

One thousand seeds were drawn from the seed sample and weighed in an electronic balance and weight was recorded as per ISTA (1985)

(j) Germination test

The pure seeds (seeds with kernels) present in 500 seeds taken from the seed sample were tested for germination. Whatman No.40 filter paper was used as substratum. Daily watering was done and continued upto 21 days. Germinated seeds were counted and removed each time and continued upto three weeks. Germination was expressed as percentage of total seeds (ISTA, 1985).

(k) Topographical Tetrazolium Test (TTC)

(Biochemical test for Viability)

The object of topographical tetrazolium test was to make a quick estimate of viability of seed samples in general and those showing dormancy in particular and 2, 3, 5 triphenyl tetrazolium chloride (colourless solution) was used as an indicator (ISTA, 1985).

The seeds with kernels were separated from 500 seeds counted from each sample. The outer chaff was removed and the kernels were soaked in water for 15 hours. Presoaked seeds were pierced through the embryo and added 0.1 per cent tetrazolium chloride solution and was kept undisturbed for 8 hours. Each seed was examined and evaluated as viable or nonviable on the basis of staining patterns. Red colored living seeds were distinguished from colourless dead ones. Red coloured seeds were recorded and reported in percentage as viable.

(l) Determination of moisture percentage

High constant temperature oven method was used for determination of seed moisture content (ISTA, 1985). Seed samples weighing 1.5 - 2.5 g were taken for test in a petri dish with lid. Empty petri dish with lid was weighed. After filling with seed, they were again weighed and placed in an oven, maintained at a temperature of 130-133°C. The seed samples were dried for a period of one hour and then cooled in a desiccator and subsequently weighed.

Moisture content of seeds was expressed in percentage by means of the following formula,

$$\frac{(M_2 - M_3) \times 100}{M_3 - M_1}$$

where,

M_1 - is the weight of petri dish with lid in grammes

M_2 - is the weight of petri dish with lid and seed before drying in grammes

M_3 - is the weight of petri dish with lid and seed after drying in grammes.

(m) Seed purity

Two grammes seeds were weighed from each seed sample. Seeds were placed on a working board and separated into 4 components viz., pure seed, other crop seed, weed seeds and inert matter. After the separation was completed rechecking was done. Then each of the components were weighed accurately and expressed as percentage.

3.2.5. Chemical analysis

(a) Plant analysis

Samples taken for chemical analysis were oven dried at 80 ± 5°C and ground into a fine powder. The nitrogen phosphorus and potassium contents of the plant samples were analysed.

(i) Nitrogen content

The total nitrogen content of the samples were determined by Modified Micro Kjeldahl method (Jackson, 1967).

(ii) Phosphorus content

The phosphorus content was determined by Vanado Molybdo - Phosphoric yellow colour method (Jackson, 1967) using Klett Summerson Photoelectric Colorimeter.

(iii) Potassium content

Potassium content in plant samples were determined using 'EEL' flame photometer.

(iv) N,P,K uptake

The total uptake of nitrogen, phosphorus and potassium at harvest was calculated based on the content of these nutrients in the plant samples and the dry weights expressed in kg/ha.

(v) Crude fibre

Crude fibre content of the different samples were determined by the method as suggested by Wright (1939).

b) Soil analysis

The total nitrogen, phosphorus and potassium content of a composite soil sample collected prior to the experiment and soil samples collected from individual plots after the experiment were analysed. Total nitrogen was determined by Modified Micro Kjeldahl method (Jackson, 1967) and available phosphorus by Bray's method (Jackson, 1967). Available potassium was determined by Ammonium Acetate Method (Jackson, 1967).

c) Economics of cultivation

The economics of cultivation was worked out based on various input costs.

Net income (Rs./ha) = Gross income - cost of cultivation.

Benefit - cost ratio = Gross income / Cost of cultivation.

d) Statistical analysis

The experimental data were analysed statistically by applying the technique of analysis of variance for partially confounded 3^3 factorial experiment and significance was tested by 'F' test (Cochran and Cox, 1965).

RESULTS

4. RESULTS

With the object to find out the effect of nitrogen, phosphorus and potassium on seed production of gamba grass (*Andropogon gayanus*), an experiment was conducted in the College of Agriculture, Vellayani during the period from July 1993 to January 1994. The treatments consisted of the combinations of 3 levels of nitrogen, 3 levels of phosphorus and 3 levels potassium. The data obtained from the experiment were statistically analysed and the results are presented in this chapter.

4.1. Effect of treatment on morphological characters

4.1.1. Height of plants at first cut

The mean height of plants recorded at the first harvest are presented in table 4.1.(a) It can be seen from the table that application of nitrogen significantly increased the height of plants at the first harvest. The highest level of nitrogen recorded maximum height. Height differences were not detected at the lowest levels of nitrogen.

The effect of phosphorus and potassium levels on plant height was not significant. The interaction effect NP, NK and PK were also not significant.

4.1.2. Number of tillers at first cut

The mean data on the number of tillers at first cut are presented in table 4.1.(b) The effect of nitrogen on number of tillers was significant. From table 4.1.(b) it is evident that the total number of tillers recorded under the highest level of nitrogen(N_3) was the maximum. Plants treated with N_3 were found to produce more number of tillers than treated with N_1.

The effect of phosphorus and potassium levels on number of tillers was not significant. The different interaction effects were also not significant.

4.1.3. Number of leaves at first cut

The mean data on number of leaves are presented in table 4.1.(c). It may be seen from the table that the effect of nitrogen on number of leaves was significant. The maximum number of leaves was recorded at the highest level of nitrogen(N_3). The levels N_3 and N_1 were only significantly different.

There was no significant influence due to application of phosphorus and potassium. The interaction effects were also not significant.

4.1.4. Height of plants at second cut

The mean data on height of plants at second cut are presented in table 4.1.(d). It can be seen from the table that the effect of nitrogen on height of plants was not significant at second harvest.

Though not significant, an increasing trend in plant height with increase in the level of nitrogen was noted. Effect of phosphorus and potassium also did not show any significant influence . The interaction effects were also not significant.

4.1.5. Number of tillers at second cut

The mean data on number of tillers at second cut is presented in table 4.1.(e). Maximum number of tillers were recorded under the treatment which received the highest level of nitrogen. N_3 level of treatment was significant over the other two levels of nitrogen. But N_2 and N_1 were on par, while N_3 was superior over N_2 level.

The effect of phosphorus and potassium levels on tiller production was not significant.

NP interaction was significant. When nitrogen is combined with P_1, a significant increase in number of tillers at second cut was observed at N_3P_1. While no significant difference was observed when nitrogen is combined with P_2. Nitrogen in combination with P_3 did not produce any variation in the number of tillers at N_2 and N_3, but at these treatment combinations, the number of tillers was significantly high in comparison to N_1P_3.

NK and PK interactions were not significant.

4.1.6. Number of leaves at second cut

The mean data on number of leaves at second cut is given in table 4.1.(f). It can be seen from the table that the number of leaves at second cut was significantly

Table 4.1. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Plant height at first cut	(b) Number of tillers at first cut	(c) Number of leaves at first cut	(d) Plant height at second cut	(e) Number of tillers at second cut	(f) Number of leaves at second cut
N_1	72.82	20.46	89.40	220.62	36.86	109.41
N_2	77.54	24.85	103.83	226.56	39.30	118.87
N_3	87.47	28.71	118.55	233.17	44.86	131.04
F(2,22)	7.82^{**}	7.06^{**}	4.40^{**}	1.28^{ns}	10.95^{**}	20.42^{**}
P_1	80.31	25.04	104.44	227.54	41.49	126.61
P_2	78.29	23.85	102.51	229.52	39.33	118.26
P_3	79.24	25.11	104.83	223.28	40.25	119.96
F(2,22)	0.14^{ns}	0.21^{ns}	3.19^{ns}	0.33^{ns}	0.764^{ns}	1.93^{ns}
K_1	74.99	25.76	104.99	223.50	42.58	130.76
K_2	82.31	23.96	102.53	229.40	38.87	114.19
K_3	80.54	24.32	104.28	227.44	39.57	119.87
F(2,22)	2.04^{ns}	0.387^{ns}	3.32^{ns}	0.294^{ns}	2.53^{ns}	7.04^{**}
CD	7.84	4.55	20.37	16.25	3.63	9.3
SE_d	3.78	2.19	9.82	7.84	1.75	4.48

(Continued ....)

Table 4.1. (Continued ....)

N_1P_1	71.17	19.58	86.79	225.73	35.75	105.0
N_1P_2	72.96	22.29	96.17	219.28	39.67	118.71
N_1P_3	74.33	19.50	85.25	216.83	35.17	104.54
N_2P_1	75.87	21.54	93.17	221.92	38.00	116.12
N_2P_2	77.78	24.42	105.46	236.93	37.62	112.08
N_2P_3	78.96	28.58	112.87	220.82	42.29	125.83
N_3P_1	93.87	34.04	133.75	234.95	50.71	158.71
N_3P_2	84.12	24.83	105.92	232.35	40.71	124.00
N_3P_3	84.42	27.25	116.37	232.20	43.16	129.50
F	0.761^{ns}	2.51^{ns}	1.11^{ns}	0.40^{ns}	3.95^{**}	6.69^{**}
N_1K_1	71.29	19.71	85.58	216.12	37.62	112.58
N_1K_2	73.96	19.08	83.42	218.33	35.71	104.42
N_1K_3	73.21	22.58	99.21	227.40	37.25	111.25
N_2K_1	70.12	26.75	106.33	220.89	41.29	126.08
N_2K_2	77.42	25.58	108.42	234.35	39.00	114.87
N_2K_3	85.07	22.21	96.75	224.43	37.62	113.08
N_3K_1	83.54	30.83	123.04	233.48	48.83	153.62
N_3K_2	95.54	27.12	115.75	235.52	41.91	123.29
N_3K_3	83.33	28.17	116.87	230.49	43.83	135.29
F	1.465^{ns}	0.68^{ns}	0.42^{ns}	0.34^{ns}	0.60^{ns}	1.48^{ns}
P_1K_1	76.58	25.04	98.58	230.31	42.58	129.92
P_1K_2	79.21	24.87	104.67	225.07	40.71	118.87
P_1K_3	85.12	25.25	110.08	227.23	41.17	131.04
P_2K_1	74.21	24.96	108.83	221.02	41.17	130.25
P_2K_2	85.54	23.00	100.87	244.23	38.58	113.25
P_2K_3	75.20	23.58	97.83	223.32	38.25	111.29
P_3K_1	74.17	27.29	107.54	219.17	44.00	132.12
P_3K_2	82.17	23.92	102.04	218.91	37.32	110.46
P_3K_3	81.37	24.12	104.92	231.77	39.29	117.29
F	0.80^{ns}	0.12^{ns}	0.23^{ns}	1.07^{ns}	0.39^{ns}	1.05^{ns}
CD	13.58	7.89	35.29	28.15	6.29	16.11

ns - not significant
** significant at 5% level

increased by application of nitrogen. All the 3 levels of nitrogen (N_1, N_2 and N_3) were significantly different from each other.Higher the dose of nitrogen, the higher was the number of leaves. Phosphorus did not have a significant effect on number of leaves. But levels of potassium significantly reduced the number of leaves. At the initial dose number of leaves was high. But there was a significant reduction at K_2 and K_3 levels.

NP interaction effect was found to be significant. Number of leaves was significantly high at N_3P_1, in comparison to N_1P_1 and N_2P_1 which were on par. A similar trend was observed when nitrogen is combined with P_2. When nitrogen is combined with P_3 a differential response was observed. A significant increase in number of leaves was observed at N_2P_3 and N_3P_3 which were on par.

NK and PK interactions were not significant.

4.2. Effect of treatment on fodder characters

4.2.1. Green fodder yield at first cut

Mean data on fodder yield at first cut is given in table 4.2.(a). It can be seen from the table that fodder yield significantly increased by nitrogen levels. Maximum fodder yield was recorded at the highest level of nitrogen.

Phosphorus and potassium did not have any significant influence on fresh fodder yield.

Among the interaction effects, NP interaction effect was found to be significant. When nitrogen is combined with P_1, an increasing trend in fresh weight was observed at various levels of nitrogen. But when nitrogen is combined with P_2 no signficant difference in fresh weight was observed at all levels of nitrogen. However a significant increase in fresh weight of fodder was observed at N_2P_3 and N_3P_3 in comparison with N_1P_3.

4.2.2. Green fodder yield at second cut

The data on green fodder yield at second cut is given in table 4.2.(b) and is graphically represented in fig. 4.1. Fresh fodder yield at second cut was significantly increased by nitrogen levels. From the table it can be seen that fresh weight was not different at the initial doses, but at the higher dose significant difference was seen.

Phosphorus and potassium did not have any significant influence on fodder yield.

NP interaction was found to be significant. The same trend as in the first cut was found in the case of NP interaction. When nitrogen is combined with lower doses of phosphorus, an increasing trend was observed at various levels of nitrogen.

When combined with P_2 no significant difference in fresh weight was observed. While when nitrogen is combined with P_3, there was a significant difference in fresh weight. Fresh weight was significantly high at N_1P_1 when compared to N_1P_3.

NK and PK interactions were not significant.

4.2.3. Dry fodder yield

Data on dry fodder yield is given in table 4.2.(c) and is graphically represented in fig. 4.2. From the table it can be seen that dry fodder yield was significantly increased by nitrogen application. The maximum dry fodder yield was recorded under the highest level of nitrogen. Only

Fig. 4.1 Fresh weight of fodder at second cut as influenced by the different levels of N, P and K (t / ha)

