INTENSIVE FODDER PRODUCTION THROUGH LEGUME INTERCROPPING IN HYBRID NAPIER

By

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DECLARATION

I hereby declare that this thesis entitled "**Intensive fodder production through legume intercropping in hybrid napier**" 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society

Vellayani,
14-11-1997.

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CERTIFICATE

Certified that this thesis entitled "**Intensive fodder production through legume intercropping in hybrid napier**" is a record of research work done independently by Mr. JAYAKUMAR, G (94-11-14) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him

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INTRODUCTION

INTRODUCTION

Agriculture continues to be the back bone of Indian economy with 64 percent of the population depending directly or indirectly on agriculture, animal husbandry and allied activities. Our mythologies, epics and legends are replete with references to cattle signifying its importance. The livestock is of paramount importance in the day today life of the rural poor and it provides a source of livelihood to them. Animals are viewed not only for their importance in providing milk and meat in higher order for nutrition, but also as a source of energy for farm work. The efficiency with which the livestock provide these depends largely on their genetic potential and management.

India, having $1/5^{th}$ of the total world's cattle strength ranks first in population; but the corresponding milk, meat and wool production is one of the world's lowest. On analysing this situation, it can be seen that one of the major reasons for the low productivity of animals is the malnutrition where the availability of quality forages in sufficient quantity as per the demand of various breeds is totally lacking. It is quite unfortunate that cattle in our country do not have adequate nutritious and palatable fodder to eat with the result that they have to remain underfed for major part of the year which in turn adversely affect their efficiency.

In our country, fodder production is not getting due importance in the farming system except in the states of Punjab, Haryana and Gujarat. The demand of green fodder for the country's livestock population (495 million) by 2000 A.D has been estimated to be 1136 million tonnes (LPAC, 1990)

However, the corresponding deficit is estimated to be 65 percent. With the present feed and fodder resources in the country, it will be able to meet only 46.6 percent of the requirement. About 6.9 m ha or only 4.4 percent of the country's cropped area is under fodder crops and as such there is little scope for expansion because of the pressure on agricultural land for food and or cash crops. It is impossible to think of improving agriculture with out having good cattle. It is therefore necessary that a balanced agricultural policy should be evolved in which the cultivation of fodder crops finds an appropriate position in the existing farming systems.

In Kerala there are about 3.5 million adult cattle which require about 53 lakh tonnes of drymatter annually through roughages (Farm guide. 1997). The present production of roughages through various sources is only 30 lakh tonnes and the deficit accounts for about 23 lakh tonnes (44 percent of the requirement). The main constraint in ensuring adequate supply of green forages through out the year in the state is the limited land space available for fodder cropping. To overcome this, the available land area is to be effectively utilised by intensification of fodder production by the cultivation of high yielding fodder crops. The peculiar agro-climatic conditions and the unique cropping pattern of Kerala necessitates the cultivation of fodder crops as one of the components of the existing cropping pattern. Fodder crops are not raised as sole crop, but usually being raised as intercrops in coconut garden. In order to get high tonnage and quality fodder, nothing is better than mixed cropping of protein rich leguminous fodder crops with grasses of wider adaptability.

Adoption of suitable agronomic practices in gardenland areas for grassland farming and introduction of nutritious annual herbage species are found helpful in mitigating the crisis of fodder scarcity. The fodder production utility of bajra- napier hybrid is well understood. It is one of the most popular high yielding, nutritious and perennial grass being recommended in Kerala. It is vigorously growing and is capable of providing high yield of less fibrous and more palatable green forage. It has outyielded many grass species (Pathirana and Sirivardene, 1973). Cowpea (*Vigna unguiculata*(L.) Walp) is an excellent leguminous crop of short duration, quick growth high palatability and high protein content. Most of the varieties are shade tolerant and yield reasonably under rainfed condition. Lablab bean (*Lablab purpureus* (L.) Sweet) is another vigorously growing leguminous crop which can grow in poor soils where most of the other legumes fail. It is highly nutritious and can be used as an ideal fodder. The yield and palatability of hybrid napier has been found to increase by intercropping of annuals like cowpea, Chinese cabbage (Mahander Singh *et al*, 1984) and berseem (Virendra Singh, 1987). New varieties of hybrid napier (CO-2), cowpea (CO-5) and lablab bean (Highworth) are very high yielding and such varieties need testing since the old varieties are not found promising.

The beneficial effect of legume is well recognised. Fixation of atmospheric nitrogen by legume serves to be a viable source of biological nitrogen for crop production. Cultivated fodder grasses produce green fodder with low protein content while leguminous fodder crops, though rich in protein content have low forage potential. Advantages of both quantity and quality could be availed of by growing them together.

The success of any intercropping system depends greatly on the selection of appropriate planting geometry. The space required for the grass so as to accommodate legume in the inter row space for maximum production of good quality fodder has to be worked out.

The sole crop of all these crops was found to be growing successfully under Kerala condition. But their fodder production potential as mixtures have not yet been investigated. Hybrid napier being a high tonnage crop, legume intercropping alone can not meet the N requirement of the grass. This has to be supplemented with artificial nitrogen. Trials conducted so far indicated that supplementary nitrogen in addition to legume intercropping benefited forage production. However, no such trial was taken up under Kerala condition and hence the experiment was proposed with the following objectives :-

1. To compare the performance of fodder crops under normal and paired row planting methods.
2. To assess the yield and quality of fodder crops in an intercropping system.
3. To assess the effect of nitrogen levels in quantitative and qualitative improvement of fodder crops.
4. To investigate the effect of grass-legume mixture on the physico-chemical properties of the soil.
5. To study the economics of growing legume in association with hybrid napier.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Intercropping fodder grasses with legumes is generally found to increase the yield from the total system, by providing better returns to the farmer and producing better quality fodder for the cattle than the practice of sole cropping of grass. The legumes capable of utilizing atmospheric nitrogen play a supplementary role when intercropped with grasses in meeting the nitrogen requirement of the crop. The major research work conducted so far in India and abroad on hybrid napier - legume intercropping with the objective of intensive fodder production are reviewed hereunder. Wherever the literature is scanty, works on related crops are also reviewed.

2.1 Effect of planting geometries on growth, yield and quality of fodder crops

Successful and profitable cultivation of fodder crops depend greatly on selection of appropriate planting geometry and maintenance of optimum plant density.

2.1.1 Growth

Studies conducted on the influence of planting geometries on the growth of hybrid napier grass by Shukla *et al.* (1970) revealed that normal row planting with a spacing of 0.6 x 0.6 m resulted in maximum growth of the plant. Tomer and Chiller (1970) observed that normal row planting with a spacing of 60 x 30 cm and combined application of 120 kg N and 60 kg P ha^{-1} recorded the maximum growth. Daulay *et al.* (1972) reported that paired row planting of bunch grass provided sufficient space for growth of greengram in between the interspaces and resulted in increased height and number of branches of greengram. Tiwana *et al.* (1975) pointed out that napier bajra hybrid recorded maximum growth and yield under normal row planting with a spacing of 60 x 30 cm than with 90 x 40 cm and 60 x 60 cm spacings while *Pennisetum purpureum* recorded maximum growth and yield under normal row planting with a spacing of 50 x 50 cm compared to 60 x 60 cm or 70 x 70 cm spacings. Bhadoria and Chauhan (1994) opined that normal row planting with a spacing of 45 x 45 cm resulted in increased growth and yield of cluster bean. Khanna *et al.* (1996) reported that a planting geometry involving fodder sorghum and fodder cowpea in 2:2 ratio resulted in maximum growth of crops than pure cropping of the same.

2.1.2 **Yield**

In the case of sorghum, several experiments conducted all over India clearly showed that paired row planting gave comparable yield with normal row planting (Palaniappan *et al.*, 1975; Ravichandran, 1976; Singh, 1981; Tarhalkar and Rao, 1981). Balbatti (1980) reported from Vellayani that the growth attributes like plant height and tiller production were maximum under paired row planting of hybrid napier and resulted in increased green and dry fodder yields. Mahander Singh (1986) concluded that maximum green forage and dry matter yields were produced when *Cenchrus ciliaris* was grown under normal row system of planting with a spacing of 60 x 60 cm. Among the mixed crop treatments, forage yields of *Pennisetum pedicellatum* + cowpea in alternate paired rows were comparable with the green fodder yield of pure crop. Paneerselvam (1986) reported that the sorghum fodder yield in reduced row strips at 3:1 and 4:1 ratio with soyabean and lablab bean was lower than paired row planting and pure stand of sorghum. Jayakumar (1988) found that change in planting geometry of guinea grass from normal to paired row did not make any changes in fodder yield and quality. Sasireka (1992) reported that maximum green and dry fodder yields were obtained under paired row planting of hybrid napier when compared to three and four row strip planting methods. Sunitha and Sreekandan (1992) stated that paired row planting of cowpea at 45 / 15 x 15 cm spacing with one row of maize in between resulted in comparatively higher dry matter production of 4.08 t ha^{-1}.

2.1.3 **Quality**

Sasireka (1992) reported that the crude protein content of hybrid napier was maximum when raised under paired row system of planting. Singh and Patel (1984) revealed that the content and uptake of phosphorus was higher in buffel and *Stylosanthes hamata* cv. *verano* association with alternate single row planting, but paired row planting reduced the degree of competition and resulted in a comparable value as that of alternate single row planting.

2.2. Effect of legume intercropping on quantitative and qualitative improvement of fodder crops

Intercropping / mixed cropping system of forge production comprising grass / cereal and legume components increases the biomass production and improves the herbage quality. Hybrid napier grass is generally grown with wider spacing and in order to utilize the inter row space, many research workers have reported ample scope for growing intercrop of legumes.

2.2.1 **Yield**

Agboola and Fayemi (1972) observed a slight competition between maize and legumes in an intercropping system, but the yield of maize was not affected. Harkishan Singh (1975) reported that hybrid napier intercropped with pea gave significantly higher yields than when grown with berseem. At Dharwar, Gowda and Patel (1976) used a mixture of hybrid napier, *Calapagonium muconoides, Centrosema pubescens* and *Glycine jawanica* and found that the mixture outyielded pure stands. At Vellayani, Krishnaraj (1976) reported that intercropping caused significant increase in total green fodder over no intercrop and was maximum (62.826 t ha^{-1}) when cowpea was intercropped with guinea grass under 60 x 20 cm spacing. Experiment at College of Agriculture, Vellayani under coconut garden conditions revealed that guinea grass when grown mixed with cowpea and horsegram gave more total fodder yield than when the grass was grown alone (AICRPF. 1978). The superiority of grass-legume mixtures in terms of increased fodder yield consisting of stylosanthes and guinea or congosignal grass has been reported by Chandini and Pillai (1983). Tripathi *et al.* (1985) revealed that pearlmillet and maize recorded significantly higher green forage yield in mixed stand as compared to sole crop when legume was used as the intercrop. Panjab Singh (1986) reported that hybrid napier + cowpea (1^{st} crop), hybrid napier + cowpea (2^{nd} crop) and hybrid napier + berseem (3^{rd} crop) yielded green fodder of 210 t ha^{-1} $year^{-1}$ in eastern regions while the same crop rotation yielded 133.4 t ha^{-1}

year^{-1} in western regions of Bundelkhand. Rai (1986) found that when hybrid napier / guinea grass + siratro / velvet bean / hedge lucerne were used in a year round rotation, it yielded upto 2500 kg ha^{-1}. Agarwal *et al* (1993) reported that berseem intercropped with oats sown in rows produced the highest tonnage of green forage (769.7 q ha^{-1}) and 121.77 q ha^{-1} of dry matter yields. Pisal *et al.* (1993) noticed that planting of bajra (*Pennisetum typhoides*) in skip rows + one row of cowpea for green forage and application of 75 per cent NPK to intercrop was beneficial under rainfed situation producing 62.3 q ha^{-1} stover from pearl millet and 97.2 q ha^{-1} green forage of cowpea. Gangwar and Niranjan (1994) reported that maximum green fodder (140 q ha^{-1}) and dry matter (29.9 q ha^{-1}) yields were obtained when fodder maize was intercropped with prickly sesban (*Sesbania aculeata* Pers.)

2.2.2. **Quality**

Crops grown in association are found to influence some of the quality of the base crop such as crude protein, crude fibre etc.

2.2.2.1. **Crude protein**

Patel *et al.* (1968) reported that the crude protein content of guinea grass grown mixed with lucerne was significantly higher than that of guinea grass grown alone. Total yield of protein in a period of 2 years from the plot of guinea grass-lucerne mixture was higher by 50 per cent than that obtained from plots in which sole cropping of guinea grass was practiced. Mixed cropping of sorghum variety MP-Chari and cowpea not only increased the green fodder yield, but also increased the crude protein content of the forage from 4.9 per cent for sorghum alone to 7.5 per cent for the mixture (Anon,

1972) Russell (1973) pointed out that legume can transfer nitrogen to the associated non-legume crops by various ways and help to increase the nitrogen and protein contents of the associated non- legume crops. Higher crude protein content in timothy grass was reported by Lehman *et al.* (1967) when the grass was grown mixed with white clover bean. Mannikar and Shukla (1974) opined that there was an increase in crude protein content of the mixture (7.5 per cent in a mixture of sorghum variety MP-Chari and berseem) as compared to 4.5 per cent in pure stands of MP-Chari. Balbatti (1980) concluded that the crude protein content of hybrid napier was increased when grown mixed with rice bean. Mahander Singh (1984) reported that the crude protein content of hybrid napier was increased significantly when legume was included in the cropping system. Tripati *et al.* (1997) obatined higher content of crude protein when maize was intercropped with cowpea.

2.2.2.2. **Crude fibre**

Higher content of crude fibre was reported in guinea grass when grown alone as compared to the mixed crop of guinea and lucerne (Patel *et al.*, 1968). Singh and Sogani (1968) reported that growing of jowar alone had the least crude protein and more crude fibre contents while fodder from a mixture of jowar and cowpea in the ratio 3 : 1 had a high crude protein and moderate content of crude fibre. Increasing the proportion of legume in the fodder helped to increase the crude protein, but reduced the crude fibre content. Mercy George (1981) reported that the content of crude fibre in guinea grass was less when legumes were raised as intercrops.

2.3. Effect of legume intercropping on Land Equivalent Ratio (LER)

Chandrasekhar (1981) obtained greater LER values in sorghum + pigeonpea intercropping than other rotations. Faris *et al.* (1983) observed that in general, intercropping systems produced higher LER (1.32) than sole cropping. Mahander Singh (1984) recorded a maximum LER value of 1.51 in hybrid napier + cowpea + chinese cabbage system than other cropping systems. Pal and Malik (1984) concluded that double rows of pigeonpea grown with paired rows of sorghum gave the highest LER of 1.79. Singh and Jain (1984) stated that sorghum + cowpea and sorghum + greengram intercropping systems recorded LER values of 1.63 and 1.58 respectively.

2.4. Effect of legume intercropping on the content and uptake of nutrients

Shukla *et al.* (1970) observed that maximum nutrients were removed when hybrid napier was grown under 1.2 x 1.2 m. spacing with intercrops of guar and lucerne during winter. Ravichandran (1976) reported that cowpea favourably influenced the content and uptake of nitrogen in sorghum. Improvement in calcium content and uptake was observed by Tuley (1968) and reported 25 per cent increase in calcium content of guinea grass by legume intercropping. Selvaraj (1978) reported that intercrops *viz*., greengram, soyabean and sunflower when raised in paired row system with sorghum recorded higher nitrogen uptake than those in uniform row system. There was a definite improvement in calcium content in 1 : 1 and 2 : 1 mixtures of NB- 21 and lucerne than pure stand of the grass (NB - 21) alone (Shanmughasundaram, 1980). Elmore (1982) reported that sorghum raised under wider row spacing with soyabean increased the nitrogen uptake by sorghum. Singh and Patel (1984) concluded that in buffel grass and *Stylosanthes hamata* cv. *verano* association, the uptake of nitrogen and phosphorus in both years and potassium in the first year were maximum, specifically due to the inclusion of legume. Mixtures of *Cenchrus ciliaris*, annual fodder and grain legumes exhibited higher nutrient content and uptake (nitrogen, phosphorus, potassium, calcium and magnesium) than pure sward (Mahander Singh and Singh., 1986; Rai, 1986). The role of legume crops in the enhanced content and uptake of nitrogen in maize has been reported by Ghosh and Singh (1996).

2.5. Effect of legume intercropping on soil fertility improvement

It is important to study the transfer of fixed nitrogen from leguminous plants to non-legumes growing in association with them in grass-legume mixtures, intercropping and other similar situations.

Subba Rao (1974) found that by growing legumes, the nitrogen status of the soil was increased. Krishnaraj (1976) reported an increase in the N content of the soil due to intercropping guinea grass with legumes. Morachan *et al.* (1977) identified that growing cowpea in association with fodder sorghum added 30 kg N ha^{-1} in the soil. Fixation of nitrogen in soil by legumes as sole crop or as intercrop has been well documented by voluminous research (Dusad and Morey, 1979; Taylar, 1980.) Nair *et al.* (1979) concluded that legume when included in the cropping system increased the nitrogen content of soil. Shanmughasundaram (1980) reported that NB -21 hybrid napier grass + lucerne mixture in 1 : 1 and 2 : 1 ratio improved the soil fertility in terms of increased N, P and K status of the soil. The soil nitrogen and phosphorus balance was positive after pea and negative after maize in pea - maize crop sequence (Rai and Singh, 1986) and in legume - cereal rotation (Subedar Singh and Singh, 1986).

2.6 Effect of grass cropping on the physico-chemical properties of soil

2.6.1 Physical properties

2.6.1.1 Bulk density

Page and Willard (1946) found that cultivation of grasses decreased the pore space and correspondingly increased the soil bulk density. Pasture cultivation for eight years continuously changed the bulk density of cultivated soil (White *et al.*, 1976). Anderson and Gantzer (1989) noticed the soil physical properties after 100 years of continuous cultivation of pasture crops and reported that annual addition of organic matter by way of decomposition of plant parts decreased the bulk density by an average of 0.12 g cm^{-3}. Asok (1993) reported that the bulk density of soil was reduced by growing fodder crops.

2.6.1.2 Porosity

Page and Willard (1946) found that root penetration of grasses brings out cleavages in soil and porosity is produced. The porosity resulted from old root channel was as high as in certain crops like sweet clover and alfalfa.

Skidmore *et al.* (1975) reported that a cropping system involving grass can alter the soil porosity.

2.6.1.3 **Water holding capacity**

Sahasranaman *et al.* (1976) suggested that by intercropping fodder grass in coconut garden, there had been little effect on the size of soil aggregation when observed after a period of five years, but the water holding capacity of the soil was increased.

2.6.2 **Chemical properties**

2.6.2.1 **Nitrogen content**

Sahasranaman *et al.* (1976) reported that there was no significant change in the available nitrogen content when fodder grasses were grown in coconut stand for a period of five years. According to White *et al.* (1976) the pasture cultivation for eight years continuously changed the total nitrogen content of the soil.

2.6.2.2 **Phosphorus content**

Sahasranaman *et al.* (1976) found that available phosphorus increased in soil at depths 0 to 50 cm and 50 to 100 cm due to continuous cultivation of fodder grass in coconut garden.

2.6.2.3 **Potassium content**

Sahasranaman *et al.* (1976) found an increase in the available potassium content at 50 cm and 100 cm depths of soil where fodder grasses were grown in coconut garden.

2.6.2.4 **Soil reaction**

Sahasranaman *et al.* (1976) observed no change in soil reaction after five years of intercropping in coconut garden. Similar results were also reported by Asok (1993).