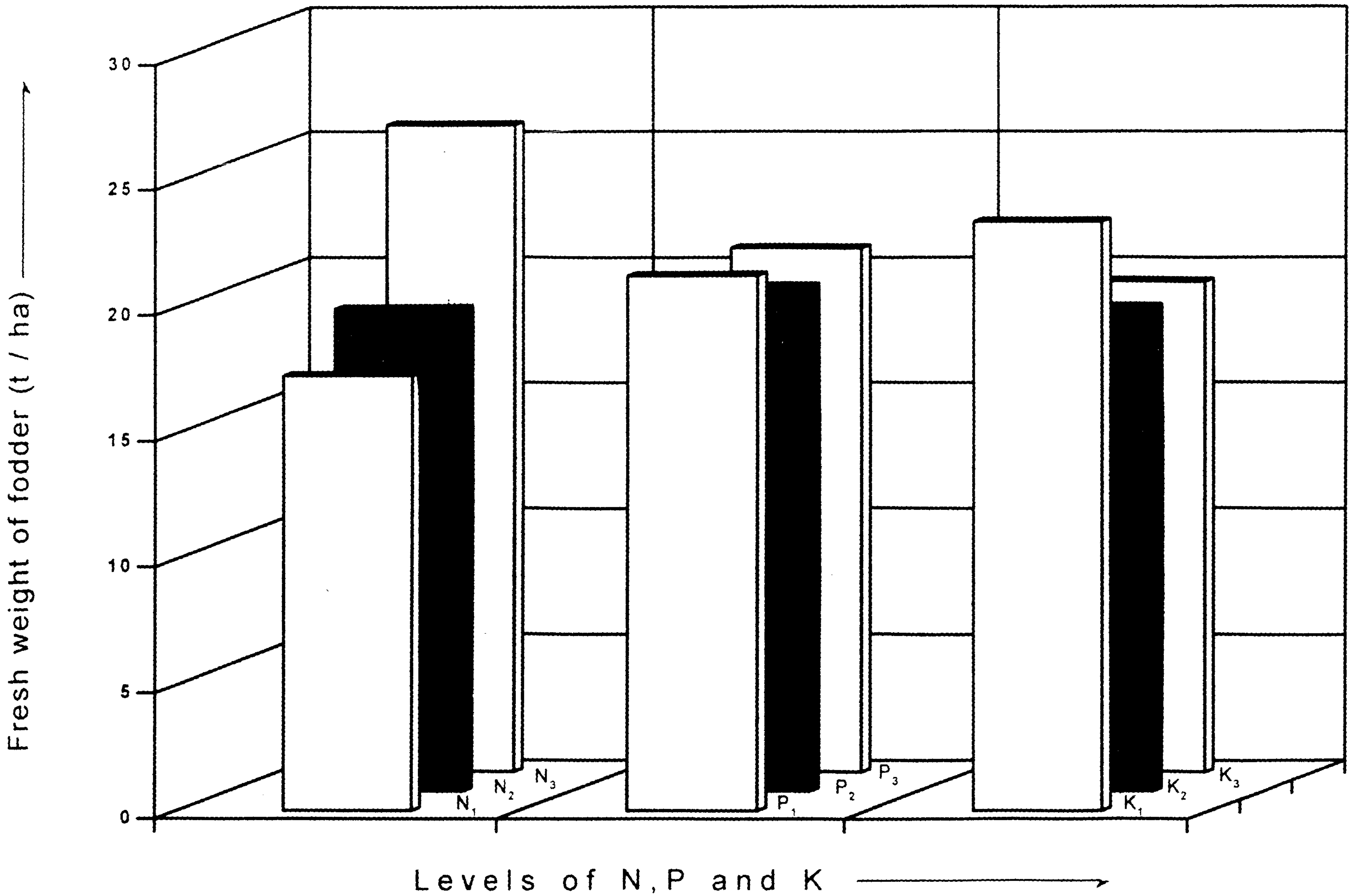


Table 4.2. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Fresh weight of fodder at first cut (t/ha)	(b) Fresh weight of fodder at second cut (t/ha)	(c) Dry weight of fodder at second cut (t/ha)
N_1	6.63	17.28	6.91
N_2	10.03	19.16	7.40
N_3	12.27	25.72	9.66
F(2,22)	19.67**	10.62**	8.84**
P_1	9.96	21.27	8.23
P_2	9.31	20.05	7.74
P_3	9.67	20.83	8.01
F(2,22)	0.26^{ns}	0.20^{ns}	0.25^{ns}
K_1	10.18	23.43	9.04
K_2	9.40	19.24	7.38
K_3	9.36	19.49	7.54
F(2,22)	0.52^{ns}	2.99^{ns}	3.47**
CD	1.88	3.99	1.45
SE_d	0.90	1.92	0.69

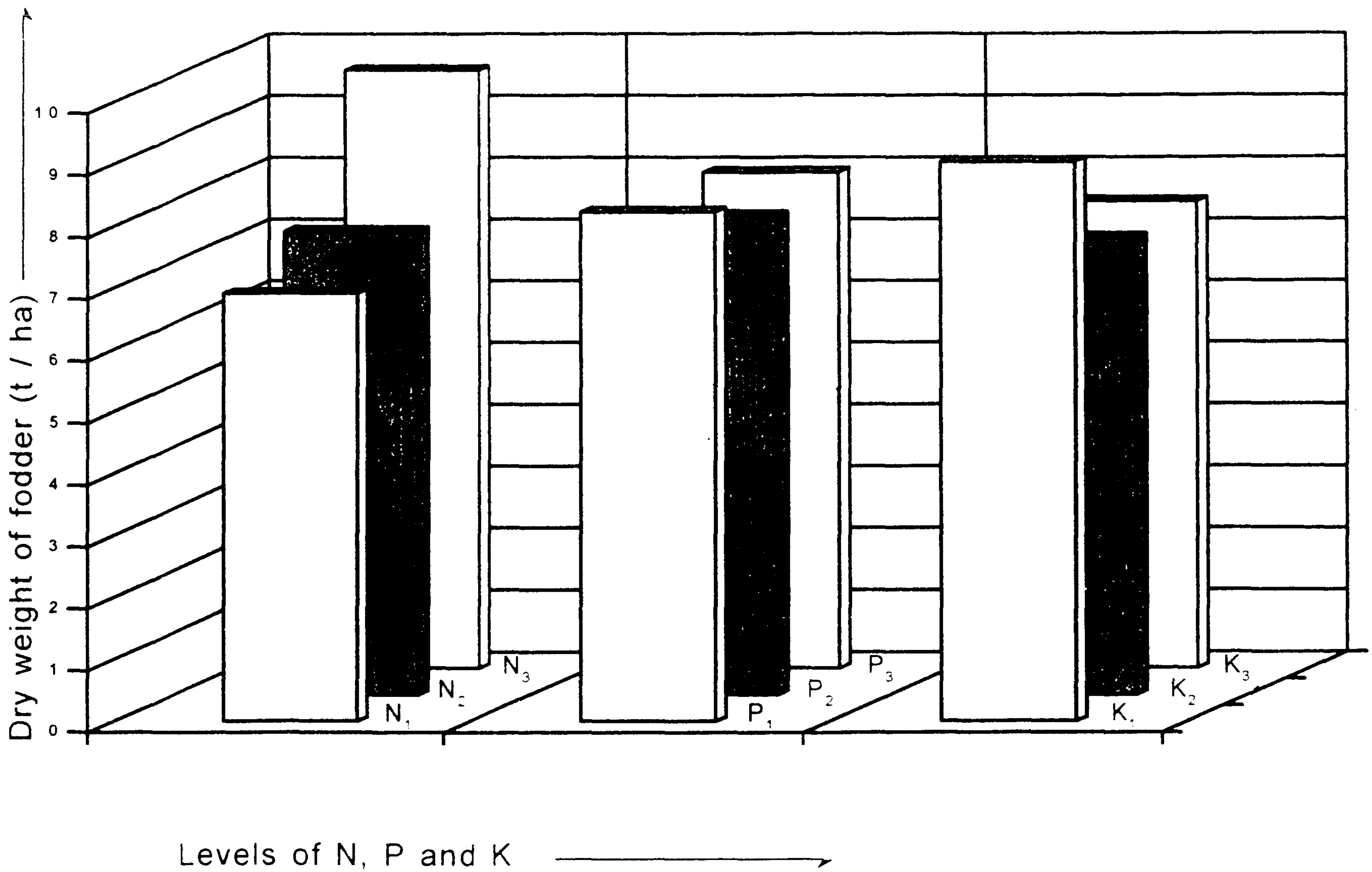
(Continued ....)

Table 4.2. (Continued ....)

N_1P_1	5.86	15.89	6.35
N_1P_2	7.56	20.52	8.14
N_1P_3	6.48	15.43	6.24
N_2P_1	9.10	16.82	6.58
N_2P_2	9.72	18.75	7.23
N_2P_3	11.26	21.91	8.39
N_3P_1	14.93	31.09	11.75
N_3P_2	10.64	20.91	7.83
N_3P_3	11.26	25.15	9.40
F	2.85**	3.57**	3.88**
N_1K_1	6.78	18.83	7.48
N_1K_2	6.17	16.51	6.53
N_1K_3	6.94	16.51	6.71
N_2K_1	10.95	22.14	8.54
N_2K_2	10.33	19.13	7.35
N_2K_3	8.79	16.20	6.31
N_3K_1	12.80	29.32	11.12
N_3K_2	11.69	22.07	8.28
N_3K_3	12.34	25.77	9.60
F	0.43 ns	0.65 ns	0.68 ns
P_1K_1	10.03	21.3	8.34
P_1K_2	9.83	21.60	8.30
P_1K_3	10.03	20.91	8.04
P_2K_1	10.18	23.07	8.86
P_2K_2	8.79	19.44	7.45
P_2K_3	8.95	17.67	6.90
P_3K_1	10.33	25.92	9.94
P_3K_2	9.56	16.67	6.41
P_3K_3	9.09	19.90	7.68
F	0.13 ns	1.19 ns	1.17 ns
CD	3.25	6.90	2.51

ns - not significant
** - significant at 5% level

Fig. 4.2. Dry weight of fodder at second cut as influenced by different levels of N, P and K (t / ha)



N_3 was significantly different from N_1.

Phosphorus did not have any significant influence on dry fodder yield. But potassium had a significant influence on dry fodder yield. There was reduction in fodder yield with increase in levels of potassium. K_1 was superior to K_2 and K_3 which were on par.

Among the interaction effects NP interaction alone was found significant. When nitrogen is combined with lowest level of phosphorus, the same response of application of nitrogen was observed. When nitrogen is combined with P_2, no significant difference was seen. But N_3P_3 recorded a significantly high dry weight in comparison with N_1P_3.

4.3. Effect of treatments on nutrient content

The data on content of nutrients in fodder is given in tables 4.3.(a),(b) and (c). From table 4.3.(a), it can be seen that nitrogen content in the fodder was not significantly influenced by the levels of nitrogen, phosphorus and potassium applied. The interaction effects were also not significant.

Table 4.3. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Nitrogen content in fodder (%)	(b) Phosphorus content in fodder (%)	(c) Potassium content in fodder (%)	(d) Crude fibre content in fodder (%)
N_1	0.582	0.181	2.174	41.00
N_2	0.629	0.185	1.752	35.69
N_3	0.667	0.190	1.890	33.11
F(2,22)	2.169^{ns}	0.948^{ns}	8.570**	151.40**
P_1	0.632	0.121	1.860	38.44
P_2	0.608	0.178	1.919	36.44
P_3	0.638	0.256	2.038	34.92
F(2,22)	0.300^{ns}	206.670**	1.523^{ns}	29.29**
K_1	0.629	0.181	1.625	37.64
K_2	0.621	0.187	2.004	36.44
K_3	0.628	0.186	2.188	35.72
F(2,22)	0.002^{ns}	0.448^{ns}	15.270**	8.77**
CD	0.842	0.0013	0.215	0.958
SE_d	0.41	0.0006	0.104	0.462

(Continued ....)

Table 4.3. (Continued ....)

N_1P_1	0.531	0.107	1.890	43.17
N_1P_2	0.625	0.176	2.337	41.83
N_1P_3	0.590	0.259	2.297	38.00
N_2P_1	0.615	0.124	1.768	37.75
N_2P_2	0.596	0.179	1.620	34.67
N_2P_3	0.677	0.252	1.878	34.67
N_3P_1	0.748	0.132	1.923	34.42
N_3P_2	0.603	0.180	1.808	32.83
N_3P_3	0.648	0.257	1.940	32.08
F	1.760^{ns}	0.865^{ns}	1.841^{ns}	3.73^{ns}
N_1K_1	0.555	0.178	1.833	41.83
N_1K_2	0.568	0.184	2.338	41.00
N_1K_3	0.623	0.181	2.351	40.17
N_2K_1	0.652	0.176	1.545	37.32
N_2K_2	0.700	0.182	1.838	34.92
N_2K_3	0.537	0.198	1.875	34.83
N_3K_1	0.682	0.192	1.498	33.75
N_3K_2	0.595	0.197	1.835	33.42
N_3K_3	0.723	0.182	2.338	32.17
F	2.540^{ns}	1.344^{ns}	1.602^{ns}	0.93^{ns}
P_1K_1	0.637	0.110	1.475	39.92
P_1K_2	0.630	0.130	2.083	37.50
P_1K_3	0.628	0.125	2.023	37.92
P_2K_1	0.628	0.169	1.685	37.17
P_2K_2	0.577	0.185	1.957	37.75
P_2K_3	0.620	0.182	2.115	34.42
P_3K_1	0.623	0.267	1.717	35.83
P_3K_2	0.657	0.249	1.972	34.08
P_3K_3	0.635	0.253	2.427	34.83
F	0.146^{ns}	1.709^{ns}	1.302^{ns}	4.36^{**}
CD	0.205	2.390	0.372	1.66

ns - not significant
** - significant at 5% level

It may be seen from table 4.3.(b) that phosphorus content in the fodder was not significantly influenced by nitrogen and potassium levels. But there was a progressive increase in phosphorus content with incremental levels of nitrogen. However levels of phosphorus significantly increased the content of phosphorus in the fodder. All the 3 levels of phosphorus were significantly different from each other.

From table 4.3.(c), it can be seen that the potassium content of fodder was influenced by nitrogen and potassium. Nitrogen levels significantly reduced the potassium in the fodder. The levels N_2 and N_3 were on par and N_1 was significantly different from N_2 and N_3. The highest potassium content was recorded at the lowest level of nitrogen (N_1). The levels of potassium significantly increased the potassium content. K_2 and K_3 were on par and K_1 was inferior to K_2 and K_3.

The various interaction effects did not have any significant influence on content of nutrients in the fodder.

4.4. Effect of treatments on uptake of nutrients

The data on the uptake of nutrients is given in tables 4.4.(a), (b) and (c). From table 4.4.(a), it can be seen that uptake of nitrogen was significantly increased by nitrogen application. No significant difference was detected at N_1 and N_2 levels. Phosphorus and potassium did not have any significant influence on the uptake on nitrogen. Among the interaction effects, NP interaction was found to be significant.

From table 4.4.(b), it can be seen that uptake of phosphorus was significantly influenced by the levels of nitrogen, phosphorus and potassium. Nitrogen and phosphorus caused an increase in the uptake of phosphorus, while potassium, significantly reduced the phosphorus uptake.

The highest level of nitrogen alone recored a significant differnce. The different levels of phosphorus were significantly different from each other. Maximum uptake of phosphorus was recorded by the highest level of phosphorus.

Levels of potassium significatly reduced the uptake of phosphorus. The highest uptake was recorded by the lowest level of potassium viz. K_1, K_2 and K_3 were on par and noticeably inferior to K_1.

Among the various interaction effects PK interaction was significant.

From table 4.4.(c), it can be seen that the uptake of potassium was significantly influenced by nitrogen levels. Highest uptake of potassium was recorded at the highest level of nitrogen.

Levels of phosphorus and potassium did not have any significant influence on the uptake of potassium.

Among the interaction effects, NP interaction was found significant. When nitrogen is combined with P_1 a highest potassium uptake was seen at N_3 levels. But when nitrogen is combined with P_2 a significant reduction at N_2 and N_3 was observed. When nitrogen was combined with P_3 no significant difference in potassium uptake was seen.

4.5. Effect of treatments on crude fibre content of fodder

Data on crude fibre content of fodder is given in table 4.3 (d). It can be seen from the table that nitrogen caused a significant reduction in crude fibre content. The highest crude fibre content of 41 per cent was recorded with

N_1 level. All the 3 levels of nitrogen (N_1, N_2 and N_3) were significantly different from each other.

Phosphorus also significantly reduced the crude fibre content. The lowest crude fibre content (34.92 per cent) was recorded with the highest level of phosphorus. All the 3 levels of phosphorus were significantly different from each other.

Potassium caused significant reduction in the crude fibre content. All the 3 levels of potassium ware found to be significantly different from each other.

NP and PK interactions were significant. When nitrogen is combined with phosphorus, trend in response was similar at all the dose combinations, but the rate of change was different. When potassium is combined with phosphorus, no significant difference was observed at K_2 and K_3 levels. When potassium is combined with P_2, no significant difference was detected at K_1 and K_2 levels but with P_3 significant difference was seen.

NK interaction was not significant.

Table 4.4. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Nitrogen uptake by plants (Kg/ha)	(b) Phosphorus uptake by plants (Kg/ha)	(c) Potassium uptake by plants (Kg/ha)
N_1	41.22	12.450	155.512
N_2	48.51	14.140	125.829
N_3	65.50	17.900	180.062
F(2,22)	8.45**	8.310**	5.690**
P_1	53.81	10.226	155.832
P_2	47.93	13.724	143.337
P_3	53.49	20.536	162.235
F(2,22)	0.59ns	29.310**	0.712ns
K_1	58.87	16.969	145.330
K_2	46.61	13.536	144.000
K_3	49.76	13.981	172.075
F(2,22)	2.20ns	3.715**	1.936ns
CD	12.57	2.84	33.33
SE_d	6.06	1.37	16.09

(Continued ....)