2.7 Influence of nitrogen on growth, yield and quality of fodder crops

2.7.1. Growth

2.7.1.1. Plant height

Height of plants is one of the deciding factors contributing to increased crop yields especially in the case of fodder crops where vegetative growth is more important. Singh *et al.* (1973) reported that there was considerable increase in plant height with the application of N to oats. Shanjeevirayar (1978) observed a linear increment in height of sorghum with higher levels of N at 30^{th} and 60^{th} days after sowing. Thomas (1978) observed a significant increase in height and tiller number with N doses upto 250 kg ha^{-1} in hybrid napier. Balbatti (1980) reported that growing hybrid napier under wider row spacing with legume intercropping as well as supplementing with N favoured better development of plants in terms of height and tiller number. Taller plants were recorded by Singh and Singh (1983) in sorghum applied with 120 kg N ha^{-1}. Balyan and Singh (1985) reported that there was a marked increase in the height of sorghum with 40 kg N ha^{-1} over no N and the response was not significant beyond 40 kg N ha^{-1}. Devasenapathy and Subbarayulu (1985) reported significant increase in plant height of grain sorghum fertilized upto 90 kg N ha^{-1}. Shanmughasundaram (1980) reported that N had less influence on growth parameters as pure and in the mixture (grass + legume). Increase in plant height of sorghum due to application of organic and inorganic sources of nitrogen was reported by Gangwar and Niranjan (1991). Sasireka (1992) concluded that application of 75 kg N ha^{-1} as urea along with FYM at 2.5 t ha^{-1} recorded taller plants with more tiller production and leaf number per clump in hybrid napier. Dubey *et al* (1995) observed that the plant height of sorghum was higher when intercropped with pigeon pea and supplemented with 60 kg N ha^{-1}.

2.7.1.2. **Tiller count**

Number of tillers was found to be influenced by N application.

Rathore and Vijayakumar (1977) got increased number of tillers with increase in N fertilization in *dinanath* grass and fodder sorghum. Balbatti (1980) reported that increment in N level increased tiller production and maximum tiller count was recorded when 120 kg N ha^{-1} was applied. Yadav and Sharma (1989) reported that increasing levels of N upto 120 kg ha^{-1} significantly increased the number of tillers in *dinanath* grass. Singh *et al* (1989) recorded increased number of tillers in pearl millet + cluster bean mixture for higher N doses.

2.7.1.3 **Leaf Area Index**

Leaf area may have direct influence on photosynthetic efficiency of crop plants in addition to increase in biomass of forage crops.

Dhanram *et al.* (1971) reported that application of N was ineffective in increasing the leaf number, growth and leaf area index of cowpea. Nitrogen application increased the number of leaves per plant and leaf area index at 30th and 60th days (Shanjeevirayar, 1978). Ofroi and Stern (1987) concluded that leaf area index increased with increase in the level of nitrogen. LAI was less in the intercrop than in sole crop. Jena *et al* (1995) found that the leaf area index of fodder cowpea was maximum when 40 kg N ha^{-1} was applied.

2.7.1.4. **Root growth**

Warsi *et al* (1973) reported that N fertilization had significant effect on root growth which increased with fertility of the soil. Asis *et al* (1976) obtained increased spread and weight of roots with wider spacings and nitrogen levels in elephant grass. Lorenz (1978) observed an increased root development with increased N rate in wheat grass. Too high a concentration of N in the soil can restrict root growth (Hurd and Spartt, 1979). Balbatti (1980) reported that intercropping along with application of 60 kg N ha^{-1} recorded the maximum growth and weight of roots in hybrid napier.

2.7.2. **Yield**

2.7.2.1. **Green fodder yield**

Quality green fodder is the outcome of any forage production programme which is the contribution by several factors in general and the nutrient management in particular.

Harish Kumar and Rai (1976) reported higher green fodder yield in oats with increased levels of N and the increase was in the order of 59.9 to 100.2 per cent with 80 to 100 kg N ha^{-1}. Tripathi *et al* (1979) studied the effect of various levels of N on the yield of oats and concluded that application of N upto 120 kg N ha^{-1} increased the forage yield. Veeraghaviah *et al.* (1979)

obtained higher green forage yield of oats with 80 kg N ha^{-1}. Balbatti (1980) reported that the total green matter production of hybrid napier and rice bean was maximum at 60 kg N ha^{-1}. Application of 100 kg N ha^{-1} recorded higher green fodder yield over 50 and 0 kg N ha^{-1} (Mani and Kothandaraman, 1983). Green fodder yield response to N application was reported in pearl millet by Katoria *et al.* (1981) and in sorghum by Singh and Singh (1983). Rathi and Vaishya (1983) reported that application of 90 kg N ha^{-1} in three splits resulted in the highest green fodder yield of oats. Sharma and Prem Singh (1984) reported significant increase in green fodder yield with the application of 120 kg N ha^{-1} over 40 and 80 kg N ha $^{-1}$. Sawant and Khanvilkar (1987) reported that N had significant effect on the green fodder yield of maize and N at 120 kg ha^{-1} proved significantly superior to 40 and 0 kg N ha^{-1}, but had hardly any difference between 120 and 80 kg as well as 40 and 80 kg N ha^{-1}. Deshmukh *et al.* (1989) stated that the application of 180 kg N ha^{-1} proved superior to the levels tried below, whereas N application at 60 kg ha^{-1} was found on par with 120 kg and control, but 120 kg N ha^{-1} was found significantly superior in terms of green matter production in maize. Hunshal *et al.* (1989) observed that 200 kg N ha^{-1} increased the green fodder yield of South American maize significantly (60.44 t ha $^{-1}$) over 50 kg N ha $^{-1}$ (53.14 t ha^{-1}). Shukla and Menhilal (1990) got increased green fodder yield of pearl millet with 90 kg N ha $^{-1}$. Thaware *et al* (1991) noticed that application of 200 kg N ha^{-1} produced significantly higher yield over 100 kg N ha^{-1}. Palanivel *et al.* (1992) reported that application of N at 100 kg ha^{-1} after each cutting exercised a highly significant influence and resulted in maximum green fodder yield in B N - 2 grass. Sasireka (1992) obtained maximum green fodder yield with the application of 75 kg N ha^{-1} as urea along with 2.5 t ha^{-1} of FYM. Shukla and Sharma (1994) reported that every higher dose of N from 30 to 120 kg N ha^{-1} greatly increased the green fodder yield and was maximum for 120 kg N ha^{-1} in fodder sorghum. Prasad and Kumar (1995) obtained the maximum green fodder yield of 81.1 t ha^{-1} when hybrid napier was supplemented with 60 kg N ha^{-1}. Ghosh and Singh (1996) recorded maximum green fodder yield for fodder maize when supplemented with 90 kg N ha^{-1}. Vashishatha and Dwivedi (1997) got maximum green and drymatter yields when fodder sorghum was supplemented with 150 kg N ha^{-1}.

2.7.2.2. **Dry fodder yield**

Singh *et al.* (1973) recorded a maximum dry matter yield of 110.3 q ha^{-1} in oats supplemented with 120 kg N ha^{-1}. Harish Kumar and Rai (1976) concluded that application of N from 80 to 160 kg ha^{-1} increased the yield from 54.2 to 95.6 per cent and accumulation of drymatter per unit area in forage oats. Joshi and Rajendra Prasad (1979) observed linear response on the drymatter yield of oats up to 200 kg N ha^{-1}. Narwal *et al.* (1977) reported that increasing level of N increased the dry matter yield of *dinanath* grass. Ravi Kumar *et al* (1980) reported that application of 90 kg N ha^{-1} to *Cenchrus setigerus* resulted in 135 per cent increase in dry matter yield over no N. Munkund Singh *et al.* (1981) concluded that significant increase in dry matter yield could be obtained in maize with the application of 120 kg N ha^{-1}. Nehra *et al* (1981) reported a positive response on the dry matter yield of maize with application of 90 kg N ha^{-1}. Virendra Singh *et al.* (1984) recorded a significant increase in the dry matter yield of Napier - Bajra hybrids with the application of 100 kg N ha^{-1}. Gill *et al.* (1988) studied the effect of N fertilization on the fodder production of oats and concluded that application of N increased the dry matter yield significantly. Patel and Raj (1988) reported significant increase in the dry matter production in sorghum with increasing N levels and was the highest at 120 kg N ha^{-1}. Studies of Hunshal *et al.* (1989) envisaged that increase in the dry matter production of maize with the application of 50, 100, 200 kg N ha^{-1} was in the order of 32 to 49 per cent over no N application. Jena *et al.* (1995) reported that the dry matter yield of fodder cowpea was maximum when 20 kg N ha^{-1} was applied. Prasad and Kumar (1995) got the maximum dry matter yield when 60 kg N ha^{-1} was applied to hybrid napier.

2.7.3. Quality

2.7.3.1. Crude protein

Nitrogen forms the basis for crude protein content in crop plants.

Hegde and Relwani (1974) indicated that increasing levels of N increased the crude protein content and yield of fodder sorghum. Similar increase in crude protein content and yield was observed by Harish Kumar and Rai (1976) and Narwal *et al.* (1977). In pearl millet, Tripathi *et al* (1979) recorded higher crude protein content and yield with higher levels of N from 20 to 60 kg N ha^{-1}. Crude protein content was increased to 6.09, 6.86 and 8.13 per cent respectively with the application of 20, 40 and 60 kg N ha^{-1} from only 4.96 per cent with no application. Dwivedi *et al.* (1980) recorded the highest crude protein content (5.98 per cent) with 90 kg N ha^{-1} in

Chrysopogon fulvus. Ravikumar *et al.* (1980) also reported increased crude protein content by 153 per cent over control when 90 kg N ha^{-1} was applied to *Cenchrus setigerus.* No significant increase in crude protein content of fodder maize hay was recorded when 120 kg N ha^{-1} was applied (Thind and Sandhu, 1980). Shanmughasundaram and Govindasamy (1984) reported that the mean crude protein content of fodder maize was significantly increased from 7.95 to 9.18 per cent with the application of 60 to 90 kg N ha^{-1}. Crude protein content was increased from 8.41 to 9.90 per cent in Bajra Napier -2 grass with the application of 150 kg N ha^{-1}(Govindasamy and Manickam, 1988). Patel and Raj (1988) reported that the crude protein yield of sorghum was enhanced significantly with the supplementation of N. The per centage increase in crude protein yield was 61.5 at 120 kg N ha^{-1} as compared to 40 kg N ha^{-1}. The total crude protein yield was maximum (9.12 q ha^{-1}) in a fodder production system involving fodder sorghum and cowpea when 200 kg N ha^{-1} was applied (Khanna *et al*, 1996).

2..7.3.2. **Crude fibre**

Crude fibre is also an important quality character of fodder crops which contributes mainly to the palatability.

Studies conducted by Johnson *et al.* (1967) in guinea grass and Demarquilly (1970) in perennial rye grass revealed that the crude fibre content of forage was reduced by nitrogen application. Tiwana *et al.* (1975) reported a reduction in crude fibre content in hybrid napier with N application. Reduction in crude fibre content with enhanced N application was reported by Abraham (1978). Thomas (1978) from Vellayani found that the crude fibre content in hybrid napier was significantly reduced with increased N application up to 250 kg N ha^{-1}.

But Koter (1974) failed to get any decrease in the crude fibre content on account of N fertilization in cock's foot and timothy grasses.

Mercy George (1981) from Vellayani reported that the crude fibre content of guinea grass reduced significantly with the inclusion of legume and increased level of N application.

2.7.3.3. **Leaf : stem ratio**

Leaf : stem ratio is an important parameter in fodder quality which in turn has a direct influence on palatability of fodder. The more the leafy portion, the more will be the acceptability by cattle. Eventhough basically it is a genetic factor, it can be effectively managed by agronomic practices.

Singh *et al.* (1973) recorded a gradual decrease in leaf : stem ratio with increase in the N level. The results indicated that at 120 kg N ha^{-1} , the leaf : stem ratio decreased significantly to 1.70 from 2.00 in forage oats. Similarly Rathore and Vijayakumar (1977) got a significant decrease in leaf : stem ratio due to nitrogen application in fodder sorghum and *dinanath* grass. The leaf : stem ratio of *dinanath* grass was not significantly affected by N fertilization eventhough a decreasing trend was noticed (Abraham. 1978). Thomas (1978) got significant reduction in leaf : stem ratio with 200 and 250 kg N ha^{-1} as compared to the lower level of 150 kg in hybrid napier. Yadav and Sharma (1989) concluded that varying N levels did not influence the leaf : stem ratio of *dinanath* grass.

2.7.4 Influence of nitrogen on nutrient contents of fodder crops

2.7.4.1 Influence of nitrogen on phosphorus content of fodder crops

Bahl *et al.* (1970) reported appreciable increase in phosphorus content of hay with increase in levels of nitrogen. But Acharya (1973) noticed that phosphorus content of *dinanath* grass remained unchanged with nitrogen application, although the yield increased significantly. Rai *et al.* (1979) also reported that phosphorus content of herbage under various levels of nitrogen remained unchanged in the case of *Sehima-Heteropogan* grass species at IGFRI, Jhansi. Mc Lean (1957) observed that the percentage of phosphorus was generally depressed in many fodder grasses with increased levels of nitrogen. Monterio and Werner (1977) studied the effect of nitrogen fertilization of guinea grass in Brazil and found that phosphorus content of fodder was reduced by nitrogen application. Rathore and Vijayakumar (1977) observed a decreasing trend in the phosphorus content of grass due to nitrogen fertilization. A similar decrease in phosphorus content of *dinanath* grass was reported by Abraham *et al.* (1980) at Vellayani.

2.7.4.2 Influence of nitrogen on potassium content of fodder crops

Lorsen (1966) reported that potassium content of cock's foot-timothy grasses increased with increasing levels of nitrogen application. Reid *et al.* (1967) observed that nitrogen treated herbage at any stage of maturity generally contained higher level of potassium than grasses without nitrogen. An increased potassium uptake by increased nitrogen application was reported by Miranova (1971), Fillipek *et al.* (1975), Balsako (1977) and Hojjati *et al.*

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

2.7.4.2 **Influence of nitrogen on calcium and magnesium contents of fodder crops**

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

2.8. **Economics of intercropping.**

Besides quantitative and qualitative improvement, intercropping with legumes provides better returns from unit area.

Chatterjee *et al.* (1978) reported that the maize + cowpea + *dinanath grass* + oats sequence gave a net profit of Rs. 4000 ha^{-1} $year^{-1}$. Shanmughasundaram (1980) reported that in hybrid napier + lucerne mixture, highest net returns per day was Rs. 3.31 and Rs. 3.42 in the ratio 1 : 2 and 2 : 1 respectively when compared to Rs. 2.15 in pure stand of grass for every rupee investment. Maximum returns per rupee invested (Rs. 2.66) on production was obtained with berseem - hybrid napier - cowpea rotation while minimum (Rs. 1.49) was obtained with oat - bajra + cowpea - maize + cowpea (Tripathi *et al.* 1981). Chandini and Pillai (1983) from Vellayani reported that maximum net profit of Rs. 4477.50 was obtained when guinea grass was intercropped with stylosanthes. Yadav (1985) reported that soyabean mixed with sorghum (1: 2) gave the highest net returns of Rs. 1998 ha^{-1} than growing pure crop of sorghum. Mahander Singh and Singh (1986) reported that maximum gross returns (Rs. 30000 ha^{-1}), net returns (Rs. 2447 ha^{-1}) and net returns per rupee of variable cost (Rs. 4.43) were obtained with *Cenchrus ciliaris* grass + moth bean. In another intercropping study, Gangwar and Sharma (1994) got the highest net returns of Rs. 3021, when maize was intercropped with blackgram. Jayanthy *et al.* (1994) reported that maximum returns (Rs. 4125 ha^{-1}) were obtained when maize was intercropped with cowpea in the ratio 2 : 1.

MATERIALS AND METHODS

MATERIALS AND METHODS

A field investigation was carried out during 1995-1996 to find out the fodder production efficiency of two high yielding legume intercrops for hybrid napier under two planting geometries (normal row planting and paired row planting) , to work out the quantity of nitrogen required for hybrid napier-legume combination, to study the physico-chemical changes in the soil and also to evaluate the economics of fodder production in a grass-legume intercropping system. The experiment was carried out for a continuous period of ten months. The materials used and methods adopted are detailed below.

3.1 **Experimental site and location**

The experiment was conducted at the Instructional farm attached to the College of Agriculture, Vellayani, Thiruvananthapuram.

Vellayani is located 8^0 N latitude and 29 m above the mean sea level. The centre enjoys a warm humid tropical climate. The average annual rainfall received was 2013 mm distributed over a period of 92 days. The maximum temperature ranged between 30-35^{0}C and minimum temperature ranged between 21-24 ^{0}C. The average humidity was between 80-85 percent. The experimental area received abundant solar energy throughout the year.

3.1.1 **Soil**

Soil of the experiment site was red loam coming under the order Alfisol. Data on chemical properties and mechanical composition of the soil are given in Table 1.1 and 1.2 respectively.

3.1.2 **Season and climate**

The experiment was started in the month of July 1995 and continued upto May 1996. The meteorological data for the above period are presented in Table. 1.

Tab. 1 **Mean values of the weather parameters during the cropping period.**

Sl.No	Parameter	Average values (From July 1995 to May 1996)
1.	Mean maximum temperature (^{0}C)	30.41
2.	Mean minimum temperature (^{0}C)	23.55
3.	Mean relative humidity (%)	83.15
4.	Mean daily evaporation (mm)	3.20
5.	Mean monthly rainfall (mm)	179.75
6.	Total rainfall (mm)	2013.70

3.1.3 **Cropping history of the field**

In the previous year, the experimental site was under bulk crop of fodder sorghum during Kharif and fallow during Rabi and Summer seasons.

Table 1.1 **Chemical properties of soil before the experiment**

Chemical composition of soil

Sl. No	Parameter	Content	Method
1	Available N	198.00 kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija, 1956).
2	Available P	23.10 kg ha^{-1}	Bray extraction and Klett Summerson photoelectric colourimetry making use of chlorostannous reduced molybdo phosphate blue colour in Hcl system (Jackson, 1973)
3	Exchangeable K	104.14 kg ha^{-1}	Neutral Normal Ammonium acetate extraction and flame photometry (Stanford and English. 1949)
4	pH	5.1	Direct reading using pH meter (Elico-model L1.120) in 1 : 2.5 soil-water suspension (Jackson, 1973)

Table 1.2 **Physical properties of the soil before and after the experiment**

Sl. No	Parameter	Mean values		Method
		Before the expt.	After the expt.	
1	Mechanical composition Constituents Coarse sand	16.70	-	Bouyoucos Hydrometer method (Bouyoucos, 1962)
	Fine sand	31.30	-	”
	Silt	25.40	-	”
	Clay	26.60	-	”
2	Bulk density (g cc^{-1})	1.38	1.342	International pipette method (Gupta and Dakshinamoorthi, 1980)
3	Water holding capacity (%)	20.03	24.610	”
4	Porosity (%)	30.65	35.130	”

Textural class-Sandy clay loam

3.2 Experimental procedure

3.2.1 Treatment schedule

The treatment included two planting geometries - P_1 and P_2 (normal row planting - 60 x 30 cm and paired row planting - 40 / 80 x 30 cm), two intercrops - I_1 and I_2 (cowpea variety CO-5 and lablab bean variety Highworth) and three N levels - N_1, N_2 and N_3 (50, 75 and 100 % recommendations of both crops).

Note : Recommended dose for hybrid napier is 200 : 50 : 50 and for fodder cowpea and lablab bean is 25 : 60 : 30 kg NPK ha^{-1}.

Treatment combinations

T_1 ($P_1I_1N_1$) - Normal row planting x cowpea x 50 % N

T_2 ($P_1I_1N_2$) - Normal row planting x cowpea x 75 % N

T_3 ($P_1I_1N_3$) - Normal row planting x cowpea x 100 % N

T_4 ($P_1I_2N_1$) - Normal row planting x lablab bean x 50 % N

T_5 ($P_1I_2N_2$) - Normal row planting x lablab bean x 75 % N

T_6 ($P_1I_2N_3$) - Normal row planting x lablab bean x 100 % N

T_7 ($P_2I_1N_1$) - Paired row planting x cowpea x 50 % N

T_8 ($P_2I_1N_2$) - Paired row planting x cowpea x 75 % N

T_9 ($P_2I_1N_3$) - Paired row planting x cowpea x 100 % N

T_{10} ($P_2I_2N_1$) - Paired row planting x lablab bean x 50 % N

T_{11} ($P_2I_2N_2$) - Paired row planting x lablab bean x 75 % N

T_{12} ($P_2I_2N_3$) - Paired row planting x lablab bean x 100 % N

Along with the above 12 treatment combinations, pure crops one each of hybrid napier (normal row planting), cowpea and lablab bean were tagged thus making a total of 15 plots per replication.

3.2.2 Experimental design

Design	: Factorial Randomised Block Design
Replications	: 3
Size of plot	: Gross - 5.4 x 3.3 m
	Net - 4.8 x 3 m

3.3 Crops and varieties

Base crop (Bajra-Napier Hybrid grass-CO-2)

Parentage : *Pennisetum purpureum* x *Pennisetum americanum*

This was the base crop of the experiment. The grass is drought resistant, perennial and well relished by all categories of livestock.

Varietal characters

Green fodder yield (t ha^{-1})	: 350-385
Dry matter yield (t ha^{-1})	: 55.00
Crude protein yield (t ha^{-1})	: 6.00
Mean plant height (cm)	: 275.00
Number of leaves per clump	: 360.00
Number of tillers per clump	: 30.00

Leaf : stem ratio	:	(.95
Leaf length(cm)	:	89.31
Dry matter (%)	:	15.00
Crude protein (%)	:	9.38
Calcium (%)	:	0.88
Phosphorus (%)	:	0.24
Oxalate (%)	:	2.92
Invitro dry matter digestibility (%)	:	58.00

The slips were obtained from the Department of Forage Crops, Tamil Nadu Agricultural University, Coimbatore.

Intercrops

1. **Cowpea (*Vigna unguiculata.* (L.)Walp., variety CO-5)**

This is a fodder legume suitable for cultivation in intercropping systems. Seeds were obtained from the Department of Forage Crops, Tamil Nadu Agricultural University, Coimbatore.

2. **Lablab bean (*Lablab purpureus* (L.) Sweet., variety Highworth)**

It is another fodder legume suited for mixed cropping. Seeds were obtained from the Kerala Livestock Development Board regional unit, Dhoni farm, Palakkad.

3.4 Details of cultivation

During the first week of July, the experimental site was given thorough diggings, stubbles were removed and land was levelled. Plots of size 4.8 x 3 m were laid out as per the experimental design.

3.4.1 Manuring

A uniform basal dose of 25 t ha^{-1} of farm yard manure was applied and incorporated into the plots during the final preparation of land.

3.4.2 Fertilizer application

3.4.2.1 Hybrid napier

The recommended dose for hybrid napier is 200 : 50 : 50 kg NPK ha^{-1}. Full doses of phosphorus and potassium were applied as basal and nitrogen in five equal split doses.

3.4.2.2 Intercrops (cowpea and lablab bean)

Intercrops, both cowpea and lablab bean were fertilized separately at the rate of 25 : 60 : 30 kg NPK per hectare at the time of sowing as per the package of practices recommendations.

3.4.3 Planting

3.4.3.1 Hybrid napier

Young, healthy, three noded and fresh rooted cuttings of Bajra-Napier Hybrid CO-2 grass slips were selected and planted on 20th July 1995. One slip

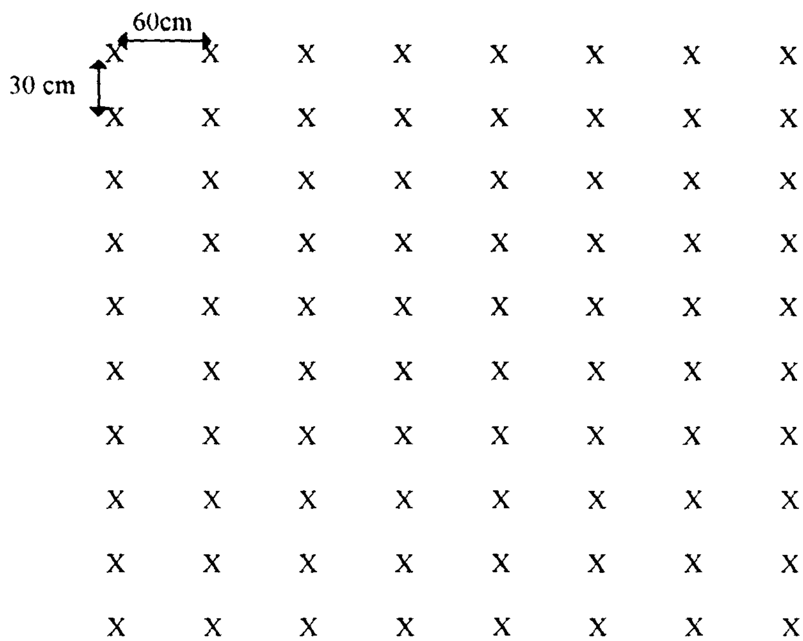
Field lay out of the experiment

R1	T_9	T_7	PH*	T_{11}	T_2
	T_8	T_5	T_{12}	PC*	T_6
	PL*	T_{10}	T_3	T_1	T_4
R2	T_3	T_8	PC*	T_{12}	T_5
	T_{10}	T_4	T_1	PL*	T_7
	T_6	T_{11}	T_9	T_2	PH*
R3	T_{10}	T_3	PL*	T_7	T_{12}
	T_5	T_9	T_{11}	PH*	T_4
	T_1	PC*	T_8	T_2	T_6

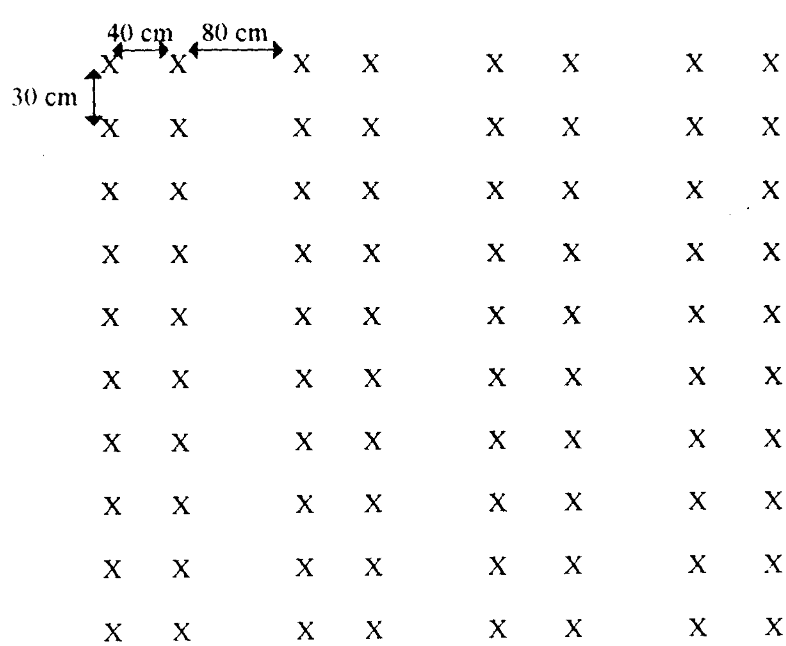
PH* - Pure crop of hybrid napier   PC* - Pure crop of cowpea   PL* - Pure crop of lablab bean

Planting methods

Normal row planting



Paired row planting



per hill was planted with a spacing of 60 x 30 cm for normal row and 40/ 80 x 30 cm for paired row systems of planting.

3.4.3.2 **Intercrops**

Seeds of cowpea and lablab bean were sown in between the rows of hybrid napier at 15 cm apart on 25th July 1995, 5 days after planting of the base crop.

3.4.4 **General condition of the crops**

General growth of hybrid napier slips was good. Few slips which exhibited poor initial growth were removed and planted with fresh ones within two weeks of planting. Further growth was quite satisfactory.

Germination of the seeds of both the legumes was good. Within the first week of germination, thinning and gap filling were done wherever necessary.

3.4.5 **Aftercare**

For hybrid napier, earthing up was given after each cut. Irrigation was given once in 10 days. Intercultivation and hand weeding operations were done twice. Necessary plant protection measures were carried out whenever required.

3.4.6 **Harvest**

Five cuts were taken from hybrid napier with the first harvest on 25th September 1995 and subsequent harvests at 45 days interval, upto 3rd May 1996. Legumes were harvested on 5th October 1996, at the time of flowering.

3.5 Biometric observations

Growth observations on five randomly selected hybrid napier plants in each plot were recorded prior to each cut. Average of five cuts was worked out and presented.

In the case of legume intercrops, observations were taken on five randomly selected plants from each plot at the time of harvest, their average was worked out and presented.

3.5.1 Growth and yield of fodder crops

1. Base crop (Hybrid napier)

3.5.1.1 Height of plants

Height was measured from the base of the plant to the tip of the topmost leaf. Mean height was arrived at and presented in cm.

3.5.1.2 Tiller count

The number of tillers per clump in hybrid napier were counted on the previous day of harvest and recorded.

3.5.1.3 Leaf : stem ratio

Plant samples collected at each harvest were separated into leaf and stem and the ratio was computed on dry weight basis. The ratio was worked out and expressed as unit of leaf per unit of stem weight.

3.5.1.4 Green fodder yield

The green fodder yield from the net plot area was recorded immediately after harvest.

3.5.1.5 **Dry fodder yield**

The samples from each cut of grass were first sun dried and then oven dried to a constant weight at 80 ^{0}C. The dry matter content was computed for each treatment and their dry matter yield worked out.

3.5.1.3 **Leaf Area Index (LAI)**

The leaves separated from the plant samples were fed to the leaf area meter to read out the leaf area directly. LAI was worked out using the formula suggested by Watson (1947).

$$LAI = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area occupied by the plant (cm}^2\text{)}}$$

3.5.1.7 **Root spread and depth at the time of harvest of intercrops**

A 40 cm^3 soil around the selected hybrid napier clump was dug out. Grass with roots were washed in water and the lateral roots of the root system were spread over a plain paper. The length and spread of the longest lateral root was measured using a thread and scale and expressed in cm.

2. Intercrops (cowpea and lablab bean)

3.5.2.1 **Plant height and spread**

In the case of legumes, the height was measured from the base to the growing tip of the tallest branch. The maximum diameter from the main stem of each plant was measured and expressed in cm as plant spread.

3.5.2.2 **Number of branches**

The total number of branches present in the selected sample plants from each plot were recorded prior to harvest.

3.5.2.3 **Leaf : stem ratio**

The samples taken for computing dry matter production were separated into leaf and stem and the ratio was recorded as in the case of base crop.

3.5.2.4 **Green fodder yield**

The green matter yield from the net plot area was recorded immediately after harvest.

3.5.2.5 **Dry fodder yield**

The samples from each plot were first sun dried and then oven dried to a constant weight at 80 ^{0}C. The dry matter content was computed for each treatment and their dry matter yield worked out.

3.5.2.6 **Root spread and depth at the time of harvest**

As in the case of base crop, a 40 cm^3 soil around the selected plant was dug out along with the whole plant and roots, washed in water and the lateral roots of the root system were spread over a plain paper. The length and spread of the longest lateral root was measured using a thread and scale and expressed in cm.

3.6 **Chemical analysis of the plant samples**

3.6.1 **Quality studies**

The oven dried plant samples used for determination of dry matter content were ground in a Wiley mill and chemical analyses were carried out for the estimation of nutrients as per the methods given below.

Table. 1.3 **Analysis of plant samples**

Sl. No	Estimated character	Method
1.	N	Microkjeldhal digestion in sulphuric acid and distillation (Jackson, 1973)
2.	P	Digestion in nitric-perchloric-sulphuric acid (10:4:1) and Klett Summerson photoelectric colourimetry making use of vanado-molybdate yellow colour in sulphuric acid medium (Jackson, 1973)
3.	K	Digestion in nitric-perchloric-sulphuric acid (10:4:1) and flame photometry
4.	Ca	Digestion in nitric-perchloric-sulphuric acid (10:4:1) and atomic absorption spectrophotometry (Piper, 1967)
5.	Mg	Digestion in nitric-perchloric-sulphuric acid (10:4:1) and atomic absorption spectrophotometry (Piper, 1967)
6.	Crude fibre	A.O.A.C (1975).

Protein content was calculated by multiplying the nitrogen content by the factor 6.25 (Simpson *et al.* 1965).

3.6.2 **Uptake studies**

Nitrogen, phosphorus, potassium, calcium and magnesium contents in the whole plant on dry weight basis were estimated and expressed as percentage of nitrogen, phosphorus, potassium, calcium and magnesium of plant dry matter. From these figures, nitrogen, phosphorus, potassium, calcium and magnesium uptake were computed.

3.6.3 Chemical properties of the soil before and after the experiment

Before commencement of the experiment, a composite sample of soil was collected from the experimental field in the surface layer (0-15 cm) from each plot. At the end of the experiment, soil samples were collected from each plot. The samples were dried in shade, gently powdered to pass through a 2 mm sieve and were analysed for available nutrients. The soil samples collected before commencement and after completion of the experiment were analysed separately for determining the chemical properties as per the methods mentioned earlier.

3.7 Parameters for assessing biosuitability

3.7.1 Land Equivalent Ratio (LER)

The land equivalent ratio for intercropped treatments was computed as per the procedure suggested by Mead and Willey (1980).

$$\text{LER} = \frac{\text{Intercrop yield of A}}{\text{Pure crop yield of A}} + \frac{\text{Intercrop yield of B}}{\text{Pure crop yield of B}}$$

where A and B are component crops

3.7.2 Aggressivity

This term was proposed by McGilchrist (1965). It gives a simple measure of how much relative yield increase in species 'a' is greater than that for 'b' in an intercropping system.

$$Aab = \frac{Yab}{YaaZab} + \frac{Yba}{YbbZba}$$

where

Yaa = Pure stand yield of species ‘a’

Ybb = Pure stand yield of species ‘b’

Yab = Mixture yield of species ‘a’ in combination with ‘b’

Yba = Mixture yield of species ‘b’ in combination with ‘a’

Zab = Sown proportion of species ‘a’ in mixture with ‘b’

Zba = Sown proportion of species ‘b’ in mixture with ‘a’

3.8 Economics

The gross returns per hectare for each treatment based on the present market rate were worked out. The net returns were calculated by subtracting the cost of cultivation from the total monetary value of yield.

3.9 Statistical analysis

Statistical analysis of the data was performed by using the analysis of variance technique proposed by Snedecor and Cochran (1967). Wherever the differences between the treatments were significant, critical differences were worked out at 5 % and 1 % probability level. Important correlations were also worked out.

RESULTS

Plate 1. **A general view of the experiment**

RESULTS

A field experiment was conducted at the Instructional farm- Vellayani for studies on intensive fodder production through legume intercropping in hybrid napier. The observations recorded on various treatments were analysed statistically, compared with the respective pure crops and the results are given below. The mean values are given in tables 2 to 37.

4.1 Growth characters and yield of fodder crops

4.1.1 Base crop (Hybrid napier)

4.1.1.1 Plant height

The results on plant height as influenced by different planting geometries, intercrops and nitrogen levels are presented in Table 2.

Plant height of the grass was found to be influenced significantly by planting geometries. Paired row planting recorded the maximum plant height (172.59 cm). Mean height of the grass significantly increased in presence of intercrops and was maximum with lablab bean (171.85 cm). Application of inorganic nitrogen in addition to legume intercropping also enhanced the height of grass significantly. Increase in height of hybrid napier was noticed with every increment in N level and was maximum when supplied with 100 per cent N (174.82 cm). The lowest plant height was recorded by the pure crop of hybrid napier (158.81 cm).

The interaction effects also showed varying tendency. In the case of planting geometry x intercrop interaction, paired row planting x lablab bean was found to be superior (174.58 cm). Normal row planting x 75 per cent N was on par with paired row planting x 50 per cent N as far as the planting geometries x N interaction was concerned. In the case of planting geometries x intercrops x N interaction the maximum height was recorded for paired row planting x lablab bean x 100 per cent N and the following groups of treatment combinations were found to be on par

Group 1 : Normal row planting x cowpea x 75 % N
Normal row planting x lablab bean x 75 % N

Group 2 : Paired row planting x lablab bean x 50 % N
Paired row planting x cowpea x 75 % N

Group 3 : Normal row planting x lablab bean x 100 % N
Paired row planting x lablab bean x 75 % N
Paired row planting x cowpea x 100 % N

Green as well as dry fodder yields were found to have significant positive correlation with plant height.

4.1.1.2 **Tiller count**

The data on tiller count are presented in Table 2.

There was significant effect on tiller production due to planting geometries Paired row planting produced significantly more tillers (27.30) than normal row planting (24.87). Significantly more number of tillers were produced due to legume intercropping and lablab bean was found to be the best promoter of tiller production (27.03). Application of 100 per cent N along with intercropping produced the maximum number of tillers (27.31). Pure crop recorded the lowest tiller production (20.77).

Paired row planting x lablab bean produced the maximum number of tillers due to interaction effect of planting geometries x intercrops (28.47). In the case of planting geometries x N interaction, normal row planting x 100 per cent N was on par with paired row planting x 50 per cent N and the maximum tiller production was noticed with paired row planting x 100 per cent N (28.05).

Tiller count was found to have positive correlation with green and dry fodder yields.

4.1.1.3 **Leaf : Stem ratio**

The data on mean leaf : stem ratio of all cuts are presented in Table 3.

The results showed that leaf : stem ratio of hybrid napier was not significantly influenced by planting geometries; however a lesser ratio was obtained for paired row planting (1.75). The lowest ratio (1.75) was recorded when lablab bean was grown as intercrop. Leaf : stem ratio had inverse relationship with N levels and was the least (1.63) when supplied with 100 per cent N. Pure crop recorded the highest leaf : stem ratio (1.94).

The following groups of treatment combinations were found to be on par for the interactions planting geometries x intercrops (group 1, 2) and planting geometries x intercrops x N (group 3, 4, 5, 6) respectively.

Group 1 : Normal row planting x 50 % N

Paired row planting x 50 % N

Group 2 : Normal row planting x 75 % N

Paired row planting x 75 % N

Table 2. **Effect of treatments on the height and tiller count of hybrid napier**

Treatment combinations	Plant height (cm)				Tiller count			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	163.80	168.76	172.62	168.39	22.067	24.400	26.000	24.156
Normal row planting x lablab bean	164.70	169.33	174.51	169.51	23.633	26.000	27.133	25.589
Paired row planting x cowpea	167.60	170.65	174.77	171.00	25.033	26.367	27.000	26.133
Paired row planting x lablab bean	170.46	174.72	177.37	174.18	27.667	28.633	29.100	28.467
Normal row planting	164.25	169.04	173.57	168.96	22.850	25.200	26.567	24.872
Paired row planting	169.03	172.68	176.07	172.59	26.350	27.500	28.050	27.300
Cowpea	165.70	169.70	173.70	169.70	23.550	25.383	26.500	25.144
Lablab bean	167.58	172.02	175.94	171.85	25.650	27.317	28.117	27.028
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	166.64	170.86	174.81	170.77	24.600	26.350	27.308	26.086
	Pure crop			158.81	Pure crop			20.767
SE of P (planting geometries) marginal mean	0.1019				0.0848			
SE of I (intercrops) marginal mean	0.1019				0.0848			
SE of N (nitrogen levels) marginal mean	0.1248 (CD = 0.3643)				0.1039 (CD = 0.3033)			
SE of body of P x I Table	0.1441 (CD = 0.4206)				0.1200 (CD = 0.3503)			
SE of body of P x N Table	0.1764 (CD = 0.5150)				0.1470 (CD = 0.4290)			
SE of body of I x N Table	0.1764				0.1470			
SE of body of P x I x N Table	0.2495 (CD = 0.7284)				0.2078			

Group 3 : Normal row planting x cowpea x 50 % N
Paired row planting x cow pea x 50 % N
Paired row planting x lablab bean x 50 % N

Group 4 : Normal row planting x cowpea x 75 % N
Paired row planting x cowpea x 75 % N
Normal row planting x lablab bean x 75 % N

Group 5 : Paired row planting x cowpea x 75 % N
Normal row planting x lablab bean x 75 % N
Paired row bean x lablab bean x 75 % N

Group 6 : Normal row planting x cowpea x 100 % N
Paired row planting x cowpea x 100 % N
Normal row planting x lablab bean x 100 % N

4.1.1.4. **Leaf area index (LAI)**

The data on leaf area index are presented in Table 3.