Table 4.4. (Continued ....)

N_1P_1	34.47	6.791	121.418
N_1P_2	50.81	14.240	185.533
N_1P_3	38.38	16.308	159.586
N_2P_1	41.50	8.227	115.990
N_2P_2	44.80	12.993	114.653
N_2P_3	59.24	21.195	146.845
N_3P_1	85.47	15.660	230.088
N_3P_2	43.19	13.936	129.826
N_3P_3	62.85	24.106	180.273
F	4.37^{ns}	2.706^{ns}	4.640^{**}
N_1K_1	41.17	13.151	136.475
N_1K_2	38.87	11.987	159.423
N_1K_3	43.63	12.203	170.640
N_2K_1	59.08	16.941	129.805
N_2K_2	52.05	13.265	129.371
N_2K_3	34.40	12.210	118.312
N_3K_1	76.35	20.815	169.710
N_3K_2	48.91	15.357	143.205
N_3K_3	71.25	17.532	227.273
F	2.35^{ns}	0.648^{ns}	1.852^{ns}
P_1K_1	55.39	9.683	131.565
P_1K_2	51.87	10.653	163.985
P_1K_3	54.17	10.341	171.946
P_2K_1	55.19	14.848	145.565
P_2K_2	44.20	13.833	134.102
P_2K_3	44.41	12.490	150.347
P_3K_1	66.02	26.375	158.860
P_3K_2	43.76	16.122	133.913
P_3K_3	50.69	19.113	193.932
F	0.46^{ns}	3.375^{**}	0.879^{ns}
CD	21.77	4.919	57.828

ns - not significant
** - significant at 5% level

4.6. Effect of treatments on number of days to 50 per cent flowering

The mean data on days to 50 per cent flowering is presented in table 4.5.(a). From the table it can be seen that nitrogen and phosphorus did not have any significant effect on days to 50 per cent flowering. But potassium significantly influenced the number of days to 50 per cent flowering. The maximum number of days to 50 per cent flowering was taken by the K_2 treatment. While at K_1 and K_2 number of days for 50 per cent flowering was more or less similar. The interaction effects were also not significant.

4.7. Effect of treatments on number of panicles/plant

Mean data on the number of panicles per plant is given in table 4.5.(b). From the table it may be seen that there is a significant increase in the number of panicles per plant due to nitrogen application. The maximum number of panicles was recorded under the highest level of nitrogen(N_3). The N_2 level was superior to N_1 level and N_2 level was superior to N_1 level.

Phosphorus and potassium did not have any significant effect. NP interaction was significant. When nitrogen is combined with P_1, panicle number was high at N_3P_1. When nitrogen is combined with P_2 also same trend was seen. With P_3 a significant increase at N_2 and N_3 was detected which were on par.

NK and PK interactions were not significant.

4.8. Effect of treatments on number of seeds per panicle

Mean data on number of seeds per panicle is given in the table 4.5.(c). It can be seen from the table that the nitrogen levels reduced the number of seeds significantly. The minimum number of seeds per panicle was recorded by the highest level of nitrogen(N_3). At the lower levels N_1 and N_2 significant difference was detected. The highest number of seeds per panicle, (112.34) was recorded at the lowest level of nitrogen(N_1).

Phosphorus and potassium did not have any significant effect. The interaction effects were also not significant.

4.9. Effect of treatments on number of kernels/500 seeds

The mean data on number of kernels/500 seeds is given in table 4.5.(d). The table shows that nitrogen did not have any significant influence on the number of kernels. But there was a progressive increase in the number of kernels with incremental levels of nitrogen.

Phosphorus significantly influenced the number of kernels. All the three levels were significantly different from each other. Thus the highest level of phosphorus recorded the maximum number of kernels.

Potassium showed no significant influence on the number of kernels. But there was a progressive increase in the number of kernels with potassium levels and the highest level of potassium recorded the maximum number of kernels. The different levels of potassium (K_1, K_2, K_3) were on par.

The interaction effects were not significant.

4.10. Effect of treatments on seed yield

Mean data on seed yield is given in table 4.5.(e).

Table 4.5. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Number of days to 50 percent flowering	(b) Number of panicles /plant	(c) Number of seeds/ panicle	(d) Number of kernels/ 500 seeds	(e) Seed yield (Kg/ha)
N_1	118.83	9.24	112.34	19.5	211.44
N_2	119.33	10.97	97.68	19.89	218.96
N_3	118.94	12.71	92.16	20.28	240.27
F(2,22)	0.863^{ns}	25.77^{**}	27.23^{**}	0.46^{ns}	2.03^{ns}
P_1	118.61	11.11	99.59	17	222.63
P_2	119.33	10.70	101.53	20.33	219.92
P_3	119.17	11.11	101.06	22.33	228.11
F(2,22)	1.79^{ns}	0.482^{ns}	0.259^{ns}	21.89^{**}	0.158^{ns}
K_1	118.27	11.51	101.3	19.44	236.19
K_2	119.78	10.72	100.41	19.78	217.59
K_3	118.61	10.69	100.48	20.44	216.88
F(2,22)	5.159^{**}	1.82^{ns}	0.06^{ns}	0.78^{ns}	1.09^{ns}
CD	0.83	1.00	5.86	1.69	30.75
SE_d	0.401	0.482	2.825	0.814	14.82

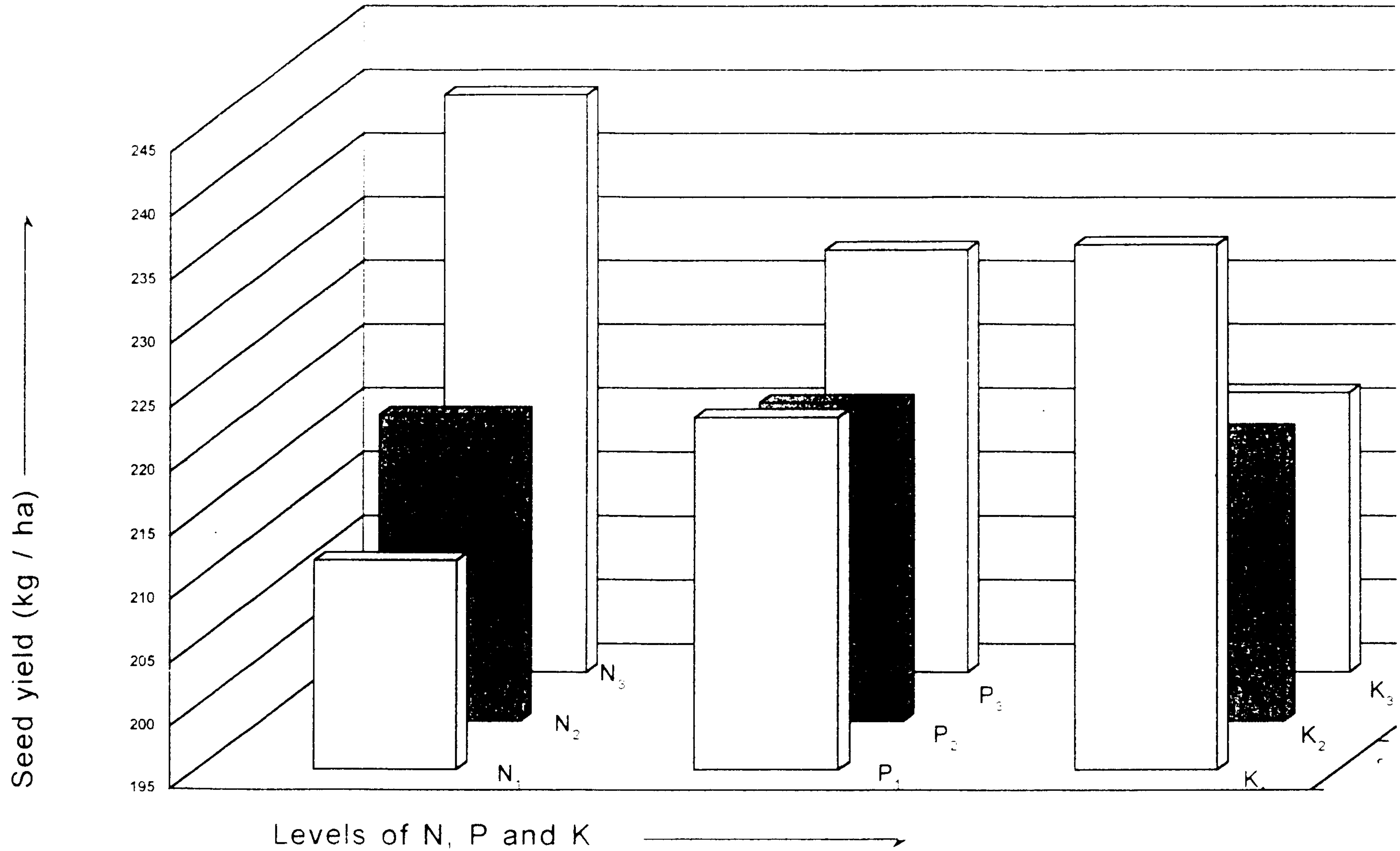
(Continued ....)

Table 4.5. (Continued ....)

N_1P_1	118.67	8.92	106.58	17.17	190.31
N_1P_2	119.17	9.81	117.68	19.67	236.45
N_1P_3	118.67	9.00	112.77	21.67	207.55
N_2P_1	118.67	10.17	96.38	16.50	198.76
N_2P_2	119.83	10.54	97.10	21.00	207.77
N_2P_3	119.50	12.21	99.57	22.17	250.35
N_3P_1	118.50	14.25	95.80	17.33	278.80
N_3P_2	119.00	11.75	89.82	20.33	215.55
N_3P_3	119.33	12.12	90.87	23.17	226.44
F	0.388 ^{ns}	4.39**	1.730^{ns}	0.386 ^{ns}	3.63**
N_1K_1	118.83	9.23	112.83	18.83	212.55
N_1K_2	119.67	9.21	110.46	19.83	205.88
N_1K_3	118.00	9.29	113.60	19.83	215.88
N_2K_1	119.00	11.50	96.61	20.17	229.11
N_2K_2	120.17	11.42	102.43	19.33	238.23
N_2K_3	118.83	10.00	94.00	20.17	189.54
N_3K_1	118.33	13.70	94.45	19.33	266.91
N_3K_2	119.50	11.54	88.20	20.17	208.66
N_3K_3	119.00	12.79	93.88	21.33	245.22
F	0.658 ^{ns}	1.92^{ns}	1.34^{ns}	0.40 ^{ns}	1.82^{ns}
P_1K_1	118.33	11.46	102.33	16.00	236.78
P_1K_2	119.50	11.00	97.31	17.50	214.00
P_1K_3	118.00	10.87	99.12	17.50	217.11
P_2K_1	119.17	11.02	100.23	20.33	224.45
P_2K_2	120.00	10.42	102.53	19.17	216.33
P_2K_3	118.83	10.67	101.83	21.50	219.00
P_3K_1	118.67	12.04	101.33	22.00	247.35
P_3K_2	119.83	10.75	101.38	22.67	222.44
P_3K_3	119.00	10.54	100.48	22.33	214.54
F	0.194 ^{ns}	0.298^{ns}	0.31^{ns}	0.726 ^{ns}	0.153 ^{ns}
CD	1.44	1.73	10.15	2.92	53.26

ns - not significant
** - *significant at 5% level*

Fig. 4.3. Seed yield as influenced by different levels of N, P and K (kg / ha)



From the table it can be seen that there is a progressive increase in seed yield with incremental levels of nitrogen. The maximum seed yield was recorded under the highest level of nitrogen. But the influence was not significant.

Phosphorus and potassium also did not significantly influence seed yield.

Among the interaction effects NP interaction alone was significant.

4.11. Effect of treatments on seed germination

4.11.1. As percentage of kernels

The data on seed germination as percentage of kernels is given in table 4.6.(a). From the table it can be seen that nitrogen, phosphorus and potassium did not significantly influence the seed germination.

NK interaction was found to be significant, while NP and PK interaction were not significant.

4.11.2. As percentage of seeds

The data on seed germination as percentage of seeds is given in table 4.6.(b). It can be seen from the table that seed germination was not significantly influenced by nitrogen, but phosphorus showed significant influence. The level P_2 was significantly superior to P_1 and P_3 was superior to P_2.

There was an increase in germination percentage at the highest levels of potassium, but did not have a significant influence.

The interaction effects were not significant.

4.12. Effect of treatment on seed viability

4.12.1 As percentage of kernels

The data on seed viability as percentage of kernels is given in table 4.6.(c). From the table it can be seen that seed viability was not significantly influenced by the levels of nitrogen or phosphorus or potassium.

Among the different levels of nitrogen, highest percentage viability was recorded under N_2 level. Among the phosphorus levels, P_2 recorded the highest viability. But among the potassium levels, the highest viability percentage was obtained under the K_3 level. All the 3 levels of potassium were on par.

The interaction effects were not significant.

4.12.2. As percentage of seeds

The mean data on seed viability as percentage of seeds is given in table 4.6.(d). It can be seen from the table that application of nitrogen did not significantly influence seed viability, even though there was a progressive increase in viability with incremental levels of nitrogen. The different levels of phosphorus significantly influenced seed viability. The higher two levels were superior to the lowest level.

With increase in potassium levels, there was an increase in seed viability but did not show any significant influence.

The interaction effects were not significant.

4.13. Effect of treatments on seed moisture

Mean data on seed moisture is given in table

Table 4.6. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Seed germination as percentage of kernels	(b) Seed germination as percentage of seeds	(c) Seed viability as percentage of kernels	(d) Seed viability as percentage of seeds
N_1	8.88	1.75	85.09	3.32
N_2	9.02	1.79	87.63	3.45
N_3	8.87	1.78	87.44	3.55
F(2,22)	2.09^{ns}	0.52^{ns}	1.47^{ns}	0.99^{ns}
P_1	9.00	1.65	86.96	2.93
P_2	8.95	1.80	88.16	3.61
P_3	8.81	1.86	85.04	3.79
F(2,22)	3.09^{ns}	13.95**	1.83^{ns}	14.78**
K_1	8.95	1.76	86.93	3.35
K_2	8.83	1.75	86.00	3.41
K_3	8.98	1.81	87.23	3.57
F(2,22)	1.90^{ns}	1.42^{ns}	0.305^{ns}	0.868^{ns}
CD	0.168	8.33	3.42	0.344
SE_d	0.081	4.015	1.65	0.166

(Continued ....)

Table 4.6. (Continued ....)

N_1P_1	8.88	1.64	83.54	2.86
N_1P_2	8.97	1.79	86.38	3.40
N_1P_3	8.78	1.82	85.35	3.70
N_2P_1	9.18	1.66	87.82	2.83
N_2P_2	8.95	1.83	89.51	3.77
N_2P_3	8.92	1.88	85.56	3.77
N_3P_1	8.95	1.66	89.52	3.10
N_3P_2	8.94	1.80	88.60	3.67
N_3P_3	8.73	1.88	84.20	3.90
F	0.748^{ns}	0.006^{ns}	0.811^{ns}	0.317^{ns}
N_1K_1	8.94	1.74	84.82	3.20
N_1K_2	8.79	1.75	85.24	3.40
N_1K_3	8.90	1.77	85.20	3.37
N_2K_1	9.20	1.84	91.17	3.57
N_2K_2	8.75	1.71	84.12	3.27
N_2K_3	9.10	1.82	87.60	3.53
N_3K_1	8.70	1.70	84.79	3.30
N_3K_2	8.97	1.79	88.63	3.57
N_3K_3	8.96	1.85	88.89	3.80
F	3.42^{**}	1.53^{ns}	2.022^{ns}	0.79^{ns}
P_1K_1	9.18	1.64	89.66	2.80
P_1K_2	8.83	1.64	89.39	3.00
P_1K_3	9.00	1.68	85.22	3.00
P_2K_1	9.00	1.82	87.20	3.60
P_2K_2	8.80	1.72	87.33	3.37
P_2K_3	9.06	1.88	89.96	3.87
P_3K_1	8.67	1.81	83.93	3.67
P_3K_2	8.88	1.89	85.27	3.87
P_3K_3	8.90	1.88	85.90	3.83
F	2.318^{ns}	1.09^{ns}	0.946^{ns}	0.62^{ns}
CD	0.291	8.33	5.92	0.59

ns - not significant
** - significant at 5% level

4.7.(a). From the table it can be seen that seed moisture was not significantly influenced by nitrogen, phosphorus and potassium.