LAI of the grass when planted under paired row system was significantly superior (14.63). Among the intercrops lablab bean was found to be more effective in increasing the LAI of the grass (13.92). Addition of each level of N contributed much to the increased LAI and the maximum was reported for 100 per cent N application (13.94). Lowest LAI was recorded by the pure crop (10.73).

In the case of planting geometries x intercrops interaction, the maximum LAI was recorded for the paired row planting x lablab bean (15.53). Normal row planting x 50 per cent N and normal row planting x 75 per cent N were on par in the case of planting geometries x N interaction. Similarly cowpea x 100 per cent N and lablab bean x 100 per centN were on par for the intercrops x N interaction.

Normal row planting x lablab bean x 75 per cent N was on par with paired row planting x cowpea x 50 per cent N for the planting geometries x intercrops x N interaction and the maximum LAI was recorded for paired row planting x lablab bean x 100 per cent N.

LAI had significant positive correlation with green and dry fodder yield.

4.1.1.5. **Green fodder yield**

Data pertaining to green fodder yield are presented in Table 4.

Yield data showed that planting geometries had significant influence on the green fodder yield of grass. Paired row planting produced maximum tonnage of green fodder (41.35 t ha^{-1}). Increase in N level increased green fodder yield and was maximum with 100 per cent N (41.52 t ha^{-1}). Legume intercropping had significant influence on green fodder production and lablab bean when raised as intercrop produced the maximum green fodder (40.57 t ha^{-1}). Pure crop produced the lowest quantity of green fodder (32.76 tha^{-1}).

In the case of planting geometries x intercrops interaction, all the treatments differed significantly and maximum production was recorded with paired row planting x lablab bean (42.04 t ha^{-1}). Similar trend was noticed for the planting geometries x N interaction and maximum yield was recorded by paired row planting x 100 per cent N (42.52 t ha^{-1}).

4.1.1.6. **Dry fodder yield**

The dry fodder yield of the grass are presented in Table 4.

The results indicated that planting geometries had significant influence on dry fodder yield and paired row planting produced the maximum quantity of dry fodder (7.98 t ha^{-1}). Legume intercropping had a favourable influence on dry matter production of grass and was maximum with lablab bean (7.85 t ha^{-1}).

Table 3. **Effect of treatments on the leaf : stem ratio and leaf area index of hybrid napier**

Treatment combinations	Leaf : stem ratio				Leaf area index			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	1.8830	1.7630	1.6400	1.7620	11.533	12.367	13.467	12.456
Normal row planting x lablab bean	1.8630	1.7530	1.6330	1.7500	11.967	12.933	12.000	12.300
Paired row planting x cowpea	1.8800	1.7530	1.6330	1.7560	13.033	13.767	14.367	13.722
Paired row planting x lablab bean	1.8830	1.7470	1.6070	1.7460	15.100	15.567	15.933	15.533
Normal row planting	1.8730	1.7580	1.6370	1.7560	11.750	12.650	12.733	12.378
Paired row planting	1.8820	1.7500	1.6200	1.7510	14.067	14.667	15.150	14.628
Cowpea	1.8820	1.7580	1.6370	1.7590	12.283	13.067	13.917	13.089
Lablab bean	1.8730	1.7500	1.6200	1.7480	13.533	14.250	13.967	13.917
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	1.8770	1.7540	1.6280	1.7533	12.908	13.658	13.942	13.503
	Pure crop			1.9430	Pure crop			10.733
SE of P (planting geometries) marginal mean	0.0021				0.0346			
SE of I (intercrops) marginal mean	0.0021				0.0346			
SE of N (nitrogen levels) marginal mean	0.0026 (CD = 0.0076)				0.0423 (CD = 0.1235)			
SE of body of P x I Table	0.0030				0.0489 (CD = 0.1427)			
SE of body of P x N Table	0.0037 (CD = 0.0108)				0.0600 (CD = 0.1751)			
SE of body of I x N Table	0.0037				0.0600 (CD = 0.1751)			
SE of body of P x I x N Table	0.0052 (CD = 0.0151)				0.0846 (CD = 0.2469)			

Nitrogen application enhanced the dry fodder production and application of 100 per cent N was superior to others (8.27 t ha^{-1}). Pure crop recorded the lowest dry fodder yield (5.82 t ha^{-1}).

As far as the planting geometries x N interaction is concerned, all the treatments differed significantly and the maximum dry fodder yield was observed for paired row planting x 100 per cent N.

4.1.1.7. **Root depth of the grass at the harvest of intercrops**

The data on root depth of the grass at the stage of harvest of intercrops are presented in Table 5.

The results revealed that planting geometries had significant influence on root depth and paired row planting produced the maximum deep roots (34.71 cm). Legume intercropping with lablab bean resulted in deeper root growth of the grass (34.98 cm). Nitrogen application proved to have positive correlation with root depth of the grass and was maximum when supplied with 100 per cent N (35.95 cm). Pure crop of the grass recorded the lowest root depth (31.33 cm). The interaction effects were not significant.

Root depth had positive correlation with growth of the grass and indirectly contributed to green and dry fodder yields.

4.1.1.8. **Root spread of the grass at the harvest of intercrops**

The results on root spread of the grass are presented in Table 5.

Planting geometries favourably influenced the root spread of grass and paired row planting recorded the maximum spread (24.27 cm). Similar trend was noticed in the case of intercropping and lablab bean promoted maximum root spread of the grass (24.37 cm). Increased N level increased the root spread of

Table 4. **Effect of treatments on the green and dry fodder yields of hybrid napier**

Treatment combinations	Green fodder yield (t ha^{-1})				Dry fodder yield (t ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	36.107	38.780	40.097	38.328	6.6790	7.2540	7.6900	7.2080
Normal row planting x lablab bean	36.753	39.613	40.967	39.111	6.9650	7.6980	8.0660	7.5770
Paired row planting x cowpea	39.617	40.790	41.587	40.664	7.1540	7.8940	8.4850	7.8440
Paired row planting x lablab bean	40.770	41.900	43.443	42.038	7.3300	8.1960	8.8200	8.1150
Normal row planting	36.430	39.197	40.532	38.719	6.8220	7.4760	7.8780	7.3920
Paired row planting	40.193	41.345	42.515	41.351	7.2420	8.0450	8.6350	7.9800
Cowpea	37.862	39.785	40.842	39.496	6.9160	7.5740	8.0880	7.5260
Lablab bean	38.762	40.757	42.205	40.574	7.1480	7.9470	8.4430	7.8460
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	38.312	40.271	41.523	40.035	7.0320	7.7600	8.2650	7.6859
	Pure crop			32.760	Pure crop			5.8150
SE of P (planting geometries) marginal mean	0.0692				0.0029			
SE of I (intercrops) marginal mean	0.0692				0.0029			
SE of N (nitrogen levels) marginal mean	0.0848 (CD = 0.2475)				0.0357 (CD = 0.1042)			
SE of body of P x I Table	0.0978 (CD = 0.2854)				0.0412			
SE of body of P x N Table	0.1200 (CD = 0.3502)				0.0505 (CD = 0.1474)			
SE of body of I x N Table	0.1200				0.0505			
SE of body of P x I x N Table	0.1695				0.0714			

grass with the maximum value for 100 per cent N application (24.37 cm). Pure crop recorded the lowest root spread (19.20 cm).

Significant differences in interaction effects were also noticed. As far as planting geometries x intercrop interaction is concerned, the maximum root spread was recorded for paired row planting x lablab bean (24. 90 cm). Similarly paired row planting x 100 per cent N (24.80 cm) and lablab bean x 100 per cent N (24.98 cm) recorded the maximum root spread for the interactions 'planting geometries x N' and 'intercrops x N' respectively.

As in the case of root depth, root spread also had significant positive correlation with green and dry fodder yields.

4.2 Chemical analysis

4.2.1 Crude protein content

The crude protein content of grass is given in Table 6.

It is evident that planting geometries had significant influence on crude protein content of the grass. Maximum crude protein content (9.01 per cent) was recorded when the grass was grown under paired row system of planting. Legume intercropping with lablab bean resulted in maximum crude protein content (8.99 per cent). Nitrogen application had positive response with crude protein content and was maximum with 100 per cent N application (9.16 per cent). The lowest crude protein content was recorded by the pure crop of grass (8.60 per cent).

In the case of planting geometries x N interaction, all the treatments differed significantly and higher crude protein content was recorded for paired row planting x 100 per cent N (9.19 per cent).

Table 5. **Effect of treatments on the root depth and root spread of hybrid napier**

Treatment combinations	Root depth (cm)				Root spread (cm)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	32.567	34.400	35.200	34.056	20.733	22.733	23.167	22.211
Normal row planting x lablab bean	33.500	35.033	36.500	35.011	22.700	24.100	24.700	23.833
Paired row planting x cowpea	32.667	35.067	35.633	34.456	22.900	23.700	24.333	23.644
Paired row planting x lablab bean	33.367	35.033	36.467	34.956	24.400	25.033	25.267	24.900
Normal row planting	33.033	34.717	35.850	34.533	21.717	23.417	23.933	23.022
Paired row planting	33.017	33.050	36.050	34.706	23.650	24.367	24.800	24.272
Cowpea	32.167	34.733	35.417	34.256	21.817	23.217	23.750	22.928
Lablab bean	33.433	35.033	36.483	34.983	23.550	24.567	24.983	24.367
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	33.025	34.883	35.950	34.619	22.683	23.892	24.367	23.647
	Pure crop			31.333	Pure crop			19.200
SE of P (planting geometries) marginal mean	0.0977				0.0378			
SE of I (intercrops) marginal mean	0.0977				0.0378			
SE of N (nitrogen levels) marginal mean	0.1198 (CD = 0.3500)				0.0462 (CD = 0.1348)			
SE of body of P x I Table	0.1383				0.0534 (CD = 0.1559)			
SE of body of P x N Table	0.1694				0.0654 (CD = 0.1908)			
SE of body of I x N Table	0.1694				0.0654 (CD = 0.1908)			
SE of body of P x I x N Table	0.2395				0.0925			

4.2.2 **Crude fibre content**

The mean data on crude fibre content are given in Table 6.

Planting geometries had no significant effect on crude fibre content of the grass; however lower content of crude fibre was recorded when the grass was raised under paired row system of planting (28.86 per cent). Similar trend was noticed in the case of legume intercropping and lablab bean recorded lower crude fibre content (28.86 per cent). Crude fibre exhibited a declining trend with increased N levels and was the lowest when supplied with 100 per cent N (28.60 per cent). Pure crop recorded the maximum crude fibre content (29.53 per cent). None of the interaction effects were significant.

4.2.3 **Nitrogen content**

The results on N content of the grass are given in Table 7.

No significant effect on N content of the grass was recorded in the case of planting geometries though a slight increase was noticed when the grass was grown under paired row system of planting (1.44 per cent). Similarly intercropping with lablab bean recorded comparatively higher N content than cowpea (1.44 per cent). Increased N content was recorded with increment in N levels and was maximum with 100 per cent N (1.47 per cent). The lowest N content was recorded by the pure crop of the grass (1.38 per cent).

In the case of planting geometries x N interaction, all the treatments differed significantly and maximum N content was recorded by paired row planting x 100 per cent N (1.47 per cent).

Nitrogen content had positive correlation with both green and dry fodder yields.

Table 6. **Effect of treatments on the crude protein and crude fibre contents of hybrid napier**

Treatment combinations	Crude protein content (%)				Crude fibre content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	8.7680	8.9810	9.1270	8.9590	29.210	28.880	28.630	28.910
Normal row planting x lablab bean	8.7880	8.9160	9.1420	8.9750	29.170	28.840	28.610	28.870
Paired row planting x cowpea	8.7970	9.0160	9.1810	8.9980	29.190	28.860	28.610	28.880
Paired row planting x lablab bean	8.8080	9.0320	9.1970	9.0120	29.160	28.810	28.550	28.840
Normal row planting	8.7780	8.9880	9.1340	8.9670	29.190	28.860	28.620	28.890
Paired row planting	8.8020	9.0240	9.1890	9.0050	29.175	28.840	28.580	28.860
Cowpea	8.7830	8.9980	9.1540	8.9780	29.190	28.870	28.620	28.900
Lablab bean	8.7980	9.0140	9.1690	8.9940	29.170	28.830	28.580	28.860
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	8.7900	9.0060	9.1620	8.9860	29.180	28.850	28.600	28.880
	Pure crop			8.6040	Pure crop			29.533
SE of P (planting geometries) marginal mean	0.0013				0.0048			
SE of I (intercrops) marginal mean	0.0013				0.0048			
SE of N (nitrogen levels) marginal mean	0.0016 (CD = 0.0047)				0.0058			
SE of body of P x I Table	0.0018				0.0067			
SE of body of P x N Table	0.0022 (CD = 0.0064)				0.0083			
SE of body of I x N Table	0.0022				0.0083			
SE of body of P x I x N Table	0.0032				0.0117			

4.2.4 **Nitrogen uptake**

The data on N uptake are presented in Table 7.

Planting geometries had significant influence on N uptake by the grass and maximum uptake was recorded in the case of paired row system of planting (115.19 kg ha^{-1}). Legume intercropping with lablab bean resulted in maximum uptake of N (113.10 kg ha^{-1}). Nitrogen application contributed much to the uptake and maximum was recorded when supplied with 100 per cent N (121.26 kg ha^{-1}). Pure crop recorded the lowest uptake (80.21 kg ha^{-1}).

Paired row planting x 100 per cent N recorded the maximum N uptake (127.37 kg ha^{-1}) with planting x N interaction.

4.2.5 **Phosphorus content**

The results on phosphorus content of the grass are presented in Table 8.

Planting geometries had no significant effect on phosphorus content of the grass and it remained unchanged under different planting systems. Similar trend was noticed in the case of intercropping and N levels. Pure crop of grass recorded the maximum phosphorus content (0.22 per cent). The interaction effects were also not significant.

4.2.6 **Phosphorus uptake**

The results on phosphorus uptake are given in Table 8.

Phosphorus uptake by the grass was favourably influenced by planting geometries and paired row system recorded the maximum uptake (16.81 kg ha^{-1}). Intercropping with lablab bean resulted in the maximum uptake of phosphorus (16.48 kg ha^{-1}). Nitrogen application had positive impact on the uptake of

Table 7. **Effect of treatments on the nitrogen content and uptake by hybrid napier**

Treatment combinations	Nitrogen content (%)				Nitrogen uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	1.4020	1.4370	1.4600	1.4330	93.660	104.21	112.25	103.37
Normal row planting x lablab bean	1.4070	1.4410	1.4630	1.4370	97.973	110.96	118.04	108.99
Paired row planting x cowpea	1.4090	1.4430	1.4700	1.4410	100.82	113.88	124.79	113.16
Paired row planting x lablab bean	1.4090	1.4450	1.4730	1.4420	103.26	118.43	129.95	117.21
Normal row planting	1.4050	1.4390	1.4610	1.4350	95.816	107.59	115.14	106.18
Paired row planting	1.4090	1.4440	1.4720	1.4420	102.04	116.16	127.37	115.19
Cowpea	1.4060	1.4400	1.4650	1.4370	97.241	109.04	118.52	108.27
Lablab bean	1.4080	1.4430	1.4680	1.4400	100.61	114.70	123.99	113.10
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	1.4070	1.4410	1.4670	1.4383	98.927	111.87	121.26	110.68
	Pure crop			1.3790	Pure crop			80.211
SE of P (planting geometries) marginal mean	0.0005				0.4254			
SE of I (intercrops) marginal mean	0.0005				0.4254			
SE of N (nitrogen levels) marginal mean	0.0006 (CD = 0.0018)				0.5210 (CD = 1.5207)			
SE of body of P x I Table	0.0007				0.6017			
SE of body of P x N Table	0.0008 (CD = 0.0023)				0.7370 (CD = 2.1337)			
SE of body of I x N Table	0.0008				0.7370			
SE of body of P x I x N Table	0.0012				1.0420			

Table 8. **Effect of treatments on the phosphorus content and phosphorus uptake by hybrid napier**

Treatment combinations	Phosphorus content (%)				Phosphorus uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	0.2080	0.2100	0.2130	0.2100	13.910	15.238	16.408	15.185
Normal row planting x lablab bean	0.2090	0.2130	0.2060	0.2090	14.530	16.374	16.644	15.850
Paired row planting x cowpea	0.2110	0.2070	0.2130	0.2100	15.076	16.314	18.101	16.497
Paired row planting x lablab bean	0.2130	0.2130	0.2070	0.2110	15.632	17.486	18.232	17.116
Normal row planting	0.2080	0.2110	0.2100	0.2100	14.220	15.806	16.526	15.517
Paired row planting	0.2120	0.2100	0.2100	0.2110	15.354	16.900	18.166	16.807
Cowpea	0.2090	0.2080	0.2130	0.2100	14.493	15.776	17.255	15.841
Lablab bean	0.2110	0.2130	0.2060	0.2100	15.081	16.930	17.438	16.483
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	0.2100	0.2110	0.2100	0.2103	14.787	16.353	17.346	16.162
	Pure crop			0.2170	Pure crop			12.598
SE of P (planting geometries) marginal mean	0.0024				0.2014			
SE of I (intercrops) marginal mean	0.0024				0.2014			
SE of N (nitrogen levels) marginal mean	0.0029				0.2466 (CD = 0.7198)			
SE of body of P x I Table	0.0033				0.2848			
SE of body of P x N Table	0.0041				0.3488			
SE of body of I x N Table	0.0041				0.3488			
SE of body of P x I x N Table	0.0058				0.4933			

phosphorus and was maximum with 100 per cent N (17.35 kg ha^{-1}). The interaction effects were not significant.

4.2.7 **Potassium content**

The data on potassium content are given in Table 9.

There was no significant effect on potassium content of grass under varying planting geometries and it remained almost unchanged. The content of potassium when supplied with 50 per cent, 75 per cent and 100 per cent N were found to be on par; however maximum content was recorded for 100 per cent N application (0.98 per cent). Pure crop recorded a potassium content (0.98 per cent) which was comparable to the rest of the treatments. None of the interaction effects was found to be significant.

4.2.8. **Potassium uptake**

The mean potassium uptake value are presented in Table 9.

Planting geometries significantly influenced the potassium uptake by the grass. Paired row planting recorded the maximum uptake (78.47 kg ha^{-1}). Lablab bean when raised as intercrop resulted in the maximum uptake of potassium (76.71 kg ha^{-1}). Nitrogen application was found to increase the uptake of potassium and the maximum was recorded for 100 per cent N (81.23 kg ha^{-1}). The lowest uptake was recorded by the pure crop of the grass (59.68 kg ha^{-1}).

In the case of planting geometries x N interaction, paired row planting x 50 per cent N was on par with normal row planting x 75 per cent N and the maximum uptake was recorded for paired row planting x 100 per cent N (85.60 kg ha^{-1}).

4.2.9. **Calcium content**

The results on calcium content of the grass are presented in Table 10.

Table 9. **Effect of treatments on the potassium content and potassium uptake by hybrid napier**

Treatment combinations	Potassium content (%)				Potassium uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	0.9720	0.9740	0.9740	0.9730	64.914	70.678	74.901	70.164
Normal row planting x lablab bean	0.9810	0.9720	0.9770	0.9770	68.424	74.845	78.811	74.026
Paired row planting x cowpea	0.9830	0.9910	0.9910	0.9880	70.301	78.252	84.111	77.555
Paired row planting x lablab bean	0.9710	0.9750	0.9870	0.9780	71.179	79.910	87.081	79.390
Normal row planting	0.9760	0.9730	0.9750	0.9750	66.669	72.761	76.856	72.095
Paired row planting	0.9770	0.9830	0.9890	0.9830	70.740	79.081	85.596	78.472
Cowpea	0.9770	0.9830	0.9830	0.9810	67.608	74.465	79.506	73.860
Lablab bean	0.9760	0.9730	0.9820	0.9770	69.801	77.378	82.946	76.708
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	0.9770	0.9780	0.9820	0.9791	68.704	75.921	81.226	75.284
	Pure crop			1.0260	Pure crop			59.678
SE of P (planting geometries) marginal mean	0.0024				0.4017			
SE of I (intercrops) marginal mean	0.0024				0.4017			
SE of N (nitrogen levels) marginal mean	0.0029				0.4920 (CD = 1.4361)			
SE of body of P x I Table	0.0033 (CD = 0.0096)				0.5680			
SE of body of P x N Table	0.0041				0.6957 (CD = 2.0307)			
SE of body of I x N Table	0.0041				0.6957			
SE of body of P x I x N Table	0.0058				0.9840			

Irrespective of planting geometries, calcium content of the grass remained unchanged (0.72 per cent) and there was no significant influence. Calcium content of the grass was maximum when intercropped with cowpea (0.72 per cent). Nitrogen application also had no significant effect on calcium content. Pure crop of hybrid napier recorded the maximum calcium content (0.80 per cent). None of the interaction effect was found to be significant.

4.2.10. **Calcium uptake**

The data on calcium uptake are presented in Table 10.

Paired row system of planting was significantly superior to normal row planting and recorded the maximum uptake of calcium (57.31 kg ha^{-1}). Among the intercrops, lablab bean resulted in the maximum uptake (56.01 kg ha^{-1}). Nitrogen application favourably influenced the uptake of calcium and the maximum uptake was recorded for 100 per cent N (59.01 kg ha^{-1}). Pure crop recorded the lowest calcium uptake (46.53 kg ha^{-1}). The interaction effects were not significant.

4.2.11. **Magnesium content**

The results on magnesium content are given in Table 11.

There was no significant influence of planting geometries on magnesium content of the grass eventhough a slight increase was recorded under normal row system of planting (0.33 per cent). Comparatively higher nutrient content was recorded when cowpea was grown as intercrop (0.33 per cent). Nitrogen application also had no considerable impact on magnesium content of grass. The maximum nutrient content was recorded by the pure crop (0.36 per cent). The interaction effects were also not significant.

4.2.12. **Magnesium uptake**

The data on magnesium uptake by the grass are presented in Table 11.

Table 10. **Effect of treatments on the calcium content and calcium uptake by hybrid napier**

Treatment combinations	Calcium content (%)				Calcium uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	0.7270	0.7370	0.7130	0.7260	48.575	53.409	54.859	52.281
Normal row planting x lablab bean	0.7100	0.7100	0.7170	0.7120	849.450	54.676	57.480	53.869
Paired row planting x cowpea	0.7230	0.7200	0.7170	0.7100	51.735	56.835	60.804	56.458
Paired row planting x lablab bean	0.7230	0.7170	0.7130	0.7180	53.006	58.555	62.910	58.157
Normal row planting	0.7180	0.7230	0.7150	0.7190	49.013	54.043	56.170	53.075
Paired row planting	0.230	0.7180	0.7150	0.7190	52.371	57.695	61.857	57.308
Cowpea	0.7250	0.7280	0.7150	0.7130	50.155	55.122	57.832	54.370
Lablab bean	0.7170	0.7130	0.7150	0.7150	51.228	56.615	60.195	56.013
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	0.7210	0.7210	0.7150	0.7189	50.692	55.869	59.013	55.191
	Pure crop			0.8000	Pure crop			46.525
SE of P (planting geometries) marginal mean	0.0041				0.4361			
SE of I (intercrops) marginal mean	0.0041				0.4361			
SE of N (nitrogen levels) marginal mean	0.0050				0.5341 (CD = 1.5590)			
SE of body of P x I Table	0.0058				0.6167			
SE of body of P x N Table	0.0071				0.7554			
SE of body of I x N Table	0.0071				0.7554			
SE of body of P x I x N Table	0.0100				1.0683			

The results indicated that magnesium uptake by the grass was significantly influenced by planting geometries and the maximum uptake was recorded under paired row system of planting (26.21 kg ha^{-1}) . Legume intercropping also contributed much to the uptake and lablab bean was found to be the best (25.63 kg ha^{-1}). Nitrogen application also had a tremendous impact on magnesium uptake and was maximum when supplied with 100 per cent N (27.42 kg ha^{-1}). Pure crop of hybrid napier recorded the lowest uptake (20.68 kg ha^{-1}). The interaction effects were not significant.

4.3.1 Intercrops (Cowpea and lablab bean)

4.3.1.1 Plant height

The data on mean height of intercrops are presented in Table 12.

There was significant difference in the height of cowpea grown under different planting geometries. The maximum height of cowpea was noticed when grown under paired row system of planting (59.03 cm). Application of nitrogen was responsible for increased height of cowpea and the maximum height was recorded when supplied with 75 per cent N (60.60 cm) followed by 100 per cent N (58.35 cm). Pure crop recorded the minimum height (54.47 cm). Interaction effect was not significant.

Significant influence on plant height of lablab bean was observed due to planting geometries. Paired row planting was significantly superior to normal row planting and recorded the maximum height (67.48 cm). Influence of nitrogen application on plant height also was significant and the maximum height was recorded with 75 per cent N (70.63 cm). Pure crop recorded a height of 66.57 cm.

Table 11. **Effect of treatments on the magnesium content and magnesium uptake by hybrid napier**

Treatment combinations	Magnesium content (%)				Magnesium uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	0.3430	0.3320	0.3310	0.3350	22.914	24.091	25.474	24.160
Normal row planting x lablab bean	0.3260	0.3290	0.3350	0.3300	22.729	24.293	26.780	24.600
Paired row planting x cowpea	0.3240	0.3260	0.3350	0.3280	23.207	25.656	28.393	25.752
Paired row planting x lablab bean	0.3290	0.3260	0.3290	0.3280	24.210	26.746	29.016	26.657
Normal row planting	0.3350	0.3300	0.3330	0.3330	22.822	24.192	26.127	24.380
Paired row planting	0.3270	0.3260	0.3320	0.3280	23.708	26.201	28.704	26.205
Cowpea	0.3340	0.3290	0.3330	0.3320	23.061	24.873	26.934	24.956
Lablab bean	0.3280	0.3280	0.3320	0.3290	23.469	25.520	27.898	25.629
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
	0.3310	0.3280	0.3330	0.3305	23.265	25.197	27.416	25.292
	Pure crop			0.3560	Pure crop			20.675
SE of P (planting geometries) marginal mean	0.0021				0.2200			
SE of I (intercrops) marginal mean	0.0021				0.2200			
SE of N (nitrogen levels) marginal mean	0.0026				0.2691 (CD = 0.7855)			
SE of body of P x I Table	0.0030				0.3108			
SE of body of P x N Table	0.0037				0.3807			
SE of body of I x N Table	0.0037				0.3807			
SE of body of P x I x N Table	0.0052				0.5384			

In the case of planting geometries x N interaction, all the treatments differed significantly and the maximum height was recorded for paired row planting x 75 per cent N.

Plant height had significant positive correlation with green and dry fodder yields.

4.3.1.2. **Spread of intercrops**

The results on spread of legumes are given in Table 13.

Different planting geometries had significant effect on the spread of cowpea and the maximum value was recorded when grown under paired row system of planting (217.99 cm). Nitrogen application had favourable effect on the spread of cowpea and the maximum spread was recorded when supplied with 75 per cent N (226.33 cm). The lowest plant spread was recorded by the pure crop of cowpea (207.93 cm). The interaction effect was not significant.

Among the planting geometries, paired row planting was significantly superior to normal row planting and it recorded the maximum spread of lablab bean (232.30 cm). Application of inorganic nitrogen in the form of fertilizer contributed very much to increased spread and the maximum was recorded when 75 per cent N was applied. Pure crop recorded the lowest spread (217.70 cm). Interaction effect was not significant.

Plant spread also had significant positive correlation with green and dry fodder yields.

4.3.1.3. **Number of branches**

The mean value on the number of branches are presented in Table 14.

Planting geometries had promoted the branching habit of cowpea significantly and planting under paired row system produced more number of

Table 12. **Effect of treatments on the height of intercrops**

Treatment combinations	Cowpea Height (cm) Nitrogen levels				Lablab bean Height (cm) Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	54.100	59.600	57.000	56.900	61.133	70.300	65.567	65.67
Paired row planting	55.800	61.600	59.700	59.033	64.700	70.967	66.767	67.478
Mean	54.950	60.600	58.350	57.967	62.917	70.633	66.167	66.572
	Pure crop			54.467	Pure crop			62.867
SE of P(planting geometries) marginal mean	0.2926				0.1026			
SE of N(nitrogen levels) marginal mean	0.3584 (CD = 1.1046)				0.1257 (CD = 0.3873)			
SE of P x N Table	0.5068				0.1777 (CD = 0.5476)			

Table 13. **Effect of treatments on the spread of intercrops**

Treatment combinations	Cowpea Plant spread (cm) Nitrogen levels				Lablab bean Plant spread (cm) Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	204.40	223.13	215.33	214.29	210.03	240.77	233.03	227.94
Paired row planting	207.63	229.53	216.80	217.99	213.63	248.27	235.00	232.30
Mean	206.02	226.33	216.07	216.14	211.83	244.52	234.02	230.12
	Pure crop			207.93	Pure crop			217.70
SE of P(planting geometries) marginal mean	0.7532				0.7286			
SE of N(nitrogen levels) marginal mean	0.9224 (CD = 2.8424)				1.0930 (CD = 3.3681)			
SE of P x N Table	1.3046				1.4784			

branches (3.11). Nitrogen application favourably influenced the production of branches and application of 75 per cent N was significantly superior to the rest of the treatments (3.43). Pure crop of cowpea recorded the lowest number of branches(2.53).

In the case of planting geometries x N interaction the maximum number of branches was recorded for paired row planting x 75 per cent N (3.73). The following groups of treatments were found to be on par.

Group 1 : Normal row planting x 50 % N
Normal row planting x 100 % N
Paired row planting x 50 % N

Group 2 : Normal row planting x 75 % N
Paired row planting x 100 % N

It was seen that planting geometry significantly influenced the branching habit of lablab bean. Paired row planting increased the number of branches than normal row planting (5.14). Similarly production of branches due to N application was also significant and was maximum when supplied with 75 per cent N (5.58). Lowest number of branches was noticed in the pure crop (3.53). Interaction effect was not significant.

Number of branches had positive correlation with yield.

4.3.1.4. **Leaf : stem ratio**

The results on leaf : stem ratio of the intercrops are given in Table 15.

It was observed that leaf : stem ratio was not significantly influenced by planting geometries, but a lower ratio was recorded when cowpea was raised under normal row planting (3.34). Leaf : stem ratio increased with N levels and the highest ratio was obtained when supplied with 100 per cent N (3.44). The lowest leaf : stem ratio was recorded by the pure crop (3.08).

With regard to planting geometries x N interaction the lowest ratio was recorded by normal row planting x 50 per cent N. The following groups of treatments were found to be on par.

Group 1 : Paired row planting x 75 % N
Normal row planting x 75 % N
Paired row planting x 100 % N

Group 2 : Paired row planting x 100 % N
Normal row planting x 100 % N

Planting geometries had no significant influence on the leaf : stem ratio of lablab bean. However a comparatively lower ratio was reported when normal row planting was followed (3.53). Leaf : stem ratio due to N application was the least when 50 per cent N was applied (3.50). Pure crop recorded the lowest leaf : stem ratio (3.39). Interaction effect was not significant.

4.3.1.5 **Green fodder yield**

The results on green fodder yield of intercrops are presented in Table 16.

Planting geometries had significantly influenced the fodder production of cowpea. Paired row planting recorded the maximum green fodder yield (16.14 t ha^{-1}). Increased levels of nitrogen resulted in increased green fodder yield and was maximum when supplied with 75 per cent N (16.63 t ha^{-1}). Pure crop of cowpea recorded the lowest green fodder yield (15.79 t ha^{-1}). Interaction effect was not significant.

Comparatively higher green fodder yield of lablab bean was obtained when grown under paired row system of planting (17.26 t ha^{-1}). Green fodder yield in response to nitrogen application was found to be maximum with 75 per cent N

Table 14. **Effect of treatments on the number of branches of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Number of branches				Number of branches			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	2.2333	3.1333	2.2333	2.5333	3.2000	5.1000	4.1667	4.1556
Paired row planting	2.3333	3.7333	3.2667	3.1111	4.1000	6.0667	5.2667	5.1444
Mean	2.2833	3.4333	2.7500	2.8222	3.6500	5.5833	4.7167	4.6500
	Pure crop			2.5330	Pure crop			3.5330
SE of P(planting geometries) marginal mean	0.0613				0.0430			
SE of N(nitrogen levels) marginal mean	0.0750 (CD = 0.2311)				0.0525 (CD = 0.1618)			
SE of P x N Table	0.1061 (CD = 0.3270)				0.0744			

Table 15. **Effect of treatments on the leaf : stem ratio of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Leaf : stem ratio				Leaf : stem ratio			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	3.1833	3.3933	3.4533	3.3433	3.4800	3.5267	3.5933	3.5333
Paired row planting	3.2533	3.3767	3.4167	3.3489	3.5223	3.5800	3.6467	3.5833
Mean	3.2183	3.3850	3.4350	3.3461	3.5017	3.5533	3.6200	3.5583
	Pure crop			3.0830	Pure crop			3.3900
SE of P(planting geometries) marginal mean	0.0100				0.0066			
SE of N(nitrogen levels) marginal mean	0.01222 (CD = 0.0376)				0.0082 (CD = 0.0252)			
SE of P x N Table	0.0173 (CD = 0.0533)				0.0115			

level (17.68 t ha^{-1}). Pure crop produced reasonable yield and was higher than that obtained for 50 per cent N application (16.95 t ha^{-1}). The interaction effect was not significant.

4.3.1.6 **Dry fodder yield**

The results on dry fodder yield of the intercrops are given in Table 17.

The results showed that there was no significant impact of planting geometries on dry fodder yield of cowpea, but slightly higher yield was recorded under paired row system of planting (2.06 t ha^{-1}). Maximum dry fodder yield was found to be associated with 75 per cent N application (2.11 t ha^{-1}). The lowest dry fodder yield was recorded by the pure crop of cowpea (2.00 t ha^{-1}). Interaction was not significant.

There was no significant effect on dry fodder yield of lablab bean by planting geometries. A slight increasing trend in dry fodder yield was noticed under paired row system of planting (2.18 t ha^{-1}). A similar trend was noticed in the case of dry fodder production in response to N application and the maximum yield was obtained for 75 per cent N (2.24 t ha^{-1}). The lowest dry fodder yield was recorded by the pure crop (2.12 t ha^{-1}). Interaction was also not significant.

4.3.1.7 **Root spread of intercrops**

The data on the root spread of the intercrops are given in Table 18.

Planting geometries significantly influenced root spread of cowpea. Maximum root spread was noticed when cowpea was grown under paired row system of planting (13.22 cm). N application promoted root spread and the maximum spread was recorded when supplied with 100 per cent N (13.72 cm). Pure crop recorded the lowest root spread (12.17 cm). Interaction effect was not significant.

Table 16. **Effect of treatments on the green fodder yield of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Green fodder yield (t ha $^{-1}$)				Green fodder yield (t ha $^{-1}$)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	15.250	16.520	16.133	15.968	16.723	17.617	17.103	17.148
Paired row planting	15.413	16.743	16.253	16.137	16.860	17.747	17.173	17.260
Mean	15.332	16.632	16.193	16.052	16.792	17.682	17.138	17.204
	Pure crop			15.787	Pure crop			16.947
SE of P(planting geometries) marginal mean	0.0225				0.0250			
SE of N(nitrogen levels) marginal mean	0.0251 (CD = 0.0773)				0.0305 (CD = 0.0940)			
SE of P x N Table	0.0356				0.0432			

Table 17. **Effect of treatments on the dry fodder yield of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Dry fodder yield (t ha $^{-1}$)				Dry fodder yield (t ha $^{-1}$)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	1.9333	2.0933	2.0433	2.0233	2.0967	2.2200	2.1533	2.1567
Paired row planting	1.9600	2.1233	2.0600	2.0478	2.1000	2.2633	2.1733	2.1789
Mean	1.9467	2.1083	2.0517	2.0356	2.0983	2.2417	2.1633	2.1678
	Pure crop			2.0000	Pure crop			2.1200
SE of P(planting geometries) marginal mean	0.0028				0.0105			
SE of N(nitrogen levels) marginal mean	0.0034 (CD = 0.0105)				0.0130 (CD = 0.0400)			
SE of P x N Table	0.0048				0.0183			

Planting geometries had significant influence on the root spread of lablab bean. The maximum spread of 14.24 cm was recorded by lablab bean when grown under paired row system of planting. The rooting pattern of the crop responded positively to N application and the maximum spread was noticed with 100 per cent N application (14.48 cm). Pure crop recorded a root spread of13.33 cm. Interaction was not significant.

4.3.1. 8 **Root depth of intercrops**

Mean value on root depth of intercrops are given in Table 19.

Significant influence on root depth by different planting geometries was noticed in the case of cowpea. Root depth was maximum when raised under paired row planting system (21.61 cm). Application of N was helpful in promoting root depth and the maximum depth was recorded when supplied with 100 per cent N (20.77 cm). Pure crop of cowpea recorded the lowest root depth (19.33 cm). Interaction effect was not significant.

Planting geometries had significant effect on root depth of lablab bean and paired row planting was significantly superior to normal row planting (21.62 cm). N application enhanced the root growth and depth and was maximum with 100 per cent N (22.17 cm). This was on par with the root growth when supplied with 75 per cent N. Pure crop recorded the lowest root depth (19.73 cm).

With regard to planting geometries x N interaction the maximum root depth was recorded for paired row planting x 100 per cent N (23.07 cm).

The following groups of treatments were found to be on par.

Group 1: Normal row planting x 50 % N
Paired row planting x 50 % N

Table 18. **Effect of treatments on the root spread of intercrops**

Treatment combinations	Cowpea Root spread (cm) Nitrogen levels				Lablab bean Root spread (cm) Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	11.867	12.933	13.567	12.789	13.300	13.733	14.100	13.711
Paired row planting	12.467	13.333	13.867	13.222	13.567	14.300	14.867	14.244
Mean	12.167	13.133	13.717	13.006	13.433	14.037	14.483	13.978
	Pure crop			12.167	Pure crop			13.333
SE of P(planting geometries) marginal mean	0.1391				0.0586			
SE of N(nitrogen levels) marginal mean	0.1704 (CD = 0.5250)				0.0719 (CD = 0.2216)			
SE of P x N Table	0.2410				0.1016			

Table 19. **Effect of treatments on the root depth of intercrops**

Treatment combinations	Cowpea Root depth (cm) Nitrogen levels				Lablab bean Root depth (cm) Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	18.133	19.767	21.867	19.922	19.300	21.267	21.267	20.611
Paired row planting	19.967	21.867	23.000	21.611	19.533	22.267	23.067	21.622
Mean	19.050	20.817	22.433	20.767	19.417	21.767	22.167	21.117
	Pure crop			19.333	Pure crop			19.733
SE of P(planting geometries) marginal mean	0.3840				0.1231			
SE of N(nitrogen levels) marginal mean	0.4703 (CD = 1.4500)				0.1508 (CD = 0.4647)			
SE of P x N Table	0.6651				0.2132 (CD = 0.6570)			

Group 2: Normal row planting x 75 % N

Normal row planting x 100 % N

4.4 Chemical analysis

4.4.1 Crude protein content

The data on crude protein content of the intercrops are presented in Table 20.

It was seen that planting geometries had no significant effect on crude protein content of cowpea, but a slightly increasing trend was noticed when grown under paired row system of planting (19.91 per cent). Increased level of N tended to increase the crude protein content and was maximum with 75per cent N (20.31 per cent) . Pure crop recorded the lowest content of crude protein (19.42 per cent). Interaction effect was also not significant.