Interaction effects were also not significant.

4.14. Effect of treatment on seed purity

The mean data on seed purity is given in table 4.7.(b). There was an increase in seed purity with increase in nitrogen levels. From the table it can be seen that nitrogen levels could not significantly influence the seed purity. Phosphorus levels also did not significantly influence seed purity. But, with increase in potassium levels, there was a decrease in seed purity.

The interactions effects were not significant.

4.15. Effect of treatments on 1000 seed weight

Mean data on 1000 seed weight is given in table 4.7.(c). From the table it can be seen that 1000 seed weight was not significantly influenced by nitrogen,

Table 4.7. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Seed moisture(%)	(b) Seed purity(%)	(c) 1000 seed weight(g)
N_1	11.93	71.61	2.9
N_2	11.90	72.11	2.94
N_3	11.87	72.44	2.91
F(2,22)	0.147^{ns}	0.856^{ns}	0.330^{ns}
P_1	11.86	71.83	2.94
P_2	12.00	72.44	2.89
P_3	11.85	71.89	2.92
F(2,22)	0.0085^{ns}	0.557^{ns}	0.159^{ns}
K_1	12.12	72.55	2.93
K_2	11.52	71.94	2.90
K_3	12.06	71.67	2.92
F(2,22)	1.42^{ns}	1.003^{ns}	0.006^{ns}
SE_d	0.393	0.0038	0.08

(Continued ....)

Table 4.7. (Continued....)

N_1P_1	12.08	71.00	2.93
N_1P_2	11.89	72.83	2.85
N_1P_3	11.83	71.00	2.92
N_2P_1	12.20	71.67	2.93
N_2P_2	12.09	72.33	2.93
N_2P_3	11.42	72.33	2.97
N_3P_1	11.28	72.83	2.95
N_3P_2	12.00	72.17	2.90
N_3P_3	12.31	72.33	2.88
F	0.984^{ns}	0.845^{ns}	0.104^{ns}
N_1K_1	12.01	72.50	2.92
N_1K_2	11.90	71.17	2.92
N_1K_3	11.89	71.17	2.87
N_2K_1	12.00	72.17	3.00
N_2K_2	11.29	72.50	2.90
N_2K_3	12.45	71.37	2.93
N_3K_1	12.38	73.00	2.88
N_3K_2	11.37	72.17	2.90
N_3K_3	11.85	72.17	2.95
F	0.577^{ns}	0.308^{ns}	0.210^{ns}
P_1K_1	12.46	72.83	3.01
P_1K_2	11.46	71.83	2.88
P_1K_3	11.66	70.83	2.92
P_2K_1	12.14	72.17	2.88
P_2K_2	12.36	72.67	2.93
P_2K_3	12.21	72.50	2.87
P_3K_1	11.77	72.67	2.90
P_3K_2	11.47	71.33	2.90
P_3K_3	12.32	71.67	2.97
F	0.565^{ns}	0.750^{ns}	0.36^{ns}
CD	1.41	2.30	0.28

ns - not significant
** - significant at 5% level

phosphorus and potassium.

Interaction effects were not significant.

4.16. Effect of treatment on soil nutrient status

Data on soil nutrient status is given in tables 4.8.(a), (b) and (c).

It can be seen from table 4.8.(a) that the different levels of nitrogen notably increased the nitrogen status. All the 3 levels of nitrogen, N_1, N_2 and N_3 were significantly different from each other.

Phosphorus showed pronounced influence on nitrogen content of the soil. Here also different phosphorus levels were different from each other and P_3 was found to be superior to P_1 and P_2.

Potassium had a significant influence on nitrogen status of the soil. K_2 was found to be superior to K_1 and K_3. Among the interaction effects, NP and NK interactions were significant. At the initial two doses of nitrogen, the response of phosphorus showed similar trend, while at highest dose, no significant difference in soil nitrogen status was noticed at the initial two doses of phosphorus, but significant response was noted at P_3.

From table 4.8.(b) it can be seen that soil phosphorus content was not significantly influenced by nitrogen and potassium, but phosphorus had a significant effect. All the three levels of phosphorus were different from each other.

None of the interaction effects significantly affected soil phosphorus content.

From table 4.8.(c), it can seen that soil potassium content was influenced by nitrogen and potassium and not by phosphorus. Among the different nitrogen levels, N_1 and N_3 were on par, while N_2 was significantly superior to N_1 and N_3.

Increase in potassium levels increased the potassium status of the soil. Among the 3 levels of potassium, only the highest level of potassium showed a significant response.

The interaction effects were not significant.

Table 4.8. Effect of N,P,K and their interactions on

Levels (N,P,K)	(a) Soil nitrogen status (kg/ha)	(b) Soil phosphorus status (kg/ha)	(c) Soil potassium status (kg/ha)
N_1	134.23	52.308	72.77
N_2	175.58	53.170	76.85
N_3	214.64	52.513	72.67
F(2,22)	574.62^{**}	0.280^{ns}	5.31^{**}
P_1	158.02	45.899	73.39
P_2	172.51	51.758	74.62
P_3	193.925	60.335	74.29
F(2,22)	115.95^{**}	72.850^{**}	0.37^{ns}
K_1	170.23	51.464	71.88
K_2	179.81	52.988	74.42
K_3	174.42	53.540	75.99
F(2,22)	8.19^{**}	1.590^{ns}	4.018^{**}
CD	4.92	2.49	3.035
SE_d	2.37	1.2	1.46

(Continued ....)

Table 4.8. (Continued ....)

N_1P_1	108.84	44.743	75.053
N_1P_2	137.76	51.261	72.100
N_1P_3	156.09	60.922	71.176
N_2P_1	162.55	47.991	76.633
N_2P_2	173.57	52.068	77.290
N_2P_3	190.62	59.452	76.633
N_3P_1	202.67	44.963	68.493
N_3P_2	206.20	51.943	74.460
N_3P_3	235.06	60.633	75.053
F	6.186^{**}	0.801^{ns}	2.520^{ns}
N_1K_1	131.95	50.950	70.560
N_1K_2	141.31	52.533	73.810
N_1K_3	129.44	53.443	73.960
N_2K_1	164.34	51.320	74.670
N_2K_2	181.15	53.917	77.220
N_2K_3	180.95	54.275	78.670
N_3K_1	214.11	52.123	70.413
N_3K_2	216.96	52.515	72.250
N_3K_3	212.86	52.902	75.343
F	3.79^{**}	0.201^{ns}	0.169^{ns}
P_1K_1	154.65	46.467	70.670
P_1K_2	163.20	44.743	74.177
P_1K_3	156.20	46.488	75.330
P_2K_1	165.21	51.295	73.026
P_2K_2	175.54	51.808	74.790
P_2K_3	176.47	52.170	76.033
P_3K_1	190.52	56.631	71.946
P_3K_2	200.68	62.413	74.310
P_3K_3	190.57	61.962	76.606
F	1.34^{ns}	1.850^{ns}	0.108^{ns}
CD	8.52	4.320	5.257

ns - not significant
** - significant at 5% level

4.17. Economics of cultivation

The data on net return and benefit : cost ratio at harvest are presented in table 4.9.

(a) Net return

Maximum net return was recorded by the treatment combination $T_{16}(N_2P_3K_1$ viz 150 kg N + 100 kg P_2O_5 + 50 kg K_2O/ha). This was followed by $T_{19}(N_3P_1K_1$ viz 225 kg N + 50 kg P_2O_5 + 50 kg K_2O/ha). The lowest net return was given by $T_{15}(N_2P_2K_3$ viz 150 kg N + 75 kg P_2O_5 + 100 kg K_2O/ha).

(b) Benefit : cost ratio

Highest benefit : cost ratio was recorded by the treatment combination $T_{16}(N_2P_3K_1$ viz 150 kg N + 100 kg P_2O_5 + 50 kg K_2O/ha) and the lowest by $T_{15}(N_2P_2K_3$ viz 150 kg N + 75 kg P_2O_5 + 100 kg K_2O/ha).

Table 4.9. ECONOMICS OF CULTIVATION

Treatments	Cost of cultivation excluding the treatment	Additional cost for the treatment Rs Ps	Total cost for cultivaton (a) Rs Ps	Greenmatter yield (t/ha)	Seed yield (kg/ha	Gross Return b	Net Return (b-a)	Benefit Cost Ratio
T1	18.339.75	1493.33	19832.75	22.68	199.43	26668.60	6835.85	1.34
T2	18.339.75	1693.33	20033.06	22.22	177.75	25770.00	5736.95	1.28
T3	18.339.75	1893.30	20233.05	20.36	193.76	24235.00	4001.95	1.19
T4	18.339.75	1646.66	19986.41	33.79	238.12	38552.00	18565.99	1.93
T5	18.339.75	1846.66	20186.41	24.53	316.44	28858.00	8672.39	1.43
T6	18.339.75	2046.66	20386.41	25.92	254.79	31015.00	10628.59	1.52
T7	18.339.75	1800.00	20139.75	20.36	200.10	24367.00	4227.25	1.21
T8	18.339.75	2000.00	20339.75	21.29	223.44	25763.00	5423.25	1.27
T9	18,339.75	2200.00	20539.75	24.07	199.12	28052.00	7512.65	1.36
T10	18.339.75	2280.00	20619.75	21.76	180.75	25375.20	4755.45	1.23
T11	18.339.75	2480.00	20819.75	25.44	225.77	29955.40	9135.65	1.44
T12	18.339.75	2680.00	21019.75	30.56	189.76	34355.00	13335.25	1.63
T13	18.339.75	2413.33	20753.08	27.07	194.10	30952.00	10198.92	1.49
T14	18.339.75	2633.33	20973.08	37.03	241.45	41859.00	20880.02	1.99
T15	18.339.75	2833.33	21173.08	21.39	187.76	25145.20	3972.12	1.18
T16	18.339.75	2586.66	20926.41	50.45	312.49	56669.80	35743.39	2.70
T17	18.339.75	2786.66	21126.41	25.95	247.46	30899.20	9772.79	1.46
T18	18,339.75	2986.66	21326.41	23.14	191.11	26962.20	5599.79	1.26
T19	18.339.75	3060.00	21399.75	49.53	330.16	56133.40	34733.65	2.62
T20	18,339.75	3260.00	21599.75	46.65	238.45	53419.00	31819.25	2.47
T21	18.339.75	3460.00	21799.75	41.89	267.80	47246.00	25446.25	2.16
T22	18.339.75	3213.33	21553.08	38.88	241.13	43742.00	22149.42	2.02
T23	18.339.75	3413.33	21753.08	23.15	191.10	26972.00	5218.90	1.24
T24	18.339.75	3613.33	21953.08	32.63	214.44	36918.00	14965.72	1.68
T25	18.339.75	3366.66	21706.41	37.95	229.45	42539.00	20832.59	1.96
T26	18.339.75	3566.66	21906.41	31.45	196.43	35378.00	13472.19	1.61
T27	18.339.75	3766.66	22106.41	39.81	253.44	44879.00	22772.59	2.03

DISCUSSION

5. DISCUSSION

The study on the effect of nitrogen, phosphorus and potassium on the seed production of gamba grass (*Andropogon gayanus*) was conducted in the college of Agriculture, Vellayani, during the period from July 1993 to January 1994.

Growth and fodder yield characters, plant height, number of tillers, number of leaves, green yield, dry matter yield and seed yield parameters like days to 50 percent flowering, number of panicles per hill, number of seeds per panicle, number of kernels/500 seeds, seed viability, seed germination seed purity, seed moisture, 1000 seed weight and seed yield were measured and recorded. Chemical analysis was done and data on nutrient content and crude fibre of fodder and nutrient content in soil were also recorded.

The data obtained were analysed statistically. The results from this study are discussed below.

5.1. Morphological characters

5.1.1. Height of plants

The results presented in tables 4.1.(a) and (d) showed that nitrogen fertilizer significantly affected plant height at first cut, while plant height at second cut was not significantly affected by nitrogen. At the first harvest, the highest level of nitrogen (225 kg/ha) recorded 20.11 per cent increase in plant height over that of the lowest level (75 kg/ ha). The increase in plant height may be due to the increase in cell division and cell elongation (Tisdale et al., 1985). Johnkutty (1981) working on ragi reported that nitrogen hastens the meristematic activity in plants resulting in the increase of plant height. Thomas (1978) and Balbatti (1980) also reported a significant increase in plant height in hybrid napier. Similar trend was observed in giant Anjan grass (*Cenchrus ciliaris*) by Rai and Shankaranarayanan(1981) and in guinea grass by Krishnan (1993).

At the time of second cut much of the nutrients might have been used for the flowering and seed set. So there was no pronounced effect due to nitrogen doses on plant height at the time of seed cut. Ramakrishnan Nair

(1963) working on ragi, reported that plant height at the 2nd stage (60 DAS) was not significantly influenced by nitrogen. He attributed this to maturing, drying and incurving of earheads at the final stage.

From the results it can be seen that phosphorus and potassium did not show significant effect on plant height at the first and second cut. A non-significant effect of phosphorus on plant height was reported by Rai and Shankaranarayanan (1981) in pusa giant anjan (*Cenchrus ciliaris*). Similarly Thakuria (1993) working on teosinte, (*Euchlaena maxicana*), reported that application of potash did not give any significant response to growth or height of plants.

5.1.2. Number of tillers

The data on mean tiller count presented in tables 4.1.(b) and (c) revealed that nitrogen fertilizer significantly influenced number of tillers at both the first and second cut. The highest level of nitrogen caused an increase of 40.32 per cent and 21.7 per cent in respect of tiller number at the first and second cut respectively. From this trend we can see that during second cut, the contribution of nitrogen to tiller formation is less than that at 1[st] cut. This may also be due to the death of early formed tillers. It is a well known fact that nitrogen is the most important nutrient element for the growth of plants. Increased availability of this element would have contributed to higher tiller production in the grass. Similar results were obtained by Thomas (1978) in hybrid napier, Rai and Shankaranarayanan (1981) in giant anjan grass (*Cenchrus ciliaris*) Sangakkara (1988) and Krishnan (1993) in guinea grass.

The results showed that phosphorus and potassium did not have any significant influence on number of tillers. This may be due to the high phosphorus content of the soil as shown in table 3.1. No significant influence on tiller number due to phosphourus application was reported by Rai and Shankaranarayanan (1981) in giant anjan grass (*Cenchrus ciliaris*). Similar trend was obtained by Krishnan (1993) in guinea grass. He also reported that potassic fertilizers did not influence tiller production in the grass.

At the time of second harvest, NP interaction was found to be significant. It is a common observation that increased growth requires more of both N and P, the inference being that mutually synergistic effects result in growth stimulation and enhanced uptake of both the elements (Sumner and Farina, 1986). This growth stimulation might have resulted in the increased number of tillers.

5.1.3. Number of leaves

The results presented in tables 4.1.(c) and (f) showed that nitrogen significantly increased the number of leaves at the first and second cut.