No significant influence on crude protein content due to planting geometries was observed in lablab bean. Paired row planting resulted in comparatively higher crude protein content (20.53 per cent). Maximum protein content in response to N application was associated with 75 per cent N (21.06 per cent). Pure crop recorded a protein content which was comparable to the other treatments(20.43 per cent). Interaction effect was not significant.

4.4.2. Crude fibre content

The results on crude fibre content of the legumes are given in Table 21.

There was not much difference in the crude fibre content of cowpea as influenced by planting geometries ; however a slightly lower fibre content was noticed with normal row planting system (24.39 per cent). An inverse relationship between N level and crude fibre content was noticed and the lowest crude fibre content was recorded with 100per cent N application (24.21 per cent). The maximum content of crude fibre was recorded by the pure crop (24.74 per cent). Interaction effect was also not significant.

It was observed that crude fibre content of lablab bean had no significant influence on planting geometries. Slightly lower content of crude fibre was noticed when grown under paired row system of planting (23.51 per cent). N application had inverse relationship with crude fibre content and the lowest content of crude fibre was recorded with 100per cent N (23.34 per cent). Pure crop recorded the maximum crude fibre content (23.91 per cent). Interaction effect was not significant.

4.4.3. **Nitrogen content**

The data on plant content of nitrogen of the intercrops are presented in Table 22.

No significant influence on nitrogen content of cowpea was noticed due to planting geometries. Paired row planting recorded comparatively higher content of nitrogen (3.18 per cent). Nitrogen content of the plant was maximum when supplied with 75per cent inorganic nitrogen (3.25 per cent). Pure crop recorded the lowest content of nitrogen (3.11 per cent). Interaction effect was also not significant.

Nitrogen content of lablab bean was not significantly influenced by planting geometries, but a comparatively higher nitrogen content was recorded when paired row system of planting was followed (3.29 per cent). Nitrogen application almost exhibited the same pattern and higher content of nitrogen was recorded when 75per cent N was applied(3.38 per cent). Pure crop recorded the lowest nitrogen content(3.22 per cent). Interaction effect was not significant.

Table 20. **Effect of treatments on the crude protein content of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Crude protein content (%)				Crude protein content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	19.020	20.229	19.833	19.694	19.750	20.937	20.312	20.333
Paired row planting	19.313	20.396	20.021	19.909	20.000	21.187	20.416	20.534
Mean	19.167	20.313	19.927	19.802	19.875	21.062	20.364	20.434
	Pure crop			19.417	Pure crop			19.875
SE of P(planting geometrics) marginal mean	0.0230				0.0182			
SE of N(nitrogen levels) marginal mean	0.0282 (CD = 0.0869)				0.0223 (CD = 0.0687)			
SE of P x N Table	0.0400				0.0316			

Table 21. **Effect of treatments on the crude fibre content of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Crude fibre content (%)				Crude fibre content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	24.540	24.357	24.203	24.367	23.717	23.513	23.343	23.524
Paired row planting	24.543	24.407	24.213	24.388	23.713	23.473	23.340	23.509
Mean	24.542	24.382	24.208	24.377	23.715	23.493	23.342	23.517
	Pure crop			24.740	Pure crop			23.903
SE of P(planting geometrics) marginal mean	0.0235				0.0149			
SE of N(nitrogen levels) marginal mean	0.0289 (CD = 0.0890)				0.0182 (CD = 0.0560)			
SE of P x N Table	0.0408				0.0258			

4.4.3.1. **Nitrogen uptake**

The data on uptake of nitrogen are given Table 23

Different planting geometries had significant effect on nitrogen uptake by cowpea and the highest value was recorded for paired row system of planting(65.07 kg ha^{-1}). Nitrogen application increased the uptake and was maximum when supplied with 75per cent N (68.49 kg ha^{-1}). The least uptake of nitrogen was recorded by the pure crop of cowpea (62.13 kg ha^{-1}). Interaction effect was not significant.

Considerable influence on N uptake due to planting geometries was not seen in lablab bean. Nominal increase in the uptake of N was recorded under paired row system of planting (71.40 kg ha^{-1}). Fairly significant effect on N uptake was noticed with inorganic nitrogen application and the maximum was recorded when 75per cent of N was applied (74.76 kg ha^{-1}). Uptake of N by the pure crop was poor and recorded the lowest uptake(67.94 kg ha^{-1}). Interaction effect was not significant.

4.4.4. **Phosphorus content**

The data on phosphorus content of intercrops are given in Table 24.

No significant effect on phosphorus content of cowpea was noticed by different planting geometries. Comparatively higher content of phosphorus was recorded when normal row system of planting was adopted(0.12 per cent). Phosphorus content remained unchanged under 75 per cent and 100 per cent N application (0.12 per cent). Pure crop recorded the maximum phosphorus content(0.12 per cent).

In the case of planting geometries x N interaction, the following groups of treatments were found to be on par.

Table 22. **Effect of treatments on the nitrogen content of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Nitrogen content (%)				Nitrogen content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	3.0433	3.2367	3.1733	3.1511	3.1567	3.3533	3.2500	3.2533
Paired row planting	3.0900	3.2600	3.2033	3.1844	3.2067	3.3900	3.2833	3.2933
Mean	3.0667	3.2483	3.1883	3.1678	3.1817	3.3717	3.2667	3.2733
	Pure crop			3.1070	Pure crop			3.2170
SE of P(planting geometries) marginal mean	0.0033				0.0047			
SE of N(nitrogen levels) marginal mean	0.0041 (CD = 0.0126)				0.0057 (CD = 0.0175)			
SE of P x N Table	0.0057				0.0082			

Table 23. **Effect of treatments on the nitrogen uptake by the intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Nitrogen uptake (kg ha^{-1})				Nitrogen uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	58.837	67.753	64.827	63.806	66.673	74.033	70.090	70.266
Paired row planting	60.563	69.217	65.437	65.072	67.730	75.480	70.983	71.398
Mean	59.700	68.485	65.132	64.439	67.202	74.757	70.537	70.832
	Pure crop			62.133	Pure crop			67.943
SE of P(planting geometries) marginal mean	0.1827				0.1285			
SE of N(nitrogen levels) marginal mean	0.2237 (CD = 0.6893)				0.1574 (CD = 0.4850)			
SE of P x N Table	0.3164				0.2226			

Group 1: Paired row planting x 100 % N
Normal row planting x 50 % N
Paired row planting x 75 % N

Group 2: Normal row planting x 75% N
Paired row planting x 50 % N
Normal row planting x 100 %N

It was seen that planting geometries had not influenced the phosphorus content of lablab bean. Slightly increased content of phosphorus was noticed under normal row system of planting(0.23 per cent). Comparatively higher content of phosphorus was recorded when 75 per cent N was applied(0.23 per cent). Pure crop recorded the maximum phosphorus content(0.24 per cent). Interaction effect was not significant.

4.4.4.1. **Phosphorus uptake**

The results on phosphorus uptake by the intercrops are given in Table 25.

There was no significant effect on phosphorus uptake by cowpea due to planting geometries. Slightly increased uptake was noticed when raised under normal row system of planting (2.43 kg ha^{-1}). Similar trend was noticed in the case of N application and comparatively higher uptake was noticed when supplied with 75 per cent N (2.50 kg ha^{-1}). The maximum uptake of phosphorus was recorded by the pure crop (2.50 kg ha^{-1}). Interaction effect was not significant.

No significant effect on phosphorus uptake of lablab bean due to planting geometries was noticed. Higher uptake of phosphorus was recorded under normal row system of planting (4.50 kg ha^{-1}). Maximum uptake of phosphorus in response to N application was recorded when 75 per cent N was applied (5.19 kg

ha^{-1}). Performance of the pure crop was good (5.16 kg ha^{-1}). Interaction effect was not significant.

4.4.5 **Potassium content**

The data on the content of potassium are presented in Table 26.

Planting geometries had no significant effect on potassium content of cowpea. Comparatively higher content of the nutrient was noticed with paired row system of planting (1.24 per cent). Higher content of potassium due to N application was recorded when supplied with 100 per cent N (1.25 per cent). Pure crop recorded the maximum content of potassium(1.29 per cent). Interaction effect was not significant.

The influence of planting geometries on potassium content of lablab bean was not significant and paired row planting recorded higher nutrient content when compared to normal row system of planting (0.84 per cent). Potassium content exhibited a declining trend with increased N levels and higher content of potassium was recorded when 50 per cent N was applied (0.84 per cent). The maximum content of potassium was recorded by the pure crop (0.85 per cent).

In the case of planting geometries x N interaction, the maximum content of potassium was recorded for paired row planting x 75 per cent N (0.81 per cent). The performance of the following groups of treatments in respect of potassium content were on par.

Group 1 : Normal row planting x 75 % N
Normal row planting x 100 % N
Paired row planting x 50 % N
Paired row planting x 100 % N

Table 24. **Effect of treatments on the phosphorus content of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Phosphorus content (%)				Phosphorus content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	0.1133	0.1200	0.1267	0.1200	0.2267	0.2500	0.2167	0.2311
Paired row planting	0.1200	0.1167	0.1100	0.1156	0.1933	0.2133	0.2433	0.2167
Mean	0.1167	0.1183	0.1183	0.1178	0.2100	0.2317	0.2300	0.2239
	Pure crop			0.1230	Pure crop			0.2430
SE of P(planting geometries) marginal mean	0.0018				0.0094			
SE of N(nitrogen levels) marginal mean	0.0022 (CD = 0.0068)				0.0120			
SE of P x N Table	0.0032 (CD = 0.0099)				0.0163			

Table 25. **Effect of treatments on the phosphorus uptake by the intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Phosphorus uptake (kg ha^{-1})				Phosphorus uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	2.1907	2.5120	2.5883	2.4303	4.7543	5.5570	4.6677	4.9930
Paired row planting	2.2867	2.4773	2.3347	2.3662	4.0590	4.8303	5.2867	4.7253
Mean	2.2387	2.4947	2.4615	2.3983	4.4067	5.1937	4.9772	4.8592
	Pure crop			2.4970	Pure crop			4.8592
SE of P(planting geometries) marginal mean	0.0489				0.2040			
SE of N(nitrogen levels) marginal mean	0.0600 (CD = 0.1850)				0.2498			
SE of P x N Table	0.0847				0.3534			

Group 2 : Paired row planting x 50 % N
Paired row planting x 100 % N
Normal row planting x 50 % N

Group 3 : Paired row planting x 100 % N
Normal row planting x 50 % N
Paired row planting x 75 % N

4.4.5.1. **Potassium uptake**

The results on the uptake of potassium are given in Table 27.

Significant effect on the uptake of potassium by planting geometries was noticed in cowpea. Planting under paired row system resulted in the maximum uptake of potassium (25.46 kg ha^{-1}). Potassium uptake in response to N application was higher when supplied with 75 per cent N, though it was on par with 100 per cent N application (26.08 kg ha^{-1}). Pure crop recorded the lowest uptake of potassium (25.80 kg ha^{-1}). Interaction effect was not significant.

Noticeable effect on potassium uptake due to planting geometries was not seen in lablab bean. Comparatively higher uptake of potassium was recorded when paired row system of planting was undertaken (18.13 kg ha^{-1}). Higher uptake of potassium in response to N application was recorded when 75 per cent N was applied (18.42 kg ha^{-1}). Pure crop recorded an uptake of 18.02 kg ha^{-1} which was comparable with rest of the treatments.

In the case of planting geometries x N interaction, the maximum uptake of potassium was recorded with paired row planting x 75 per cent N (19.61 kg ha^{-1}). The performance of the following groups of treatments with respect to potassium uptake were found to be on par.

Group 1 : Paired row planting x 50 % N
Normal row planting x 100 % N
Normal row planting x 75 % N
Paired row planting x 100 % N

Group 2 : Normal row planting x 100 % N
Normal row planting x 75 % N
Paired row planting x 100 % N
Paired row planting x 50 % N

Group 3 : Normal row planting x 50 % N
Paired row planting x 75 % N

4.4.6 **Calcium content**

The mean values on calcium content of intercrops are given in Table 28.

Nutrient content was found to have differential response to planting geometries and higher content of calcium was recorded by cowpea when normal row system of planting was followed (1.34 per cent). The maximum content of calcium due to nitrogen application was recorded when 50 per cent N was applied. The nutrient content under 75 per cent and 100 per cent N as well as 50 per cent and 100 per cent N were found to be on par. The lowest content of calcium was recorded by the pure crop of cowpea (1.28 per cent). The interaction effect was not significant.

There was no significant effect on the content of calcium in lablab bean due to planting geometries. Slightly higher content of calcium was noticed when normal row planting was undertaken (1.16 per cent). Similarly higher content of calcium due to nitrogen application was recorded when 100 per cent N was applied

Table 26. **Effect of treatments on the potassium content of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Potassium content (%)				Potassium content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	1.2167	1.2100	1.2333	1.2200	0.8800	0.7900	0.7933	0.8211
Paired row planting	1.2000	1.2633	1.2633	1.2422	0.8067	0.8900	0.8200	0.8389
Mean	1.2083	1.2367	1.2483	1.2311	0.8433	0.8400	0.8067	0.8300
	Pure crop			1.2900	Pure crop			0.8500
SE of P(planting geometrics) marginal mean	0.0160				0.0141			
SE of N(nitrogen levels) marginal mean	0.0195				0.0173			
SE of P x N Table	0.0276				0.0245 (CD = 0.0755)			

Table 27. **Effect of treatments on the potassium uptake by the intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Potassium uptake (kg ha^{-1})				Potassium uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	23.532	25.329	25.201	24.687	18.458	17.231	17.084	17.591
Paired row planting	23.525	26.826	26.027	25.459	16.941	19.612	17.823	18.125
Mean	23.529	26.078	25.614	25.073	17.699	18.422	17.454	17.858
	Pure crop			25.801	Pure crop			18.022
SE of P(planting geometrics) marginal mean	0.3293				0.2575			
SE of N(nitrogen levels) marginal mean	0.4034 (CD = 1.2431)				0.3154			
SE of P x N Table	0.5705				0.4460 (CD = 1.3743)			

(1.17 per cent). The lowest content of calcium was recorded by the pure crop (1.14 per cent). Interaction effect was not significant.

4.4.6.1. **Calcium uptake**

The results on the uptake of calcium are presented in Table 29.

Uptake of calcium was found to be maximum in cowpea when normal row system of planting was adopted (27.13 kg ha^{-1}). Consequently the uptake of calcium in response to nitrogen application was maximum when supplied with 75 per cent N (27.62 kg ha^{-1}). Pure crop recorded the lowest uptake (25.54 kg ha^{-1}).

With regard to planting geometries x N interaction, the maximum uptake was recorded with normal row planting x 75 per cent N (27.98 kg ha^{-1}). The following groups of treatments were found to be on par.

Group 1 : Normal row planting x 50 % N
Paired row planting x 50 % N

Group 2 : Paired row planting x 50 % N
Paired row planting x 100 % N
Paired row planting x 75 % N

Group 3 : Paired row planting x 100 % N
Paired row planting x 75 % N
Normal row planting x 100 % N
Normal row planting x 75 % N

The influence of planting geometries on the uptake of calcium was not significant in lablab bean. When compared to paired row planting, raising of crop under normal row system of planting recorded higher uptake of calcium (25.07 kg ha^{-1}). The maximum uptake of calcium due to nitrogen application was recorded when supplied with 100 per cent N (25.24 kg ha^{-1}). Pure crop recorded the lowest uptake (24.27 kg ha^{-1}). Interaction effect was also not significant.

4.4.7. **Magnesium content**

The data on magnesium content of intercrops are given in Table 30.

The nutrient content remained constant under both systems of planting and there was no significant influence noticed in cowpea. Nutrient content in response to nitrogen supplementation was maximum with 100 per cent N (0.43 per cent). The lowest content of magnesium was recorded by the pure crop (0.41 per cent). Interaction effect was not significant.

No significant effect on magnesium content of lablab bean due to planting geometries was noticed. Comparative effect was more for the crop when grown under paired row system of planting (0.37 per cent). Slight inverse relationship was noticed with magnesium content and N application and the maximum content of magnesium was recorded when 50 per cent N was applied (0.37 per cent). The lowest content of magnesium was recorded by the pure crop of lablab bean (0.36 per cent). Interaction effect was not significant.

4.3.7.1. **Magnesium uptake**

The results on the uptake of magnesium are presented in Table 31.

It was observed that there was significant influence on the uptake of magnesium in cowpea by planting geometries. Nominal increase in nutrient uptake was recorded when paired row system of planting was followed (8.67 kg ha^{-1}). Similarly higher uptake of magnesium was experienced when supplied with 75 per cent N (8.88 kg ha^{-1}). Uptake of magnesium in response to N application was on par for 50 per cent and 100 per cent as well as 75 per cent and 100 per cent N. Interaction effect was not significant.

Table 28. **Effect of treatments on the calcium content of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Calcium content (%)				Calcium content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	1.3433	1.3367	1.3433	1.3411	1.1700	1.1467	1.1667	1.1611
Paired row planting	1.3500	1.2833	1.3200	1.3178	1.1567	1.1367	1.1700	1.1544
Mean	1.3467	1.3100	1.3317	1.3294	1.1633	1.1417	1.1683	1.1578
	Pure crop			1.2770	Pure crop			1.1400
SE of P(planting geometries) marginal mean	0.0075				0.0066			
SE of N(nitrogen levels) marginal mean	0.0091 (CD = 0.0280				0.0082			
SE of P x N Table	0.0130				0.0120			

Table 29. **Effect of treatments on the calcium uptake by the intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Calcium uptake (kg ha^{-1})				Calcium uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	25.971	27.980	27.452	27.134	25.017	25.023	25.160	25.067
Paired row planting	26.465	27.254	27.194	26.971	24.483	24.977	25.310	24.923
Mean	26.218	27.617	27.323	27.053	24.750	25.000	25.235	24.995
	Pure crop			25.541	Pure crop			24.270
SE of P(planting geometrics) marginal mean	0.1662				0.1558			
SE of N(nitrogen levels) marginal mean	0.2040 (CD = 0.6286)				0.1909			
SE of P x N Table	0.2878 (CD = 0.8869)				0.2700			

The results indicated that there was no significant effect on the uptake of magnesium due to planting geometries in lablab bean. Comparatively higher uptake of magnesium was noticed when paired row planting was adopted (8.02 kg ha^{-1}). The uptake of magnesium in response to N application was found to be maximum when 75 per cent N was applied (7.96 kg ha^{-1}). Pure crop performed less and recorded the lowest uptake of magnesium (7.60 kg ha^{-1}). Interaction effect also was not significant.

4.5 Soil analysis after the experiment

4.5.1 Physical properties of the soil

The data on physical properties of the soil after completion of the experiment are presented in Table. 1.2.

In general, grass-legume mixture had significant influence on the physical properties of the soil. A substantial decrease in the bulk density of the soil was noticed. Improvement in porosity and waterholding capacity of the soil was also noticed due to the adoption of grass-legume mixture.

4.5.2. Nitrogen

The data on nitrogen status of the soil after the experiment are given in Table 32.