Ajithkumar (1984) working on rice reported that higher levels of fertilizer is necessary for better growth of plants as was seen by a higher number of leaves. Similar results on the increase in the leaf number by NPK application was reported in rice plants by Sumbali and Gupta (1972). More over the trend noticed in this trial confirms with the accepted behaviour of nitrogen in enhancing vegetative growth (Tisdale and Nelson, 1975). Sobhana (1983) working on rice reported a significant increase in the number of leaves / hill due to increased nutrition at all growth stages. She also reported that the maximum leaf number was obtained with the treatment supplying maximum nitrogen (30:40:40 kg/ha NPK).

Phosphorus did not have a significant effect on number of leaves during the first and second cut.

NP interaction was found to be significant at the second cut. At the time of second cut, the combination N_3P_1 (225 kg N + 50 kg P_2O_5) recorded the maximum number of leaves. The lowest number of leaves was recorded at the combination N_1P_3 (73 kg N + 100 kg P_2O_5). N_3P_1 was found to be significantly different from all other combinations.

Potassium did not influence number of leaves at the first cut, but during the second cut, there was a significant reduction in number of leaves. It is seen that the higher levels of potassium in combination with nitrogen and phosphorus causes a negative effect. This may be due to an imbalance of the nutrients. Reneau et al (1983) also reported that the balance between nutrients is important.

5.2. Effect of treatments on fodder characters

5.2.1. Green matter yield

From the results presented in tables 4.2.(a) and (b), it can be seen that fodder yield was significantly increased by nitrogen leavels. During the first cut, the N_3 level ie 225 kg/ha produced 22 percent increase in fodder yield over that of N_2 level (150 kg/ha), while N_2 (150 kg/ha) produced 51 percent increase in fodder yield over that of N_1 level (75 kg/ha). During the second cut, the highest level of nitrogen caused 48 percent increase in fodder yield over that of the lowest level tried.

This increase in fresh weight may be due to the increase in height of plants, more number of tillers and leaves produced due to application of nitrogen. The highest fodder yield recorded in this study due to application of highest level of nitrogen may be attributed to better growth of plants as evidenced by taller plants noticed in teosinte by Thakuria (1993). From the results obtained by Mukerji and Chatterji (1955), Bose (1965), Tiwari (1965) and Relwani and Bagga (1968), under different agroclimatic conditions, it became evident that nitrogen application is very essential for higher production of dinanath grass (*Pennisetum pedicellatum*). Dwivedi et al. (1991b) working on thin napier grass (*Pennisetum polystachyon*) also found that herbage production increases with increasing nitrogen rates.

From the results it can be seen that fodder yield was not significantly influenced by application of phosphorus and potassium. This may be due to the fact that these nutrients do not have a significant influence on the vegetative characters like height and number of tillers.

Narwal et al. (1977) reported that in dinanath grass, phosphorus application showed no definite trend. In the first year application of 60 kg P_2O_5 /ha produced significantly higher green fodder yield over control, but the difference between 0 and 30 kg P_2O_5 /ha and 30 and 60 P_2O_5 /ha were not appreciable. Krishnan (1993) working on guinea grass reported that phosphorus did not have any influence on green fodder yield.

Smith (1979) working on switch grass (*Panicum virgatum*) reported that the vegetative growth was not favoured by potassium. Similarly, Thakuria (1993) working on teosinte (*Euchlaena maxicana*) also reported that application of potash did not give any significant response to fodder yields. NP interaction was found to be significant at both the harvests. Sumner and Farina (1986) reported that NP interaction effects on yield are primarily attributable to

N induced increase in P absorption by the plant.

5.2.2. Dry fodder yield

The results presented in table 4.2.(c) revealed that dry fodder yield was significantly increased by nitrogen application. N_3 level (225 kg N/ha) caused 39.79 percent increase in dry fodder yield over that of N_1 (75 kg/ha) the lowest level.

Increased supply of nitrogen seem to have resulted in improving the overall growth of the plants and hence recorded more dry matter as noticed in this study. Further increase in nitrogen application, causing an increase in vegetative growth, produces taller plants and more tillers. These favourable effects together contributed to more plant weights. Along with the over all growth, the increase in the uptake of nutrients also might have contributed to the total dry matter production. This is in accordance with the findings of Dwivedi and Kanodia (1986) in setaria grass (*Setaria sphacelata*). Similar results were obtained by Haggar (1966) in gamba grass (*Andropogon gayanus*), Ganguli et al. (1976) in fodder oats, Taneja et al. (1981) in barley and Thakuria (1993) in teosinte.

The results showed that phosphorus did not have any significant effect on dry fodder yield. Faroda (1970) also could not find any significant effect of phosphorus on dry matter yield in black anjan (*Cenchrus ciliaris*).

The higher levels of potassium was found to reduce the dry fodder yields. Smith (1979) working on switch grass (*Panicum virgatum*) reported that the vegetative growth was favoured by nitrogen fertilization, but not by potassium. This may be due to the imbalance of nutrients. Reneau et al. (1983) suggested that a balance between nutrients is important. Similarly Thakuria (1993) working on teosinte found that potassium did not give any significant response to fodder yields and Berroteran (1989) working on dry matter production in gamba grass (*Andropogon gayanus*) and *Digitaria swazilandensis* reported that gamba grass did not respond to fertilizer application.

5.3. Nutrient content in fodder

The results presented in tables 4.3.(a), (b) and (c) showed that the nitrogen content in the fodder was not significantly influenced by application of nitrogen, phosphorus and potassium.

Walmsley et al. (1978) working on hybrid napier grass and Thangamuthu et al. (1974) working on fodder sorghum reported that crude protein content was not affected by nitrogen upto 340 kg/ha and 150 kg/ha respectively. Bahl et al. (1970) observed that phosphorus application did not influence the crude protein content in black anjan (*Cenchrus ciliaris*).

Reheja (1966) reported that application of large amounts of muriate of potash to soil reduced absorption of nitrogen, phosphorus and sulphur which resulted in the reduction of protein synthesis. Bhuiya et al. (1979) working on rice reported that potassium had no significant effect on grain crude protein content.

From the above results we can see that phosphorus content in fodder was influenced only by application of phosphorus levels. Increased supply of phosphorus might have increased the growth of crop roots which further caused more phosphorus to be absorbed and translocated to the aerial portion. Thus content in shoot recorded higher value than the treatments receiving lower supply. This is in accordance with the results obtained by Bahl et al. (1970) in black anjan (*Cenchrus ciliaris*) and Falade (1975) in gamba grass (*Andropogon gayanus*). Krishnan (1993) working on guinea grass also got the same trend.

It can also be seen from the results of this study that nitrogen and potassium had no influence on phosphorus content in fodder as reported by Krishnan (1968) in rice.

From the results it can be inferred that potassium content of the fodder was influenced by application of nitrogen and potassium. Nitrogen levels significantly reduced the potassium content in the fodder. This may be due to the antagonism between ammonium and potassium ions (Loue, 1980).

Phosphorus did not have any significant effect on potassium content. Similar results have been previously reported by Thandapani and Rao (1974) in rice.

Potassium application was found to increase the potassium content of the fodder. Johnkutty (1981) working on Ragi reported that the potassium content of straw in Ragi was influenced by application of potash significantly. Similar result was obtained by Subramanian (1969) in ragi.

Tiwari and Vandana Nigam (1985) investigated the response of important legumes, oilseeds, cereals and fodder crops to potassic fertilizers and reported that potassium application markedly enhanced K uptake and K concentration.

5.4. Uptake of nutrients

The results presented in tables 4.4.(a), (b) and (c) revealed that increasing the nitrogen levels significantly increased the uptake of nitrogen. Even though the nitrogen content of the fodder was not influenced by the levels of nitrogen, the uptake was more at higher N levels. This has resulted in higher dry matter production as evidenced by more number of leaves and increased plant height recorded at higher N levels. Similar results were obtained by Dwivedi and Kanodia (1986) in setaria grass (*Setaria sphacelata*). They further reported that crude protein yield increased due to application of nitrogen and there was a linear increase in the uptake of nitrogen upto 120 kg N/ha.

Phosphorus and potassium did not show significant effect on nitrogen uptake. Bahl et al. (1970) also observed that phosphate application influenced crude protein content in anjan grass (*Cenchrus ciliaris*). Working in barley, Misra et al. (1982) reported that potassium application failed to show any notable impact on nitrogen uptake in straw upto 100 kg K_2O /ha. NP interaction had a significant influence on uptake of nitrogen. Sumner and Farina (1986) states that N and P have mutually synergistic effects and this resulted in growth stimulation and caused enhanced uptake of both the elements. In the present study also it is seen that N and P stimulate growth of the plants and hence this might have caused the increased uptake of nitrogen.

The uptake of nitrogen was maximum at N_3P_1 (225 kg N + 50 kg P_2O_5) and was minimum at N_1P_1 (75 kg N + 50 kg P_2O_5).

It is evident from the results that the uptake of phosphorus was significantly influenced by levels of nitrogen, phosphorus and potassium. This may be attributed to the increased content of phosphorus as a result of high growth rate of the plants due to higher availability of nutrients. Rathore and Vijayakumar (1978) obtained similar results in sorghum and dinanath grass. They reported that higher dry matter production was due to high P uptake at the higher levels of nitrogen.

The uptake of phosphorus increased with an increase in levels of phosphorus especially so with the high doses. It was accompanied by an increase in the P content of the fodder, showing that increased P uptake was a combined function of dry matter and phosphorus content (Rathore and Vijayakumar (1978). Misra et al. (1982) also reported similar results in barley.

The uptake of phosphorus was reduced significantly at higher levels of potassium application.

In his extensive review Adams (1980) concluded that too little progress has been made in this area (P-K interactions) to propose viable interactions. But Reneau et al. (1983) demostrated that the balance between P and K was important.

This contradicts the reports of Loganathan and Raj (1972) that the uptake of phosphorus in the rice variety CO_{32} was enhanced by the application of potassium at 40 and 80 kg/ha. But in barley, potassium application failed to show any significant contribution to phosphorus uptake in grain and straw in any of the seasons (Misra et al., 1982).

The results showed that the uptake of potassium was significantly increased due to nitrogen levels. Rathore and Vijayakumar (1978) reported that there was a consistent rise in the uptake of potassium due to nitrogen application as a result of increase in dry matter. Similar results were obtained by Esakkimuthu et al. (1975) and Singh and Modgal (1978) in rice.

Results showed that phosphorus and potassium application had no significant effect on uptake of potassium. This may be due to the medium nutrient status of the soil. (Table 3.1.) Loganathan and Raj (1972) noticed that the uptake of potassium was little affected by the different combinations of phosphorus and nitrogen in rice. In barley, potassium application had no significant influence on potassium uptake (Misra et al., 1982). NP interaction had a significant influence in the uptake of potassium. Sumner and Farina (1986) report that mutually synergistic effect of N and P resulted in increased growth of plants. This increased growth might have resulted in the increased uptake of nutrients.

5.5. Crude fibre

From the results presented in table 4.3.(d), it can be seen that crude fibre content was significantly reduced due to application of nitrogen. This may be an indirect effect of nitrogen on carbohydrate metabolism. When nitrogen supplies are adequate, the conditions are favourable for growth, proteins are formed from the manufactured carbohydrates resulting in more succulent plant parts. If the nitrogen supply is inadequate, higher carbohydrates will be deposited in the cell walls, causing them to thicken. (Black, 1957). The low crude fibre content of grass by nitrogen application noticed in this study is in agreement with the findings of Reid et al. (1967), Tiwana et al. (1975), Rinne (1976) and Abraham (1978).

Phosphorus and potassium applications also resulted in the reduction of crude fibre content of gamba grass. Among the interaction effects, NP and PK interaction effects were found to be significant.

5.6. Days to 50 per cent flowering

From table 4.5.(a), it can be seen that nitrogen and phosphorus had no significant influence on numbers of days to 50 per cent flowering.

Nair et al. (1966) working on maize reported that earliness to cobbing was not significantly influenced by the various nitrogen treatments. Similarly George et al. (1990) reported that mean anthesis date was not affected by nitrogen fertilization in switch grass (*Panicum virgatum*).

The effect of potassium was significant, which had caused an increase in the number of days to 50 percent flowering.

5.7. Number of panicles/plant

The results presented in table 4.5.(b) show that there was significant increase in the number of panicles per plant due to nitrogen application. There was 37.55 per cent increase in the number of panicles by the application of highest level of nitrogen. This increase may be due to the increased number of tillers caused by higher levels of nitrogen. This is in accordance with the result obtained by Haggar (1966) in the same grass. Sangakkara (1988), Dwivedi et al. (1991a) and Krishnan (1993) working on guinea grass reported that nitrogen application significantly increased the number of panicles/hill. Similar results were obtained by Boonman (1972) and Bahnisch and Humphreys

(1978) in setaria grass.

Phosphorus and potassium did not significantly influence the number of panicles/plant. This may be due to the non significant effect of phosphorus and potassium in increasing the number of tillers, which in turn decides production of panicles.

Alexander et al. (1974 a) and Sadanandan and Sasidhar (1976) got similar response in rice. Krishnan (1993) also reported that phosphorus and potassium had no significant influence on the number of productive tillers in guinea grass. NP interaction had significant effect on the number of panicles per plant.

5.8. Number of seeds per panicle

The experiment had shown that the number of seeds per panicle was significantly reduced by the application of nitrogen (Table 4.5.(c)). The highest number of seeds/panicle (122.34) was recorded at the lowest level of nitrogen. There is a tendency for applied nitrogen to decrease the number of seeds per spike in perennial rye grass (*Lolium perenne*) as reported by Hebblethwaite and Mc Laren (1979). Krishnan

(1993) working on guinea grass also observed a similar trend. He reported that the seeds per panicle showed a general declining trend with increasing nitrogen application and this may be due to the increased number of panicles per hill and consequent competition between source and sink.

Phosphorus and potassium did not have significant influence on number of seeds per panicle. Alexander et al. (1974 a) observed that number of grains per panicles in rice was unaffected by phosphorus application. Sadanandan and Sasidhar (1976) also obtained similar results in rice. Kalyanikutty and Morachan (1974) reported that the number of grains per panicle was not affected by the rates of application of potassium. Ajithkumar (1984) also could not find significant difference between the different levels of fertilizers in rice.

5.9. Number of filled grains or number of kernels per 500 seeds

From the results in table 4.5.(d), it can be seen that the differnt levels of nitrogen did not have any influence on number of kernels. Ramanujam and Rao (1970) working on rice found that the percentage of filled grains was not altered beyond 60 kg N/ha.

The results showed that phosphorus significantly increased the number of grains. It is an accepted fact that phosphorus plays an important role in flowering and seed set (Tisdale and Nelson, 1985). Similar result was obtained by Uexkull (1976) in rice. Potassium did not have significant influence on number of kernels. Rao et al. (1974) also reported that application of potash upto 80 kg K_2O/ha did not influence the number of filled grains and chaff per panicle.

5.10. Seed yield

Results presented in table 4.5.(e) showed that neither nitrogen, phosphorus nor potassium had significant effect on seed yield. This may be because of the fact that even though there was an increase in the number of tillers with increasing levels of nitrogen, a decreasing trend was noticed in the number of seeds per panicle. Sreekumaran (1981) studying the response of rice to graded doses of fertilizer reported that application of higher levels of nitrogen resulted in an appreciable decrease in grain yield while the straw yield was maximum at the highest nitrogen treatments. He opined that the extra dose of nutrients, particularly nitrogen might have been utilised by the plant for straw production rather than grain production. Ramanujam and Rao (1971). Nair and George (1973) and Pillai and George (1973) also reported non significant effect of N in increasing the grain yield in rice.

The non significant effect of phosphorus obtained in this study may be due to its failure to increase the number of tillers and number of panicles. This confirms the results obtained by Shukla (1969), Nair and Pisharody (1970), Abrol et al. (1980), Dargan et al. (1980) and Rojas and Alvarado (1982).

Potassium also did not have any significant effect on seed yield. Shukla(1969) and Pandey and Das (1973) could not get any significant effect of potassium on the grain yield of rice. Ageeb and Yousif (1978) reported that different doses of potassium either alone or in combination with phosphorus had no response in rice. In the case of congosignal grass different levels of NPK fertilizer had no significant difference on seed yield (Research Report, 1987-90).

5.11. Effect of treatments on seed quality

The results obtained from tables 4.6. and 4.7. are discussed below. It can be seen from the table that seed viability as percentage of kernels was not significantly influenced by either nitrogen, phosphorus or potassium. But seed viability as percentage of seeds was significantly influenced by phosphorus. There was 29.5 per cent increase in viability at the highest level of phosphorus compared to the lowest level.

Nitrogen, phosphorus and potassium did not have any significant influence on seed germination calculated as percentage of kernels. But seed germination as percentage of seeds was significantly increased by phosphorus levels.

Seed purity was not significantly affected by nitrogen, phosphorus or potassium. Seed moisture and 1000 seed weight were also not influenced by any of the treatments.

Skoblin and Perepravo (1979) reported that in cocksfoot grass (*Chloris barbata*), fertilizer rates did not affect quality of the seed. Sangakkara (1988) working on defoliation frequency and seed productivity of guinea grass (*Panicum maximum*, Jacq) reported that the defoliation and nitrogen treatments had no significant effect on 1000 seed weight. In another trial, nitrogen fertilizer application for seed yield and quality of setaria grass (*Setaria sphacelata* Var. Sericae Cv. Kazungula) was studied by Cruz et al. (1989) and reported that seed germination in all trials was unaffected by nitrogen rates. Similarly Satjipanon et al. (1989) working on ruzigrass (*Brachiaria ruziziensis*) reported that different levels of nitrogen, phosphorus and potassium had no effect on seed quality parameters like germination, purity and viability.

5.12. Soil nutrient status

The results presented in table 4.8. showed that application of nitrogenous fertilizer increased the nitrogen status of the soil. Each level of nitrogen significantly increased the nitrogen content of the soil. This may be due to the heavy dose of fertilizer applied to these treatments. This confirms the results obtained by Venkata Rao and Badigar (1971) Abraham (1978) and Sharma and Misra (1988).

Different levels of phosphorus significantly increased the nitrogen status of the soil. Similar result was obtained by Chandini (1980).

Potassium had a significant effect on nitrogen content of the soil. Geetha Kumari (1989) working on nutrient management for maize - fodder cowpea intercropping in rice fallows reported that the highest level of applied potassium (100% of recommended dose) recorded highest value for available nitrogen in the soil after the experiment. NP interaction was found to be significant.

From the results it can be seen that soil phosphorus content was not significantly influenced by nitrogen and potassium, but all the levels of phosphorus resulted in significant increase in phosphorus status of the soil. This confirms the results obtained by Kanwar (1978). He stated that phosphorus is a relatively immobile element and it is recognised that proportion of fertilizer P taken up by a single crop is often low and the P fertilizer have residual value. He has also reported that residual effect would be increased when the rate of application is increased, due to increase in phosphate potential. Raniperumal et al. (1969) reported that application of N and K had no effect on phosphorus content of soil, but applied P increased phosphorus content.

The results revealed that soil potassium content was increased by applied nitrogen and potassium, while applied phosphorus did not have any significant effect. Johnkutty (1981) stated that as a mobile cation, K is easily susceptible to loss through leaching. However K fixation counteracts the loss through leaching and converts it into slowly available fixed form. This may be the reason for the increased potassium status of soil due to applied potassium. Potash content of the soil was not influenced by applied phosphorus (Johnkutty, 1981).

5.13. Economics of cultivation

From the results presented in table 4.9., it can be seen that the highest net returns and the highest benefit cost ratio is recorded by the treatment combination T_{16}. This is because the highest fodder yield was recorded by this treatment combination and the third highest seed yield was also recorded by this treatment combination. The treatment combination T_{16} was followed by T_{19}, which recorded the second highest fodder yield and the highest seed yield.

SUMMARY

6. SUMMARY

A field experiment was conducted at the instructional farm, College of Agriculture, Vellayani, during the period from July 1993 to January 1994. The objective of the experiment was to find out the effect of nitrogen, phosphorus and potassium on seed production of gamba grass (*Andropogon gayanus*). The experiment was laid out in partially confounded factorial design with two replications having three blocks in each replication. There were twenty seven treatment combinations of three levels each of nitrogen (75, 150 and 225 kg/ha), phosphorus (50, 75, 100 kg/ha) and potassium (50, 75, 100 kg/ha).

The important findings are summarised below.

1. Plant height at first harvest was significantly increased by application of nitrogen. Maximum height was recorded at the highest level of nitrogen (225 kg/ha). But phosphorus and potassium did not have any significant effect. At the time of second harvest, nitrogen, phosphorus nor potassium had any significant effect on plant height.

2. Nitrogen application significantly increased the number of tillers at the first and second harvests. There was a progressive increase in tiller number with incremental levels of nitrogen. Phosphorus and potassium did not have any significant influence. The interaction effects were also not significant.

3. The number of leaves at first and second harvest was found to increase significantly due to nitrogen application. The highest level of nitrogen recorded the maximum number of leaves. Phosphorus did not have significant effect on the number of leaves in both the harvests. But potassium significantly reduced the number of leaves during the second harvest.

4. Fresh fodder yield at both the harvests were significantly increased by the application of nitrogen. The highest level of nitrogen (225 kg/ha) recorded the maximum fodder yield in both the harvests. Phosphorus and potassium did not significantly influence the fresh fodder yields. Among the interaction effects, NP interaction was found to be

significant in both the harvests.

5. Maximum dry fodder yield was recorded at the highest level of nitrogen. Phosphorus did not have much influence, but potassium induced a significant reduction in dry fodder yield.

6. Nitrogen content in fodder was not influenced by NPK application. But the content of phosphorus was influenced by the levels of phosphorus even though nitrogen and potassium did not have any significant effect. The phosphorus content was highest at the highest level of phosphorus (100 kg/ha). The potassium content of the fodder was significantly reduced due to nitrogen application while the higher levels of potassium increased the potassium content.

7. Uptake of nitrogen was significantly influenced only by the levels of nitrogen and uptake was maximum at the highest level of nitrogen. Phosphorus and potassium levels did not have significant effect on phosphorus uptake. Nitrogen and phosphorus application increased the uptake of phosphorus, but potassium decreased the uptake of phosphorus. PK

interaction was found to be significant. Uptake of potassium was significantly increased by the higher levels of nitrogen, while phosphorus and potassium did not have a significant influence.

8. Crude fibre content was significantly reduced by nitrogen, phosphorus and potassium. There was a progressive reduction in the fibre content with an increase in the levels of fertilizers. NP and PK interaction effects were significant.

9. Number of days to 50 per cent flowering was not influenced by the different levels of nitrogen and phosphorus. But potassium caused a significant increase. The maximum number of days to 50 per cent flowering was recorded by the level 75 kg K_2O/ha.

10. There was a significant increase in the number of panicles per plant due to nitrogen application. The highest level of nitrogen (225 kg/ha) recorded the maximum number of panicles. Phosphorus and potassium did not have any significant influence on the number of panicles per plant. NP interaction was found to be significant.

11. Number of seeds per panicle was significantly reduced by higher levels of nitrogen. Minimum number of seeds per panicle was recorded by the highest level of nitrogen. Effects of phosphorus and potassium were non significant.

12. The number of kernels/500 seeds was significantly increased by the levels of phosphorus. The highest level of phosphorus (100 kg/ha) recorded the maximum number of kernels. Number of kernels were not influenced by nitrogen and potassium levels.

13. Seed viability as percentage of kernels was not significantly influenced by the different levels of nitrogen, phosphorus or potassium. But seed viability as percentage of seed was influenced by the different levels of phosphorus and the highest viability was recorded at 100 kg P_2O_5 /ha.

14. Seed germination as percentage of kernels was not influenced by the different levels of nitrogen, phosphorus or potassium. But seed germination as percentage of seeds was significantly influenced by

phosphorus. Maximum germination percentage was recorded at 100 kg P_2O_5 /ha.

15. With increase in nitrogen levels, there was an increase in seed purity, but the influence was not significant. Phosphorus levels showed no influence on seed purity. But increase in potassium levels, reduced seed purity.

16. There was a progressive reduction in seed moisture content with incremental levels of nitrogen. But the influence was not significant. Phosphorus and potassium also had no significant effect on seed moisture.

17. 1000 seed weight was not influenced by either nitrogen or phosphorus or potassium.

18. Maximum seed yield was recorded at the highest level of nitrogen, but the influence was not significant. Phosphorus and potassium had no effect.

19. Nitrogen content of the soil after the experiment was influenced only by the levels of nitrogen. The

highest level of nitrogen recorded the maximum nitrogen status in soil. Phosphorus also had a significant effect. Potassium did not have any significant effect. Phosphorus content of the soil was increased by phosphorus fertilizer, but nitrogen and potassium did not have a significant effect. Increase in nitrogen and potassium fertilizer levels increased the potassium status of the soil while phosphorus showed no significant influence.

REFERENCES

REFERENCES

Abraham, C.T. (1978). Performance of Dinanath grass (*Pennisetum pedicellatum* Trim) as influenced by nitrogen and lime applications. MSc (Ag) dissertation submitted to Kerala Agricultural University.

Abrol, I.P., Chhabra, R., Dargan, K.S. and Gaul, B.L. (1980). Save on phosphate fertilizers in alkali soil reclammation. Indian Fmg. 30(6) : 13-15.

* Adams, F. (1980). Interaction of phosphorus with other elements in soil and plants. In. R. C. Dinauer (ed). The role of phosphorus in agriculture. American society of Agronomy, Madison, WI. pp 655-680.

Agarwal, M.M. (1978). Effect of nitrogen, phosphorus and potash on the yield, uptake and quality of rice. Indian J. Agric. Res. 12(1) : 35-56.

Ageeb, O.A.A. and Yousif, Y.H. (1978). P and K nutrition of rice. (*Oryza sativa* L.) in the Indian Kenana. Exp. Agric. 14(1) : 33-39.

Ajithkumar, R. (1984). Fertilizer management trial for the rice variety Mashuri during mundakan season MSc(Ag) thesis submitted to Kerala Agricultural University.

Alexandar, K.M., Sadanandan, N. and Sasidhar, V.K. (1974a). Effect of various levels of nitrogen and phosphorus on the yield and other agronomic characters of rice variety, Triveni. Agri. Res. J. Kerala. 11(2) : 109-113.

Alexander, K.M., Sadanandan, N. and Sasidhar, V.K. (1974b). Effect of various levels of nitrogen and phosphorus on the uptake of phosphorus by rice variety, Triveni. Agri. Res. J. Kerala. 12(2) : 140-144.

Andrew, C.S. and Robins, M.F. (1970) in. Adv. Agron. 22 : 2-66.

Annual Report. (1972). Comparative performance of different varieties of dinanath grass in relation to their N and P requirement. Annual Report of All India Co-ordinated Project for research on Forage crops. Jabalpur. 1971-72.

Annual Report. (1976). Comparative performance of different varieties of bajra / dinanath grass under different levels of N and P manuring. Annual Report of All India Co-ordinated Project for research on Forage crops. Rahuri. 1975-76.

Annual Report. (1977). Forage Research at Pantnagar. 1974-77. Presented at 4-th annual workshop on All India. Co-ordinated Research on Forage Crops; held at IGFRI, Jhansi, from October 10-12, 1977.

Annual Report. (1978). Response of dinanath grass to varying levels of N and P. Annual report of All India Co-ordinated Project for Research on Forage crops, Vellayani. 1977-78.

* Ayerza, R. (1980). Effects of phosphate fertilizer on the seed production of Buffel grass (*Cenchrus ciliaris*.L) Revista de ciencias Agrarias. 1(3) :99-102.

Bahl, D.B., Bhaid, H.U. and Srivastava, 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 Agricultural University, Hissar, 17-19, September.

Bahnisch, L.M., and Humphreys, L.R. (1977). Urea application and time of harvest effects on seed production of *Setaria anceps* Cv. Narok. Aust. J. Exp. Agric. Anim. Husb. 17(87) : 621-628.

Balbatti, M.S. (1980). Effect of Nitrogen levels and row spacing on yield and quality of hybrid napier grown with and without a legume. MSc (Ag) thesis submitted to Kerala Agricultural University.

Bavappa, K.V.A. and Rao, K.H. (1956). The response of rice to lime and potash manuring in south Kanara. Madras Agric. J. 43(10) : 505-507.

* Berroteran, J.L. (1989). Response of *Andropogon gayanus* and *Digitaria swazilandensis* to fertilizer in central plains of Venezuela. Pasturas tropicales. 11(3) : 2-7.

Bhandari, D.K. and Virmani, S.M. (1972). Effect of nitrogen fertilizers on the uptake and utilization of fertilizer phosphorus by maize (*Zea mays* L.) Indian J. Agric. Sci. 42(5) : 375-380.

Bhuiya, Z.H., Islam, S.M.N., Haque, M.S. and Mian, M.M.H.

(1979). Effect of N,P,K fertilizers on the performance of Dharial rice. Yield and protein content. Bengladesh J. Scient. Ind. Res. 14(3/4) : 311-315.

* Bilbao, B., Febles, G. and Matias, C. (1979). Nitrogen fertilization and time of harvesting seed of *Cenchrus ciliaris* L. Cv. Bilocla, Pastos Y Forrages. 2(3) : 421-434.

Black, C.A. (1957). Soil plant relationships. John Wiley and Sons. Inc. Newyork, 2nd Ed. 1968. 1-792.

* 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. (1977). Tropical pasture and Fodder plants. (Tropical Agriculture series). Longman Group Limited, London. p 475.

Bokde, S. (1968). Effect of different levels of nitrogen application and cutting intervals on growth, yield and quality of 2 varieties of oats. Ind. J. Agric. Sci. 38(5) : 887-893.

Boonman, J.D. (1972). Experimental studies on seed production of tropical grasses in Kenya. 3. The effect of nitrogen and row width on seed crops of *Setaria sphacelata* Cv. Nandi II. Neth. J. Agric. Sci. 20 : 22-34.

Boruah, A.R. and Mathur, B.P. (1979). Effect of cutting management and N fertilization on the growth yield and quality of fodder oats. Indian J. Agron. 24(1) : 50-53.

Bose, B.B. (1965). Pennisetum species over scores other grasses. Indian fmg. 15:9.

Brejda, J.J., Brown, J.R., Wyman, G.W. and Schumache, W.K. (1994). Management of switch grass for forage and seed production. J. of Rangeland management. 47(1) : 22-27.

* Caceres, O., Esperance, M. and Hernandez, N.C. (1986). Studies on haymaking on three outstanding grasses. Pastos Y Forajes. 9(2) : 185-189.

* Cameron, A.G. and Humphreys, L.R. (1976). Nitrogen supply, CCC and harvest time effects on

Paspalum plicatum seed production. Trop. Grasslands. 10 : 205.

* Carmo, M.A. Do, Nascimento Junior, D. Do and Mantorani, E.A. (1988). Effect of nitrogen fertilizer and date of harvest on seed production and quality of *Brachiaria decumbens*. Pasturas tropicales. 10 (2):19-22.

* Carvalho, M.M, Martins, C.E., Siqueira, C., Savaiva, O.F.(1992). Growth of Brachiaria species with lime as top dressing and nitrogen rates. J. Revista Brasileira de ciencia do solo. 6(1): 69-74.

* Chadhokar, P.A and Humphreys, L.R. (1973). Influence of time and level of urea application on seed production of *Paspalum plicatum* at Mt. Gatton South eastern Queensland. Aust. J. exp. Agric. Anim. Husb. 13:275.

* Chadhokar. P.A. (1978). Effect of rate and frequency of nitrogen application on dry matter yield and nitrogen content of para grass (*Brachiaria mutica*). Tropical grasslands. 12(2): 127-132.