Considerable improvement in nitrogen status was noticed after completion of the experiment. The plots where normal row planting was undertaken recorded more nitrogen content (294.31 kg ha^{-1}). Intercropping with lablab bean was found to be better and recorded more N content than cowpea (305.46 kg ha^{-1}). Application of inorganic nitrogen had residual effect on soil nitrogen level and was maximum when supplied with 100 per cent N (298.88 kg ha^{-1}). Nitrogen content

Table 30. **Effect of treatments on the magnesium content of intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Magnesium content (%)				Magnesium content (%)			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	0.4233	0.4200	0.4200	0.4211	0.3667	0.3600	0.3600	0.3622
Paired row planting	0.4133	0.4167	0.4333	0.4211	0.3733	0.3633	0.3733	0.3700
Mean	0.4183	0.4183	0.4267	0.4211	0.3700	0.3617	0.3667	0.3661
	Pure crop			0.4100	Pure crop			0.3570
SE of P(planting geometries) marginal mean	0.0047				0.0033			
SE of N(nitrogen levels) marginal mean	0.0058				0.0041			
SE of P x N Table	0.0082				0.0058			

Table 31. **Effect of treatments on the magnesium uptake by the intercrops**

Treatment combinations	Cowpea				Lablab bean			
	Magnesium uptake (kg ha^{-1})				Magnesium uptake (kg ha^{-1})			
	Nitrogen levels				Nitrogen levels			
	50 % N	75 % N	100 % N	Mean	50 % N	75 % N	100 % N	Mean
Normal row planting	8.1847	8.7923	8.5817	8.5196	7.5920	7.8330	7.7633	7.7294
Paired row planting	8.3200	8.9720	8.7060	8.6660	7.9003	8.0903	8.0767	8.0224
Mean	8.2523	8.8822	8.6438	8.5928	7.7462	7.9617	7.9200	7.8759
	Pure crop			8.1050	Pure crop			7.5850
SE of P(planting geometrics) marginal mean	0.1255				0.0820			
SE of N(nitrogen levels) marginal mean	0.1538 (CD = 0.4740)				0.1004			
SE of P x N Table	0.2175				0.1420			

of 261.56, 314.17 and 320.98 kg ha^{-1} were recorded in plots where pure crops of hybrid napier, cowpea and lablab bean respectively were grown.

In the case of planting geometries x intercrops interaction, maximum nitrogen content of 307.13 kg ha^{-1} was recorded by normal row planting x lablab bean. The nitrogen content of paired row planting x cowpea was on par with normal row planting x cowpea. With regard to planting geometries x nitrogen interaction, maximum nitrogen content was noticed with normal row planting x 100 per cent N (302.10 kg ha^{-1}). The maximum content of nitrogen was noticed with lablab bean x 75 per cent N in the case of intercrops x N interaction (314.84 kg ha^{-1}). As far as planting geometries x intercrops x nitrogen interaction is concerned, all the treatments differed significantly and the maximum nitrogen content was observed with paired row planting x lablab bean x 75 per cent N.

4.5.3 **Phosphorus**

The results on the phosphorus level of the soil after the experiment are given in Table 33.

Slight increase in phosphorus level of the soil was noticed. Paired row planting resulted in higher content of phosphorus than normal row planting (48.24 kg ha^{-1}). Raising lablab bean as the intercrop recorded more phosphorus content (48.30 kg ha^{-1}). Phosphorus content of the soil was maximum when 75 per cent N was applied (49.21 kg ha^{-1}). Pure crops of hybrid napier, cowpea and lablab bean recorded 41.07, 47.10 and 46.72 kg ha^{-1} of phosphorus respectively.

With regard to planting geometries x intercrops interaction, the maximum phosphorus content of 49.20 kg ha^{-1} was recorded by normal row planting x lablab bean. This was on par with the phosphorus content of paired row planting x

Table 32 **Nitrogen status of the soil after the experiment**

Treatment combinations	Nitrogen levels			
	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	279.37	275.54	289.56	281.49
Normal row planting x lablab bean	294.17	312.57	314.64	307.13
Paired row planting x cowpea	268.88	281.54	292.81	281.08
Paired row planting x lablab bean	295.75	317.10	298.52	303.79
Normal row planting	286.77	294.05	302.10	294.31
Paired row planting	282.31	299.32	295.66	292.43
Cowpea	274.12	278.54	291.19	281.28
Lablab bean	294.96	314.84	306.58	305.46
	Nitrogen levels			
	50 % N	75 % N	100 % N	Mean
	284.54	296.69	298.88	293.37
Pure crop	Hybrid napier			261.56
	Cowpea			314.17
	Lablab bean			320.98
SE of P (planting geometries) marginal mean	0.2052			
SE of I (intercrops) marginal mean	0.2052			
SE of N (nitrogen levels) marginal mean	0.2513 (CD = 0.7248)			
SE of body of P x I Table	0.2902 (CD = 0.8405)			
SE of body of P x N Table	0.3553 (CD = 1.0290)			
SE of body of I x N Table	0.3553 (CD = 1.0290)			
SE of body of P x I x N Table	0.5026 (CD = 1.4556)			

Table 33. **Phosphorus status of soil after the experiment**

Treatment combinations	Nitrogen levels 50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	44.113	46.903	42.163	44.393
Normal row planting x lablab bean	48.973	50.400	48.237	49.203
Paired row planting x cowpea	42.963	53.513	50.790	49.089
Paired row planting x lablab bean	48.127	46.010	48.050	47.396
Normal row planting	46.543	48.652	45.200	46.798
Paired row planting	45.545	49.762	49.420	48.242
Cowpea	43.538	50.208	46.477	46.741
Lablab bean	48.550	48.205	48.143	48.299
	Nitrogen levels			
	50 % N	75 % N	100 % N	Mean
	46.044	49.207	47.310	47.520
Pure crop	Hybrid napier			41.067
	Cowpea			47.103
	Lablab bean			460720
SE of P (planting geometries) marginal mean	0.1178			
SE of I (intercrops) marginal mean	0.1178			
SE of N (nitrogen levels) marginal mean	0.1442 (CD = 0.4176)			
SE of body of P x I Table	0.1665 (CD = 0.4822)			
SE of body of P x N Table	0.2040 (CD = 0.5908)			
SE of body of I x N Table	0.2040 (CD = 0.5908)			
SE of body of P x I x N Table	0.2884 (CD = 0.8353)			

cowpea. In the case of planting geometries x N interaction, group 1 and group 2 were on par.

Group 1 : Normal row planting x 100 % N
Paired row planting x 50 % N

Group 2 : Paired row planting x 100 % N
Paired row planting x 75 % N

The performance of lablab bean x 100 per cent N, lablab bean x 75 per cent N and lablab bean x 50 per cent N were on par with respect to intercrops x N interaction. As far as planting geometries x intercrops x nitrogen interaction was concerned, phosphorus content of the following groups of treatments were found to be on par.

Group 1 : Normal row planting x cowpea x 100 % N
Paired row planting x cowpea x 50 % N

Group 2 : Paired row planting x lablab bean x 100 % N
Paired row planting x lablab bean x 50 % N
Normal row planting x lablab bean x 100 % N

Group 3 : Normal row planting x lablab bean x 100 % N
Normal row planting x lablab bean x 50 % N

Group 4 : Normal row planting x lablab bean x 75 % N
Paired row planting x cowpea x 100 % N

4.5.4. **Potassium**

The results on the level of potassium after the experiment are given in Table 34.

It was observed that the experiment improved the potassium content of the soil. Higher content of potassium was recorded in plots where paired row system of planting was undertaken (142.36 kg ha^{-1}). Intercropping with lablab bean was significantly superior to cowpea and recorded higher content of potassium (152.17 kg ha^{-1}). Maximum content of potassium was recorded in the soil when supplied with 100 per cent N (149.91 kg ha^{-1}). Pure crops of hybrid napier, cowpea and lablab bean recorded a potassium content of 126.68, 141.93 and 140.30 kg ha^{-1} respectively.

In the case of planting geometries x N interaction, the performance of paired row planting x 50 per cent N and paired row planting x 75 per cent N were on par. Similar effect was noticed by normal row planting x lablab bean and paired row planting x lablab bean in the case of planting geometries x intercrops interaction. With regard to intercrops x N interaction, the performance of normal row planting x 50 per cent N and normal row planting x 75 per cent N on the content of potassium were on par. As far as the planting geometries x intercrops x N interaction is concerned, maximum potassium content was recorded with normal row planting x lablab bean x 100 per cent N (161.98 kg ha^{-1}). The performance of the following groups of treatments were on par.

Group 1: Normal row planting x cowpea x 75 % N
Paired row planting x cowpea x 50 % N

Group 2 : Normal row planting x cowpea x 50 % N
Paired row planting x cowpea x 75 % N

Group 3 : Paired row planting x lablab bean x 100 % N
Normal row planting x lablab bean x 100 % N

Table 34. **Potassium status of soil after the experiment**

Treatment combinations	Nitrogen levels			
	50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	129.83	125.68	134.88	130.13
Normal row planting x lablab bean	151.00	143.20	161.98	152.06
Paired row planting x cowpea	125.72	130.40	141.23	132.45
Paired row planting x lablab bean	149.46	145.78	161.55	152.27
Normal row planting	140.42	134.44	148.43	141.10
Paired row planting	137.59	138.10	151.39	142.36
Cowpea	127.77	128.04	138.06	131.29
Lablab bean	150.24	144.50	161.77	152.17
	Nitrogen levels			
	50 % N	75 % N	100 % N	Mean
	139.00	136.27	149.91	141.73
Pure crop	Hybrid napier			126.68
	Cowpea			141.93
	Lablab bean			140.30
SE of P (planting geometries) marginal mean	0.1188			
SE of I (intercrops) marginal mean	0.1188			
SE of N (nitrogen levels) marginal mean	0.1456 (CD = 0.4217)			
SE of body of P x I Table	0.1681 (CD = 0.4868)			
SE of body of P x N Table	0.2060 (CD = 0.5966)			
SE of body of I x N Table	0.2060 (CD = 0.5966)			
SE of body of P x I x N Table	0.2912 (CD = 0.8434)			

Soil reaction remained unchanged due to the adoption of grass-legume mixture.

4.6. Biosuitability parameters

4.6.1. Aggressivity

The results on the aggressivity of different treatment combinations are presented in Table 35.

Aggressivity values indicated differential response to various treatments. Paired row system of planting was significantly superior to normal row planting and recorded higher aggressivity value (0.43). With regard to the intercrops, lablab bean was found to be more aggressive than cowpea (0.42). Highest value for aggressivity was recorded when 100 per cent N was applied (0.43).

In the case of planting geometries x intercrops interactions, all the treatments differed significantly and paired row planting x lablab bean recorded the highest value (0.44). With regard to planting geometries x N interaction, the highest value was recorded for paired row planting x 100 per cent N (0.44). The performance of normal row planting x 100 per cent N, paired row planting x 50 per cent N and paired row planting x 75 per cent N were found to be on par.

4.6.2 Land Equivalent Ratio (LER)

The data on the land equivalent ratio of various treatment combinations are given in Table 36.

Land equivalent ratio varied with respect to various treatments. Paired row system of planting was comparatively better than normal row planting and recorded higher ratio (2.28). LER was found to be high when lablab bean was

Table 35. **Effects of treatments on aggressivity**

Treatment combinations	Nitrogen levels 50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	0.3580	0.3820	0.4070	0.3820
Normal row planting x lablab bean	0.3630	0.3970	0.4230	0.3940
Paired row planting x cowpea	0.4090	0.4100	0.4280	0.4160
Paired row planting x lablab bean	0.4230	0.4300	0.4600	0.4380
Normal row planting	0.3610	0.3890	0.4150	0.3880
Paired row planting	0.4160	0.4200	0.4440	0.4270
Cowpea	0.3840	0.3960	0.4180	0.3990
Lablab bean	0.3930	0.4130	0.4420	0.4160
	Nitrogen levels			
	50 % N	75 % N	100 % N	Mean
	0.3880	0.4050	0.4300	0.4076
SE of P (planting geometries) marginal mean	0.0011			
SE of I (intercrops) marginal mean	0.0011			
SE of N (nitrogen levels) marginal mean	0.0013 (CD = 0.0038)			
SE of body of P x I Table	0.0015 (CD = 0.0044)			
SE of body of P x N Table	0.0018 (CD = 0.0053)			
SE of body of I x N Table	0.0018 (CD = 0.0053)			
SE of body of P x I x N Table	0.0026			

grown as the intercrop (2.26). Highest value for LER in response to N application was recorded when supplied with 100 per cent N (2.29).

As far as planting geometries x intercrops interaction is concerned, the highest value of 2.31 was obtained for paired row planting x lablab bean. In the case of planting geometries x N interaction, highest LER was obtained for paired row planting x 100 per cent N (2.33). The following groups of treatments were found to be on par.

Group 1 : Normal row planting x 75 % N

Normal row planting x 100 % N

Group 2 : Paired row planting x 75 % N

Paired row planting x 100 % N

4.7 **Economics of cultivation**

The data on economics of cultivation are given in Table. 37.

It was seen that the net profit resulting from fodder production was maximum when paired row system of planting was undertaken with lablab bean as the intercrop and supplemented with 100 per cent N (Rs. 46579), followed closely by the treatment paired row planting x lablab bean x 75 per cent N (Rs. 44673.50). The minimum net profit of Rs. 25630 was obtained when pure cropping of hybrid napier was practised.

Table 36. **Effect of treatments on Land Equivalent Ratio (LER)**

Treatment combinations	Nitrogen levels 50 % N	75 % N	100 % N	Mean
Normal row planting x cowpea	2.0680	2.2300	2.2460	2.1810
Normal row planting x lablab bean	2.1090	2.2490	2.2600	2.2060
Paired row planting x cowpea	2.1860	2.2790	2.3090	2.2580
Paired row planting x lablab bean	2.2510	2.3260	2.3400	2.3060
Normal row planting	2.0890	2.2390	2.2530	2.1940
Paired row planting	2.2180	2.3020	2.3250	2.2820
Cowpea	2.1270	2.2540	2.2780	2.2200
Lablab bean	2.1800	2.2870	2.3000	2.2560
	Nitrogen levels			
	50 % N	75 % N	100 % N	Mean
	2.1530	2.2710	2.2890	2.2377
SE of P (planting geometries) marginal mean	0.0041			
SE of I (intercrops) marginal mean	0.0041			
SE of N (nitrogen levels) marginal mean	0.0050 (CD = 0.0147)			
SE of body of P x I Table	0.0058 (CD = 0.0170)			
SE of body of P x N Table	0.0071 (CD = 0.0208)			
SE of body of I x N Table	0.0071 (CD = 0.0208)			
SE of body of P x I x N Table	0.0100			

Tab 37. **Economics of fodder cultivation (per hectare per year)***

Treatments	Cost of cultivation of hybrid napier (Rs)	Additional cost for intercropping (Rs)	Total cost of cultivation (Rs)	Yield of fodder (t ha^{-1})			Gross income (Rs)	Net profit (Rs)
				Hybrid napier (5 harvests)	Intercrop (1 harvest)	Total		
Normal row planting x cowpea x 50 % N	58640	4775	63415	180.54	15.250	195.79	97892.50	34477.50
Normal row planting x cowpea x 75 % N	61370	4790	66160	193.90	16.520	210.42	105210.00	39050.00
Normal row planting x cowpea x 100 % N	62840	4805	67645	200.49	16.133	216.62	108309.00	40664.00
Normal row planting x lablab bean x 50 % N	59270	4775	64045	183.77	16.723	200.49	100244.00	36199.00
Normal row planting x lablab bean x 75 % N	62090	4790	66880	198.07	17.617	215.68	107841.00	40961.00
Normal row planting x lablab bean x 100 % N	63650	4805	68455	204.84	17.103	221.94	110969.00	42514.00
Paired row planting x cowpea x 50 % N	61790	4775	66565	198.09	15.413	213.50	106749.00	40184.00
Paired row planting x cowpea x 75 % N	63170	4790	67960	203.95	16.743	220.69	110346.50	42386.50
Paired row planting x cowpea x 100 % N	64190	4805	68995	207.94	16.253	224.19	112094.00	43099.00
Paired row planting x lablab bean x 50 % N	62870	4775	67645	203.85	16.860	220.71	110355.00	42710.00
Paired row planting x lablab bean x 75 % N	64160	4790	68950	209.50	17.747	227.25	113623.50	44673.50
Paired row planting x lablab bean x 100 % N	65810	4805	70615	217.22	17.173	234.39	117194.00	46579.00
Pure crop of hybrid napier	56270	-	56270	163.80	-	163.80	81900.00	25630.00

1 kg nitrogen - Rs 6.00 1 kg phosphorus - Rs 7.80 1 kg potassium - Rs 7.00
1 kg fodder - Rs 0.50 Labour charge (both for man and woman) - Rs 90 per head

* Data not analysed

DISCUSSION

DISCUSSION.

The discussion on the results of the experiment pertaining to studies on intensive fodder production through legume intercropping in hybrid napier are presented in this chapter.

5.1. Studies on grass {Bajra - Napier Hybrid grass (variety CO - 2)}

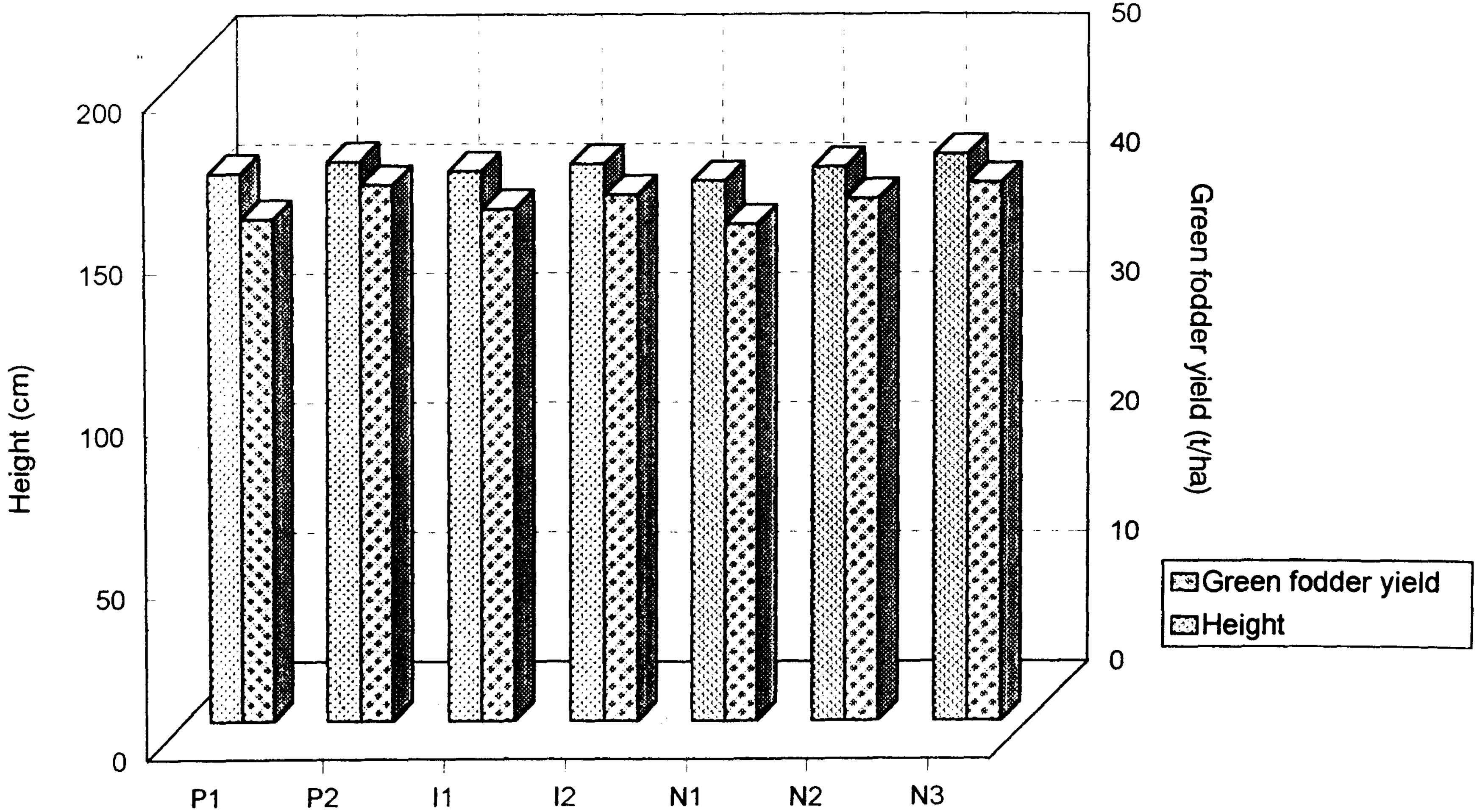
5.1.1. Growth components of the grass

The results of the present study indicated that the plant height, tiller count, leaf area index (LAI), spread and depth were significantly influenced by the treatments viz. planting geometries, intercrops and nitrogen levels.