* Chakravarthy, A.K., Roy, R.D: Verma, C.M and Das, R.B. (1966). Study on the pasture establishment technique. Effect of seed rates, method of sowing and seed treatments on seedling emergence in *Cenchrus cililaris* and *Lasiurus sindicus*. Ann. Arid. zone. 5. 145-148.

Chandini, S. (1980). Fodder production potential of Grass - Legume mixtures. MSc (Ag) thesis submitted to Kerala Agricultural University.

Chatterjee, B.N. (1964). At Sabour, Sadabahar is first among forage grasses. Indian Fmg. 14, 17-20.

CIAT. (1982). Tropical pastures program. Annual report, CIAT, Cali, Columbia. pp 163-165.

* Cochran, M.G and Cox, G.M, (1965). Experimental Designs. Asia Publication House.

* Cruz, M.E., Alvarenga, E.M and Nascimento, D.Do, Jr. (1989). Nitrogen fertilizer application for seed yields and quality of forage grasses. 1. *Setaria sphacelata* Var. Sericeae cv. Kazungula. Revista da Sociedade Brasileira de Zootecnia. 18 (3): 197-203.

R.A.(1991b). Effect of nitrogen and phosphorus levels on seed yield of *Pennisetum polystachyon* (L). Shult. Haryana J. of Agronomy. 7(1): 25-28.

Esakkimuthu, N., Krishnamoorthy, K.K. and Loganathan, S. (1975). Influence of nitrogen and potassium and method of application of potassium on yield and nutrient uptake in rice. J. Indian Soc. soil sci 23(4): 452-457.

* Falade, J.A. (1975). The effect of phosphorus on growth and mineral composition of 5 tropical grasses. East African Agricultural and Forestry Journal. 40(4) :342-350.

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 Agricultural University, Hissar, 17-19 September.

* Febles, G., Perez, J. and Padilla, C. (1982). Effect of nitrogen levels and time of application on common guinea grass, *Panicum maximum* seed

production. Cuban journal of Agricultural science. 16(3) :323-337.

Ford, B.D., Calder, G.J. and Lemcke, B.G. (1981) Unpublished data. N. T. Dep. Prim. Rrod. Darwin. In New pasture plant releases. Tropical grasslands. 21(1): 44-46.

* Foster, W.H. (1956). Factors affecting the production of seed in Rhode's grass. Rep. Dept. Agric. N. Nigeria Pt. II 1956-7 :172-176.

Ganguli, T.K., Singh, J.P. and Relwani, L.L. (1976). Note on the effect of N,P and Zn on yield and composition of fodder oat. Indian J. Agric. Sci. 46(5) :238-40.

Gangwar, K.S. and Niranjan, K.P. (1991). Effect of organic manures and inorganic fertilizers on rainfed fodder sorghum. (*Sorghum bicolor*). Indian J. Agri. Sci. 61(3):193-194.

Geetha Kumari, S.(1989). Spatial arrangement and nutrient management for maize - fodder cowpea intercropping in rice fallows. MSc (Ag) Thesis submitted to Kerala Agricultural University.

George, J.R., Reigh, G.S., Mullen, R.E. and Hunczak, J.J. (1990). Switchgrass herbage and seed yield and quality with partial spring defoliation. Crop. Sci. 30(4):845-849.

* Glogov, L.V. (1969). Nutrient uptake by maize plants at different stand densities. Izv. timiryazev. Sei-khoz. Akad. No. 4. 63-71.

Haggar, R.J. (1966). The production of seed from *Andropogon gayanus*. Proc. Int. seed Test. Ass. 31(2):251-259.

Hampton, J.G., Clemence, T.G.A. and Hebblethwaite, P.D. (1983). Nitrogen studies in *Lolium perenne* grown for seed. IV Response of amenity types and influence of a growth regulator. Grass and forage science. 38:97-105.

Harrison, P.G. (1981). Personal communication. N. T. Dep. Prim. Prod. Darwin. In New pasture plant releases. Tropical grasslands. 21(1): 44-46.

* Hebblethwaite, P.D. and Ivins, J.D. (1977). Nitrogen studies in *Lolium perenne* grown for seed I. Level of application. Journal of the British

grassland Society 32:195-204.

Hebblethwaite, P.D. and McLaren, J.S. (1979). Nitrogen studies in Lolium perenne grown for seed. III. The effect of nitrogen and water stress. Grass and Forage Science (1979). 34 : 221-227.

International Seed Testing Association (ISTA). (1985). International rules for seed testing-Annexes 1985. Seed science and Technology, 13 : 356-513.

Jackson, M.L. (1958). Soil Chemical Analysis. Prentice Hall Inc., U.S.A p.498.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentice Hall of Indian Private Ltd. New Delhi. 2nd Ed. 1-498.

* Javier, E.Q., Siota, C.M. and Mendozer, R.C. (1975). Fertilizer and water management of tropical pasture seed crops. Extn. bulletin, ASPAC food and fertilizer Technology centre No: 63 pp15.

* Javier, E.Q., Leon, B. De. and Castillo, E. (1977). Fertilizer response of pasture crops on Abortan Sandy loam - an infertile costal plain soil in

Palawan. Philippine Journal of Crop science. 2(1) : 34-36.

Johnkutty, I. (1981). Response of Ragi (*Eleusine corocana* Gaertn) to different levels of nitrogen, phosphorus and potassium under rainfed condition. MSc(Ag) thesis submitted to Kerala Agricultural University.

Joshi, H.C. and Tandon, J.P. (1984). Effect of NPK fertilization on the content of these elements in grain and straw in Ragi (*Eleusine corocana* Gaertn). Indian J. Agric. Res. 18(3) : 163-166.

Junquira, E.C., Nascimento Junior, D.Do and obeid, J.A. (1985). Nitrogen application for the production of quality seeds of setaria grass. (*Setaria sphacelata* Var. Sericea Cv. Kazungula. Revista da sociedade Brasileira de zootecnia. 14(1) : 1-4.

Kalyanikutty, T.K. and Morachan, Y. B. (1974). Influence of N.P.K. on the growth, yield and composition of rice varieties differing in inherent yield potentials. Madras Agric. J. 61(8) 239-244.

Kanwar, J.S. (1978). Soil fertility - theory and practice. ICAR. ND.

Krishnan, P. (1968). Studies on the uptake of nitrient and response of rice (var -IR-8) at different levels of nitrogen, phosphorus and potassium. MSc(Ag) thesis submitted to the University of Kerala.

Krishnan, K. (1993). Seed production potential of guinea grass (*Panicum maximum* Jacq) Cv. Riverse Dale under different management techniques. Msc (Ag) thesis submitted to Kerala Agricultural University.

* Kritayanavach, P. (1968). Effect of rate and method of nitrogen application on napier and hybrid napier. Thesis. Kasetsart University, Thailand. 65pp.

* Kuznetsov, N.I. (1970). Dependence of maize yields on increases in biomass production and dry matter accumulation in relation to fertilizer application. In Plodorodie i melioratsiya poch vv tirgizii Frenze, Kirgiz SSR from Rereratívnyl zhurnal (1980), 88-94.

Lakshminarasimhan, C.R, Honora, J.F. and Subbiah, S. (1979). Effect of N fertilization and time of cutting on yield of green matter and extractable protein in maize. Madras agric. J. 66(9):590-592.

Little, S., Vincente, J. and Abruma,F. (1959). Yield and protein content of irrigated grass, Guinea grass and Pangola grass as affected by nitrogen fertilization. Agron. J. 51(2):111-13.

Loch, D.S. (1991). Tropical herbage seed production origin, progress and opportunities. Proceedings of second international Herbage seed conference. J. of Applied Seed Production. 9:14-26.

Loganathan, S. and Raj, K. (1972). Characterisation of the pattern of uptake of different nutrients by certain high yielding paddy strains. Madras Agric. J. 59(4):215-218.

* Lotero, C.J., Bernal, E.J. and Hezzera, P.G. (1967). Planting distance and N application with elephant grass. Revta Inst. Colomb. agropec. 2(2) 123 133

Loue, A. (1980). The interactions of potassium with other nutrients. Report on Potassium Workshop Ibadan, Nigeria, Oct. 8-10 pp 67-81.

Majumdar, D.K. (1971). Effect of sowing time and fertilizers on yield attributes and yield of rice (*Oryza sativa* L.) Indian J. Agron. 16(1):6-9.

Mears, P.T. and Humphreys, L.R. (1974). Nitrogen response and stocking rate of *Pennisetum clandestinum* pastures. J. agric. Sci. Camb. 83(2): 451-467.

* Mecelis, N. and Oliveira, P.R.P. De. (1984). *Brachiaria humidicola* seed production components; effect of nitrogen fertilizer and date of harvest. Zootecnia 22(1):57-71.

* Meja, P.V., Romero, M.C., and Lotero, C.J. (1978). Factors which affect germination and vigour of seeds of guinea grass (*Panicum maximum* Jacq). Revista Instituto Columbiano Agopecuario 13(1):69-75.

Mengel, K. and Braunschwieg, L.C. Van.(1972). The effect of soil moisture upon the availability of potassium and its influence on growth of young maize plants (*Zea mayz* L.) Soil Sci. 114(2):142-148.

Mengal, K., Viro, M and Hehl, G. (1976). Effect of potassium on uptake and incorporation of ammonium nitrogen of rice plants. Plant and

Soil. 44(3):547-558.

Misra, B.N., Yerma, B.S. and Singh, K.N. (1982). Effect of varying levels of N,P and K application on grain and straw yields and nutrient uptake pattern in 2 row Barley (*Hordeum distichium* L.). Indian J. Agric. Res. 16(3):139-144.

Mohanty, S.K. and Patnaik, S. (1974). Uptake of nutrients in relation to growth of rice as influenced by varying nutrient environment in different soil types. Riso 23(4):351-363.

* Monteiro, F.A. and Werner, J.C. (1977). Effect of N and P fertilizers on the establishment and maintanance of guinea grass. Phosphorus Agric. 75:54.

* Monteiro, J.M.C., Favoretto, V. and Reis, R.A. (1984). Cutting date and nitrogen level on yield and quality of guinea grass seed. Pesquisa Agro pecuaria Brasileira. 19(5):545-552.

Mukerji, S.K. and Chatterji, B.N. (1955). Culture of *Pennisetum pedicellatum* in Bihar for forage and soil conservation. Indian J. soil water consv., 3:161-63.

Mukerjee, A.K., Roquib, M.A., Rana, S.K. and Chatterjee, B.N. (1981). Effect of fertilization and cutting management on the seed production of teosinte (*Euchlaena maxicana* L.). Forage Res 7(1):95-96.

Nair, K P.M., Menon, A.G.G. and George C.M. (1966). Studies on hybrid maize (Zea mays L.) I. Effect of spacing and fertility levels on yield of Deccan hybrid makka. Agric Res. J. 4(1):24-30.

Nair, R.R., and Pisharody, P.N. (1970). Response of rice to phosphate manuring in a waterlogged laterite sandy loam of Kerala. Agric. Res. J. Kerala. 8(1):6-13.

Nair, V.M. and George, C.M. (1973). Studies on the comparative performance of three short duration rice varieties, Vellayani I, ADT - 27 and PTB 10 at varying levels of nitrogen under semidry conditions in Vellayani. Agric. Res. J. Kerala. 11(1):5-8.

Narwal, S.S. and Tomer, P.S. (1973). Seed and stover from Dinanath grass (*Pennisetum pedicellatum* Trin) in relation to N & P levels with variable seed rates. HAU J. Res. 3(4):256-257.

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(1):61-65.

Nooruddin and Roy, L.N. (1974/77). A note on the chemical composition, digestability and nutritive value of *Andropogon gayanus* at the flowering stage. Indian Journal of Animal Sciences (1974 publ. 1977). 44(10):797-798.

* Nordestgaard, A. (1980). The effects of quantity of nitrogen, date of application and the influence of autumn treatment on the seed yield of grasses. In-Hebblethwaite P.D. (ed). Seed production. pp105-119 London Butterworths.

* Nordestgaard, A. (1988). Seed production of Westerworld rye grass (*Lolium multiflorum*. Lam. Var. Westerwoldicum). Tidsskrift for planteavl 92(2):97-101.

* Nordestgaard, A. (1990). Phosphorus-Potassium and P'H

Cameroon. J

Studies on the seed production of *Festuca arundinaceae* Schrch. II. Effect of nitrogen fertilization and method of its application on seed production of *Festuca arundinaceae*. J. of the Korean Society of grassland science. 5(2):100-105.

Patel, H.R., Joshi, R.S. and Patel, K.R.(1985). Response of hybrid maize (Ganga safed-2) to various levels of irrigation and potash. Madras Agric. J. 72(12):717-719.

* Paulino, V.T., Malavotta, E. and Pigato, A.M. (1989). Effects of gypsum, phosphorus and lime on *Andropogon gayanus*. Revista de Agricultura. 64(1):55-90.

* Paulino, V.T. and Malavotta, E. (1989). Effect of phosphogypsum, phosphorus and lime on *Andropogon gayanus* Kunth. Proceedings of the XVI International Grassland Congress, 4-11 October, 1989, Nice, France.

Perez, A., Matias, C. and Reyes, I. (1984). Influence of different nitrogen rates on seed production of

Guinea grass Cv. Likoni. Pastos y forrajes. 7(2):203-214.

Pillai, G.R. and George, C.M. (1973). Studies on the performance of rice Var. IR-8 under varying levels of N and spacing. Agric. Res. J. Kerala. 11(1):38-42.

Piper, C.S. (1950). Soil and Plant Analysis. The University of Adelaide, Australia.

Rai, P. and Kanodia, K.C. (1981). Response of *Setaria sphacelata* to nitrogen and phosphorus under rainfed conditions. Ind. J. Agron. 26(2):205-206.

Rai, P. and Sankaranarayanan, K.A. (1981). Effect of Nitrogen and phosphorus on seed yield of Pusa Giant Anjan (*Cenchrus ciliaris* Linn). Forage Res. 7(2):181-186.

* Ramakrishnan Nair. (1963). Response of Co-7 Ragi (*Eleusine corocana*) to phosphate and potash. Dissertation submitted to the University of Madras.

Ramakrishnan, V. and Vadivelu, K.K. (1981). Rice seed technology. Seeds and Farms. 7(5-6):7-11.

Ramanujam, T. and Rao, J.S. (1970). Effect of nitrogen and CHO and protein content in rice (*Oryza sativa* L.). Madras Agric. J. 57(8):435-436.

Ramanujam, T. and Rao, J.S. (1971). Influence of nitrogen supply on growth factors of rice. (*Oryza sativa* L.). Madras Agric J. 58(3):239-244.

Ramaswamy, P.P. and Raj, D. (1974). Influence of nutrient and green manure application on nutrient uptake and yield of rice. Madras Agric. J. 61(10-12):945-949.

Raniperumal, L. Ghouse, M. and Soundrarajan, R. (1969). Effect of continuous application of fertilizers and manure on the yield and composition of certain crops. I. Effect on ragi (*Eluecine corocana*). Madras Agric. J. 56(2):58-63.

Rao, T.K.G., Kolandaiswamy, S., Seshadri, P. and Sankaran, S. (1974). Studies on levels and times of application of phosphorus and potassium on rice. Madras Agric. J. 61(8):258-261.

Rathore, D.N. and Vijayakumar. (1977). Quality components of Dinanath grass and sorghum forage as affected by nitrogen and phosphorus fertilization. Indian J. Agric. Sci. 47(8):401-404.

Rathore, D.N. and Vijayakumar. (1978). Nutrient uptake and concentration in Dinanath grass and sorghum grown at different levels of nitrogen and phosphorus. Indian J. agric. sci. 48(9):546-550.

Ravikumar, Shankaranarayanan, K.A. and Rai, P. (1979). Effect of nitrogen and phosphorus on dry forage yield and quality of *Cenchrus ciliaris* L. (var. Giant anjan) and *Heteropogon contortus* (L.) Beauv. Ex Roem Et Schult. Forage Res. 5(1):69-74.

Reddy, R.K., Yogeswara Rao, Y. and Sankara Reddy, G.M. (1978). Nitrogen uptake of high yielding rice varieties in relation to seedling rates and fertility levels. Indian J. Agric. Res. 12(4):266-268.

Reheja, P.C. (1966). Soil productivity and crop growth. Asia publising house, Bombay.

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.

Reid, D. (1972). The effect of long term application of wide range of nitrogen rates on the yield from perennial rye grass swards with and without white clover. J. agric. Sci. Camb. 79 (2): 291-301.

Relwani, L.L. and Bagga, R.K. (1968). Dinanath grass (*Pennisetum pedicellatum*) a new fodder that threatens to elbow out jowar and bajra. Indian Dairyman. 20:199-201.

Reneau, R.B., Jones, G.D. and Friedericks, J.B. (1983). Effect of P and K on yield and chemical composition of forage sorghum. Agron. J. 75 (1):5-8.

Research Report. (1987-90). Fertilizer trial (N:P:K) on ruzi grass at Chakupallam. Fodder Research report; KLD Board ltd, Dhoni, Palakkad. pp 44,45.

Rinne, K.(1976). The chemical composition of pasture herbage affected by different levels of nitrogenous fertilizer. J. Sci. agric Soc. Finland. 48 (4):305-316.

* Rojas, W.C. and Alvarado, A.R. (1982). Nitrogenous and phosphatic fertilizer application to rice in the central-south zone of Chile. Agricultura Tecnica. 42 (1):15-21.

Sadanandan, N.and Sasidhar, V.K.(1976). Studies on the response of rice variety Triveni to phosphorus application. Agric. Res. J. Kerala 14 (2): 175-177.

Sadayappan, S.and Kolandaiswamy, S. (1974). Influence of added nitrogen and its time of application on grain protein, phosphorus and potash. Madras Agric J. 61 (9): 646-647.

Sangakkara,U.R. (1988). Relationship between nitrogen fertilizer, defoliation frequency and seed productivitty of *Panicum maximum* Jacq. Seed Research. 16 (2):206-210.

Sarkar, A.K., Mathur, B.S, Lal, S. and Singh, K.P. (1989). Long term effects of manure and fertilizer on important cropping systems in sub-humid red and laterite soils. Fert. News, New Delhi, 34(4):71-80.

* Sasanki, K. and Wada, S.(1975). Effects of nitrogen, phosphoric acid and potash on the percentage of sterile grains in rice plants. Proceedings of the crop science society of Japan. 44 (3): 250-254.

* Satjipanon, C, Nakmanee, G., Sugraruji, P. and Harnkla. M. (1989). Effect of chemical fertilizers on seed yield of ruzi grass, *Brachiaria ruziziensis*. Khonkaen Agriculture Journal. 17 (5):316-325.

Shankaranarayanan, K.A, Dabadghao, P.M, Rai, P Upadhyay, V.S and Maurya, R.K. (1973). Fertilizers for the grasslands of *Heteropogon contortus* (L.) Beauv. ex Roem et Schult in Jhansi. Indian J. Agric. Sci. 43(6):562-566.

Sharma, R. D and Misra, B. C. (1988). Availability of NPK and Si in a mollisol under flooded rice. J. Indian Soc. Soil Sci. 36(1) : 165-168.

Sharma, R. K. (1973). Response of maize to nitrogen fertilization. Madras Agric J. 60 (6):399-400.

* Shingareva, S.V. (1981). Effect of top dressing with nitrogen fertilizer on perennial rye grass seed yield. Referativnyi Zhurnal 1(55):388.

Shukla, G.C. (1969). Fertilizer studies with rice. Agric. Res. Gayana 3 :4-16.

Singh, B.K. and Modgal, S.C. (1978) Dry matter production, phosphorus and potassium uptake as influenced by levels and methods of nitrogen application in rainfed upland rice. Indian J Agric. Sci. 48(6) :337-341.

Singh, U.S., Singh, R.P and Singh D.N. (1976). Effect of rate and time of application of potassium on the yield and nitrogen, phosphorus and potassium turn over by high yielding rice. Fert. Technol. 13 (2/3):107-109.

Singh,V. and Jaiprakash. (1979). Effect of nitrogen, phosphrous and potassium application on the availability of nutrients to rice. Madras Agric. J. 66 (12): 794-798.

Singh, C.P., Sharma, N.N and Prasad, V.K. (1991) Response of winter maize (*Zea mays*) to seeding date, seed furrow mulching and fertilization with nitrogen, phosphorus and potassium. Indian J. Agric. Sci. 61 (12):889-892.

* Skobfin, G.S. and Perepravo, N.I. (1979). Yield and quality of cocksfoot seed as affected by various harvest dates and fertilizer rates. Izvestiya Timiryazevskoi Selskokhozyaistvennoi Akademii. No 5,43-50.

Smith, D. (1979). Fertilization of switch grass in the green house with various levels of nitrogen and potassium. Agron. J.; 71 (1):149-150.

Sobhana, S. (1983) Spacing cum fertilizer investigation on rice variety Mashuri in the Onattukara tract. MSc.(Ag) thesis submitted to Kerala Agricultural University.

Sreekumaran, V.(1981) Response of Rice culture 31-1 to graded dose of fertilizers MSc.(Ag) thesis submitted to Kerala Agricultural University.

Status paper. (1989). Status paper on feeds and fodder, Government of Kerala.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 25:259-260.

Subbiah, K.K., Rajagopalan, K., Morachan, Y.B., Balasubramanian, K.M., and Narayanaswamy.P (1975). Nitrogen application to Co_{36} rice. Madras Agric. J. 62 (6):349-352.

Subramanian, S. (1969). Sources and levels of nitrogen with phosphorus and potassium as factors influencing the yield of ragi, Co_7. Msc (Ag) dissertation submitted to and accepted by the University of Madras.

Sumbali, G. L. and Gupta D.K. (1972). Response of paddy (IR-8 and Jaya) to nitrogen. Indian J. Agron. 17 (4):279-282.

Sumner, M.E. and Farina, M.P.W. (1986). Phosphorus interactions with other nutrients and lime in field cropping systems. Advances in soil science. 5:201-236.

Suseelan, P., George, C.M. and Sreedharan, C.(1978). Effect of phosphorus and lime application on rice and hybrid napier under varying levels of nitrogen and cutting intervals. Msc(Ag) thesis, submitted to Kerala Agricultural University.

Tisdale, S.L. and Nelson, W.L. (1975). Soil fertility and fertilizers. 3rd Ed. Macmillan publishing Co-Inc. New York. PP 1-694.

Tisdale, S.L., Nelson, W.L., and Beaton, J.D. (1985). Soil fertility and fertilizers. 4th edition. Macmillion publishing company. Inc. New York pp 1-733.

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.

* Tiwana, M.S and Puri, K.P (1976). Response of three varieties of oats to N application. Ceylon Veterinary Journal. 24 (1/4):35-38.

Tiwari, K.N. and Vandana Nigam. (1985). Crop Responses to potassium fertilization in soils of Uttar Pradesh. J. of potassium Research. 1(1): 62-75.

variety IR-8. Agric. Res. J. Kerala 16 (2):240-241.

Taneja, K.D., Gill, P.S. and Solanki, K.R. (1981). Possibility of taking fodder in addition to seed from Barley (*Hordeum vulgare* L.) and Oats (*Avena sativa*) under different levels of nitrogen. Forage Res. 7 (1):31-38.

Thakuria, K. (1993). Effect of nitrogen, phosphorus and potash on fodder yield and quality of teosinte (*Euchlaena mexicana* Schrad) Forage Res. 19 (1):101-103.

Thandapani, V. and Rao, J.S. (1974). Effect of phosphorus fertilization on the nitrogen, phosphorus, potassium and calcium content of ADT-27 rice (*Oriza sativa* L.). Madras Agric J. 61 (6):135-140.

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.

Thomas, J. (1978). Comparative performance of guinea grass

Tiwari, S.R. (1965). Summary of fodder research work done in Seoni (Madhya Pradesh) from 1954-55 to 1964-65. Farm. J. 8:25.

Tripathi, S.N. and Singh, R.A. (1991). Effect of nitrogen fertilization on forage yield and quality of Deenanath grass (*Pennisetum pedicellatum*) varieties. Indian J. Agron. 36 (4):567-570.

Uexkull, H.R.V. (1976). Response of HYV rice to potassium in the long term fertilizer trials in the Philippines. Bull. Indian Soc. Soil Sci. 10:177-185.

Uexkull, H.R.V (1982). Rice: Timing is crucial in potash application. Span 21 (1):32-34.

* Varchenko, I. I. (1980). Effect of nitrogen on seed production of brome grass. Referativnyi zhurnal 12.55.261.

Venkata Rao, B.A and Badigar (1971). Manuring of groundnut in Mysore - a review of experiment in past 30 yars. Oil Seeds J. 4:234-238.

Walmsley, D., Sargeant, V.A.L. and Dookeran, M. (1978).

Effect of fertilizers on growth and composition of elephant grass (*Pennisetum purpureum*) in Tobago, West-Indies. Tropical Agriculture. 55 (4):P.329.

Wright, C.H. (1939). Soil analysis. A hand book of physical and chemical methods. Themes merby and co., 1 Fleet lane, R.C.4, London.

Yadav, M.S. and Mahendra Singh. (1986). Technology for high seed production of *Cenchrus ciliaris* in the arid regions. Abstract of papers, National seminar on Advances in Forage Agronomy and Future Strategy for increasing biomass production held at Jhansi Oct 6-7, pp 50-51.

* **Originals not seen.**

APPENDICES

Appendix 1 Weather data for the crop period(1993-94)

Standard Week	Period	Maximum Temparature (°C)	Minimum Temparature (°C)	Relative Humidity (percentage)	Rain fall (mm)
29	July 16-22	28.6	23.0	87.43	31.9
30	23-29	28.4	23.1	86.64	21.0
31	30-05 Aug	29.1	23.2	85.36	16.7
32	Aug 06-12	29.4	24.1	84.75	0.00
33	13-19	28.8	23.8	80.70	1.2
34	20-26	30.0	23.6	92.00	5.0
35	27-02 Sep	25.4	23.4	84.20	17.0
36	Sep 03-09	29.8	23.1	82.70	0.00
37	10-16	31.2	24.1	79.30	0.00
38	17-23	30.7	24.0	79.90	34.0
39	24-30	30.3	23.3	83.40	44.8
40	Oct 01-07	29.0	23.2	84.85	118.1
41	08-14	29.5	23.4	84.55	63.0
42	15-21	30.4	23.3	82.85	62.2
43	22-28	30.6	23.1	82.20	54.3
44	29-04 Nov	29.8	23.8	85.75	52.4
45	Nov 05-11	29.5	23.1	91.20	265.2
46	12-18	29.6	22.7	86.55	40.3
47	19-25	30.4	23.5	86.05	42.0
48	26-02 Dec	28.8	23.1	78.50	11.0
49	Dec 03-09	29.6	23.2	85.50	103.0
50	10-16	30.5	23.1	83.70	46.4
51	17-23	29.7	22.8	84.80	24.3
52	24-31	30.3	22.7	82.85	0.00
1	Jan 01-17	31.05	23.0	87.50	0.00
2	08-14	30.9	22.6	82.55	0.00
3	15-21	31.3	23.3	84.70	5.0
4	22-28	31.15	22.0	82.10	0.00

Appendix II SHORT DESCRIPTION OF GAMBA GRASS

Andropogon gayanus kunth, commonly known as Gamba grass or Sadabahar in India, is a large tufted perennial African species of considerable economic importance in West Africa. It has been reported to show promise upon introduction into India. In agronomic trials it has been reported to be easily established, highly productive and palatable to livestock. It is compatible with legumes and very resistant to drought stress, burning and problem soils. The species is adapted to a wide range of soil types from light sands to clay loams. It is grown as a rainfed crop and comes up well in areas having an annual rainfall of 400-1500 mm. It is capable of retaining green foliage well into the dry season and rapid production of high quality forage. The grass is raised for stall feeding or the cut and carry system and not for pastures. So far no reports on antinutritional aspects like nitrate poisoning and oxalate content have been made. The average dry matter yield may go upto 11.6 t/ha and maximum fodder yield is obtained when it is cut three times a year.

Under Kerala conditions, like guinea grass, it can be grown in the open or in coconut gardens as an intercrop. It is well accepted by cattle and is meant for the northern tracts of Kerala, where rainfall is unevenly distributed.

Andropogon gayanus is a short day plant, with a critical daylength for flowering of between 12 and 14 hours. Flowering is optimum at approximately 25^{o}C, but cool night temperatures (15^{o}C) strongly inhibit flowering. Flowering is acropetal and each raceme pair takes about 5 days to complete flowering. Yield of uncleaned seeds range from 20-100 kg/ha/yr and annual seed yields of upto 90 kg/ha/yr is obtained from India. In India, the uncleaned seeds contained only 5-10 % caryopsis and germination of caryopsis varied only slightly from 60-80 %.

Research conducted at Livestock Research station, Thiruvazhumkunnu on gamba grass during 1995 showed that 3 fodder cuts can be taken and application of 40 kg N/ha after each harvest gives better fodder yields. After fodder cut, the crop was left for seed production and approximately 100 kg seeds/ha could be received. After seed collection the residue can be converted into hay.

SEED PRODUCTION OF GAMBA GRASS (*ANDROPOGON GAYANUS* KUNTH) UNDER VARYING LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM

BY

VINEETHA. L. J.

ABSTRACT OF THESIS
Submitted in partial fulfilment of
the requirement for the degree
Master of Science in Agriculture
Faculty of Agriculture
Kerala Agricultural University.

Department of Agronomy
College of Agriculture,
Vellayani, Trivandrum.

1995.

ABSTRACT

An experiment was conducted in the college of Agriculture, Vellayani during the period from July 1993 to January 1994 with the object of finding out the effect of nitrogen, phosphorous and potassium on seed production of gamba grass (*Andropogon gayanus* kunth).

The experiment was laid out in partially confounded factorial design with two replications and three blocks in each replication. The experimental treatments consisted of twenty seven combinations of three levels each of nitrogen (75, 150 and 225 kg/ha) phosphorus (50, 75 and 100 kg/ha) and potassium (50,75 and 100 kg/ha).

Increase in nitrogen levels results in increased plant height, number of tillers, number of leaves, fresh fodder yield and dry fodder yield. Phosphorus and potassium did not have any significant effect on these parameters, except dry fodder yield which was significantly reduced by potassium levels. Nitrogen content in the fodder was not influenced by either nitrogen or phosphorus or potassium. Phosphorus

content in the fodder was increased by phosphorus application and potassium content was increased by potassium application.

Uptake of nitrogen was higher at higher levels of nitrogen while phosphorus and potassium did not have any influence. Uptake of phosphorus was increased by nitrogen and phosphorus while potassium caused a reduction in phosphorus uptake. Potassium uptake was significantly increased due to nitrogen application. Crude fibre content in the fodder was found to decrease with an increase in the levels of NPK nutrients. Nitrogen caused a significant increase in the number of panicles per plant, but reduced the number of seeds per panicle significantly.

Seed viability, seed germination and number of kernals /500 seeds were significantly increased by the levels of phosphorus while nitrogen and potassium showed no significant effect.

Seed purity, seed moisture and 1000 seed weight were not influenced by none of the treatments.

Maximum seed yield was recorded at the highest level of nitrogen, but neither nitrogen, nor phosphorus, nor potassium had any significant effect.

Nitrogen content of the soil was found to increase with nitrogen fertilization and phosphorus content by phosphorus fertilization. Potassium status was increased by nitrogen and potassium.