It was observed from the data that maximum plant height was recorded when the grass was grown under paired row system of planting (Table 2). Probably this may be because of the least competition for moisture, nutrients, light and space within the grass. Advantages of paired row system of planting was reported in *Cenchrus ciliaris* by Mahander Singh (1984). The results of of the present study are in conformity with the results obtained by Sasireka (1992) in hybrid napier. The results further revealed that height of the grass increased significantly due to intercropping of legumes. The increasing trend in height was higher with lablab bean. Legumes being spreading in growth habit cover the entire interspaces of the grass and later compete with it for solar radiation which resulted in increased height of the grass. Similar increase in height of the grass in a legume intercropping system was reported by Paneerselvam (1986). Application of inorganic nitrogen besides legume intercropping also enhanced the height of grass significantly. Increase in height of hybrid napier was noticed with every increment in nitrogen level and the maximum height was recorded when 100 per cent N was applied. This might be due to the better availability of applied N through the combination of organic and inorganic sources. This might have resulted in increased cell division, cell enlargement and chlorophyll synthesis which ultimately resulted in better growth and increased height of the grass. Increase in plant height of hybrid napier due to nitrogen application was reported by Thomas (1978) and that of maize by Gangwar and Niranjan (1991). The interaction between planting geometries and intercrops was significant and paired row planting x lablab bean was found to be superior. Availability of more space between paired rows of the grass would also have contributed to this effect. Thus the combined beneficial effects of all treatments resulted in the maximum height of hybrid napier when raised under paired row system of planting with lablab bean as intercrop and supplemented with 100 per cent N. Since plant height forms a component of vegetative growth, it is more important as far as fodder crops are concerned. The plant height had significant and positive correlation with fodder yield (Fig. 1).

As seen from the data, the tiller production was higher under paired row system of planting (Table 3). The wider space between paired rows allowed the plants to take full advantage of light and plant nutrients, resulting in the production of more number of tillers. This result was in accordance with the findings of Dhillon and Panwar (1979) and Veeraraghaviah *et al.* (1979). It was also noticed that tiller production of the grass was significantly enhanced

Fig. 1 Height and yield of hybrid napier as influenced by planting geometries, intercrops and nitrogen levels



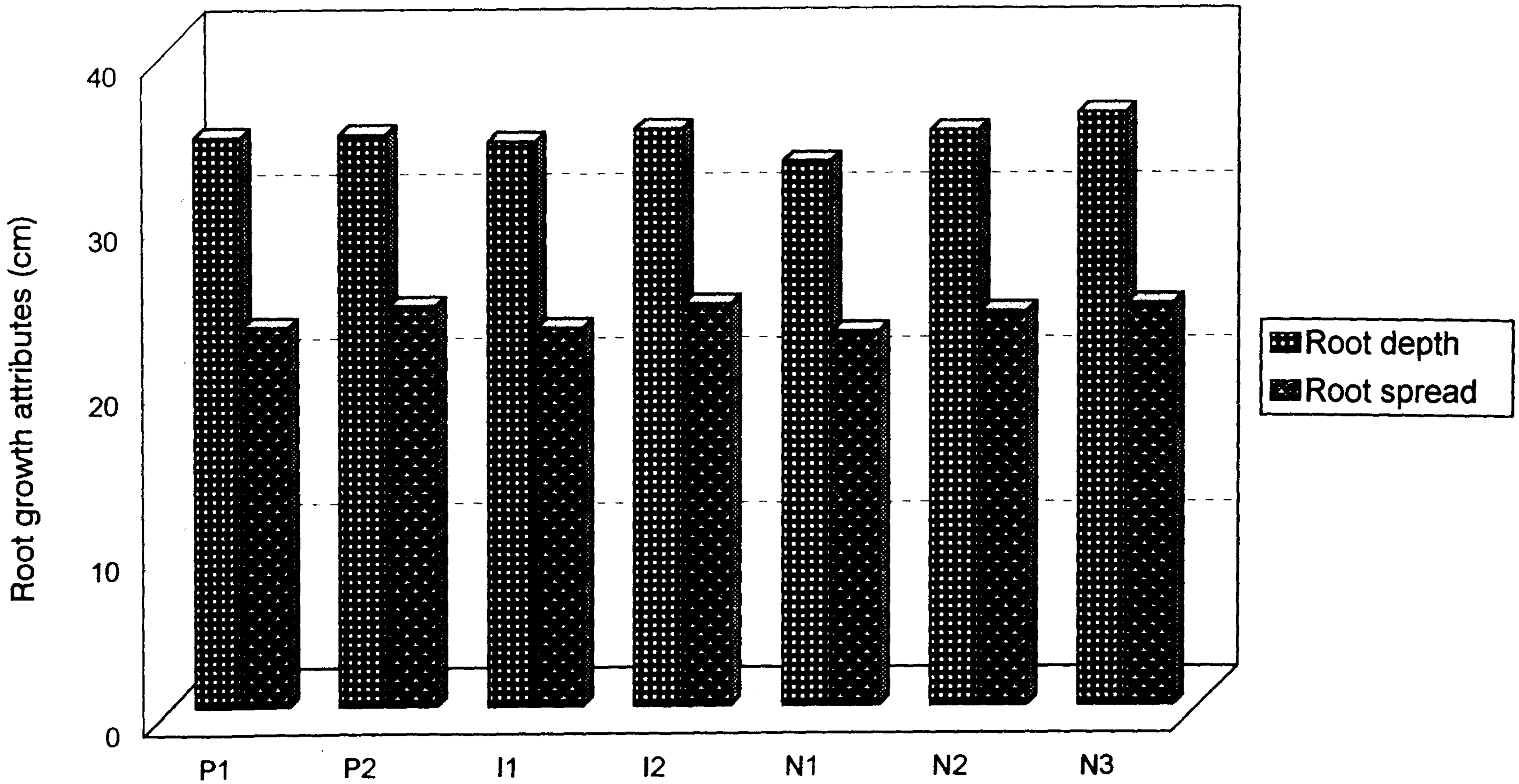
P1 - Normal row planting
P2 - Paired row planting
I1 - Cowpea
I2 - Lablab bean
N1 - 50 % N
N2 - 75 % N
N3 - 100 % N

by the treatment legume alone and in combination with nitrogen supplementation. Lablab bean promoted more tiller production of the grass than cowpea. Maximum tiller production was recorded when 100 per cent N was applied. It is well known that nitrogen is the most important element for the growth of plants. In the present study, increased availability of the element would have contributed to the higher tiller production of the grass. Similar increase in tiller count of *dinanath* grass with increased N fertilization was reported by Rathore and Vijayakumar (1977) and in hybrid napier by Thomas (1978). The interaction between planting geometries and intercrops was significant and paired row planting x lablab bean resulted in maximum tiller production with the reason that more space was available between paired rows and the legume contributed much nutrients to grass which in turn enhanced its growth. With regard to interaction between planting geometries and N levels, maximum tiller production was noticed with paired row planting x 100 per cent N due to better availability of applied inorganic nitrogen. A significant positive correlation between tiller count and fodder yield of the grass was also noticed.

A similar trend in the case of leaf area index was also seen (Table 3). Comparatively higher leaf area index was recorded when the grass was grown under paired row system of planting due to maximum availability of space and less competition among plants. This is in support of the findings of Sasireka (1992) in hybrid napier. Legume intercropping enhanced the growth of grass by supplementing with more nutrients. In response to enhanced growth, a higher leaf area index value was obtained and lablab bean when raised as intercrop resulted in the maximum value. Addition of nitrogen have enriched the vegetative growth, especially leaf growth of the grass and resulted in increased leaf area index. Leaf area index was maximum when 100 per cent N was applied. Ofroi and Stern (1987) concluded that leaf area index increased with increase in the level of nitrogen. The interaction between planting geometries and intercrops was significant and paired row planting x lablab bean recorded the maximum leaf area index. Similarly paired row planting x 100 per cent N recorded the maximum leaf area index for planting geometries x N interaction. Maximum growth and leaf area index were recorded when the grass was grown under paired row system of planting with lablab bean as the intercrop and supplemented with 100 per cent N.

Spread and depth of roots were higher when paired row system of planting was undertaken (Table 5, Fig. 3). This is attributed to the availability of more space for each plant and thus lesser competition among plants for space and nutrients as reported by Asis *et al.*. (1976) who noticed increased growth of roots with increased spacing of elephant grass (*Pennisetum purpureum*). Intercropping the grass with legume significantly increased the spread and depth of roots than grass grown alone and better performance of the crop was noticed when lablab bean was raised as the intercrop. This may be due to the effect of N contributed by legume association. Further increase in root growth was also observed with the addition of every unit of N and was maximum when 100 per cent N was applied. Increase in root growth is attributed to hastening of cell division and cell elongation resulting in increased rooting as reported by Tisdale and Nelson (1975). Similar findings were also

Fig 3 Effect of treatments on the depth and spread of roots in hybrid napier



P1 - Normal row planting
P2 - Paired row planting
I1 - Cowpea
I2 - Lablab bean
N1 - 50 % N
N2 - 75 % N
N3 - 100 % N

reported by Warsi *et al.* (1973) in sorghum and Lorenz (1978) in western wheat grass. The interaction between planting geometries x intercrops was significant and paired row planting x lablab bean recorded more spread of grass roots. With regard to other significant interactions, the root spread was maximum for paired row planting x 100 per cent N and lablab bean x 100 per cent N for planting geometries x N and intercrops x N interactions respectively. Root spread and depth contributed directly to the luxuriant growth of the grass which resulted in a significant positive correlation with yield.

5.1.2. **Yield of grass**

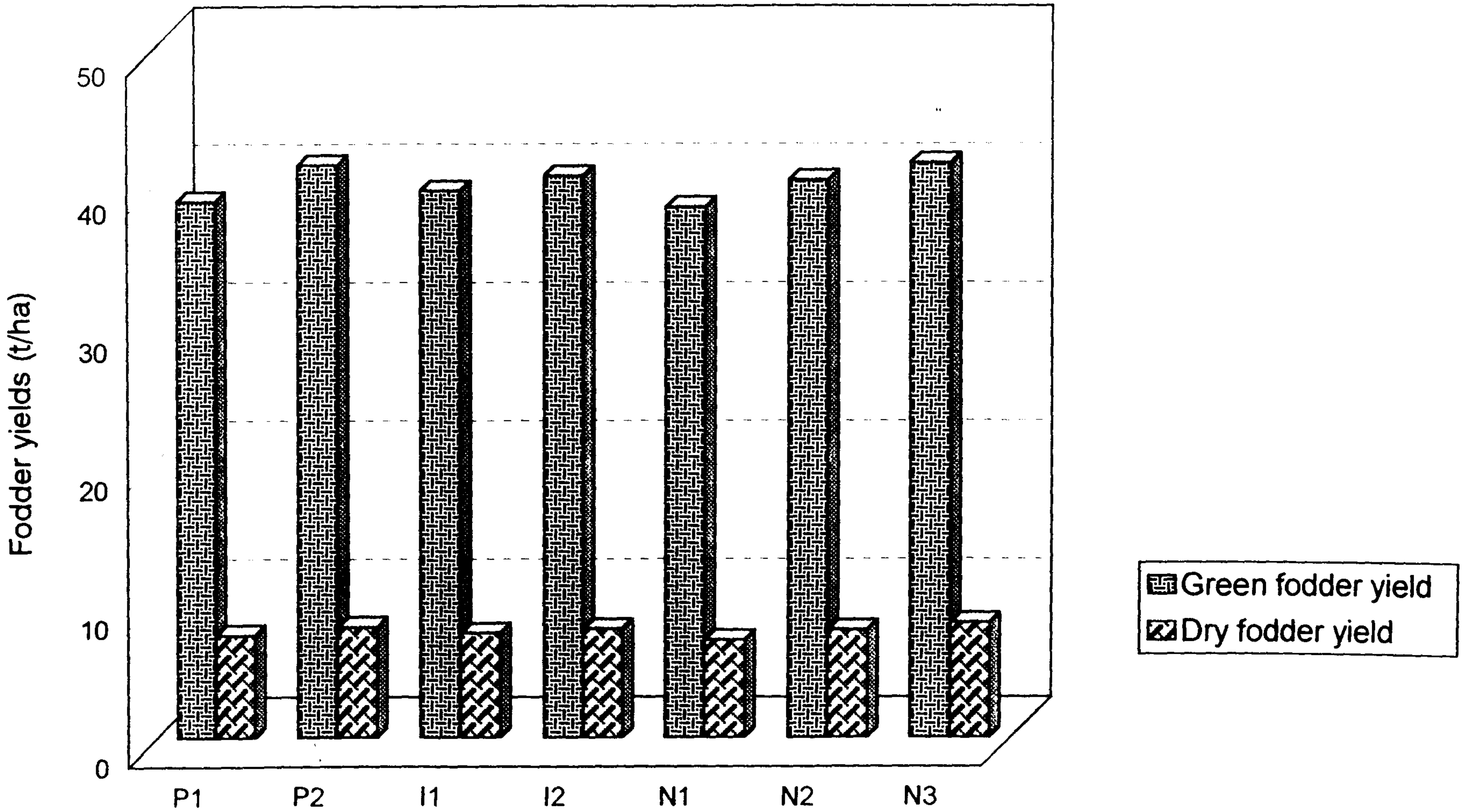
Results on green and dry fodder yields showed that the performance of grass was significantly influenced by planting geometries. Paired row planting recorded the maximum green and dry fodder yields (Table 4, Fig. 2). It may be mentioned in this connection that the growth attributes such as plant height, tiller production, leaf area index, spread and depth of roots etc. were maximum when paired row system of planting was adopted. Therefore it could be argued that higher values for growth attributes enriched better growth of the crop which ultimately resulted in increased fodder production. The present findings are in concurrence with the results obtained by Balbatti (1980). It may be seen from the data that growing legume as intercrop has increased the green and dry fodder production of the grass and was maximum when lablab bean was raised. Green and dry fodder yields increased to the tune of 7.8140 t ha^{-1} and 2.0310 t ha^{-1} due to legume intercropping compared to pure crops. The beneficial effect of legume on non-legume crop is well established by Agboola and Fayemi

(1972) and Khanna *et al.* (1996). Application of nitrogen further enhanced the green and dry fodder yields of the grass and the maximum yield was recorded when 100 per cent N was applied. Increased yield with N application substantiates the known effect of nitrogen on vegetative growth of plants especially on fodder crops. Applied nitrogen might have helped to increase the chlorophyll content resulting in higher photosynthesis which lead to increased green and dry matter yields (Tisdale and Nelson, 1975). Similar results were also reported by Vashishatha and Dwivedi (1997). The increase in yield of the grass by the inclusion of legume or by the application of nitrogen is attributed to the beneficial effect of the treatments on soil as well as on the plant. In the case of dry fodder yield, no substantial increase in yield beyond 75 per cent N application was noticed. Probably the additional N beyond a certain level was not utilised for dry matter production, but it might have helped the plant to become more succulent as revealed from the data wherein a reduction in the dry matter content was recorded. The interaction effect between planting geometries and intercrops was significant and maximum green fodder yield was recorded for paired row planting x lablab bean. Both green and dry fodder yields were maximum for paired row planting x 100 per cent N for planting geometries x intercrop interaction.

5.1.3. **Quality aspects of the grass**

Leaf : stem ratio is an important character which indicates the leafiness of the fodder. On perusal of the data it was clear that planting geometries had no significant effect on the lea f: stem ratio of the grass (Table 3). However an increasing trend was noticed with normal row system of planting which was

Fig. 2 Effect of treatments on root depth and green fodder yield of hybrid napier



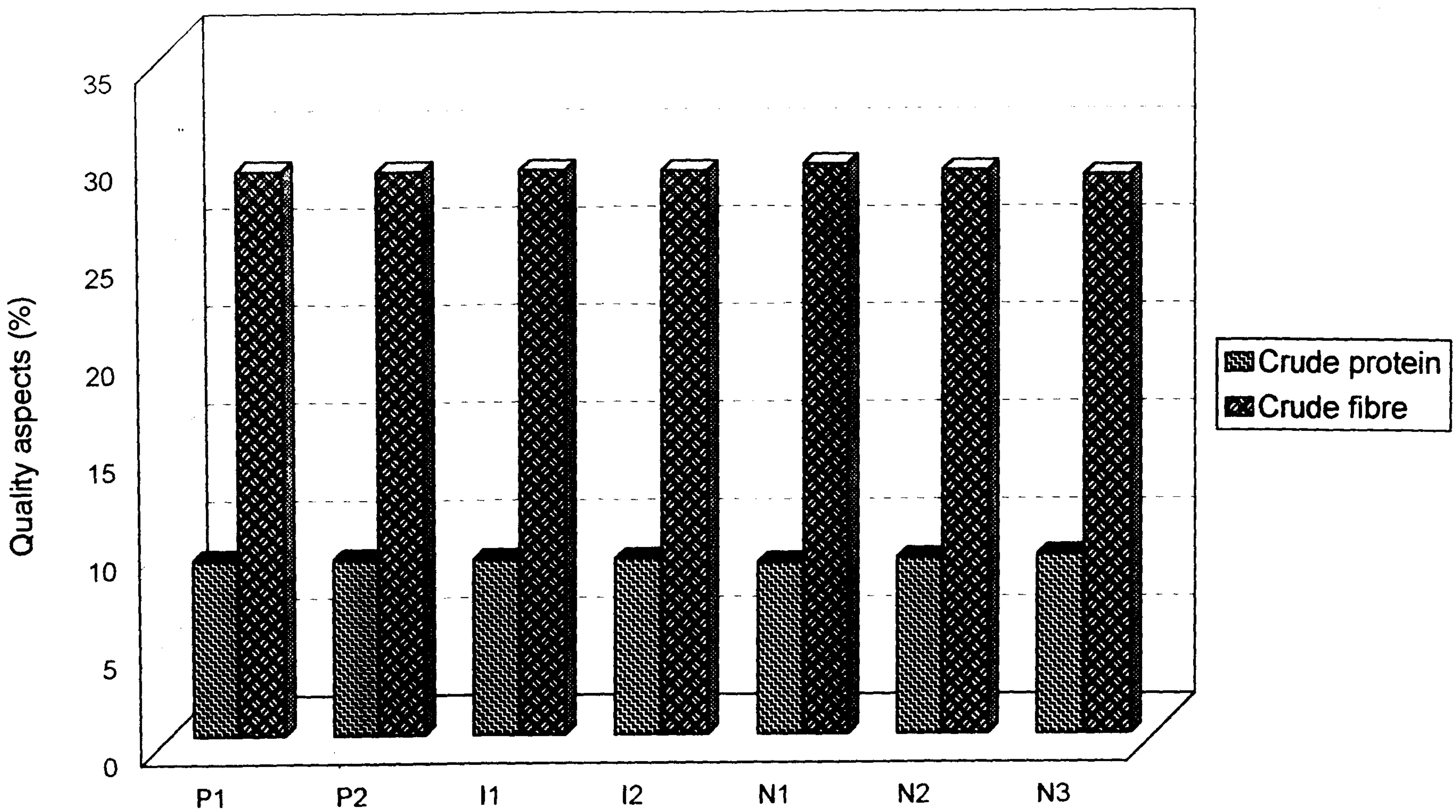
P1 - Normal row planting   P2 - Paired row planting
I1 - Cowpea   I2 - Lablab bean
N1 - 50 % N   N2 - 75 % N   N3 - 100 % N

an indication of comparatively better leaf growth under normal row system of planting. Grass grown alone or with legume had no significant influence on leaf : stem ratio. However, intercropping with higher levels of N application reduced the leaf : stem ratio of grass when supplemented with 100 per cent N. This means that in the presence of legume, applied nitrogen favoured higher proportion of stem in the dry matter. This is in conformity with the findings of Thomas (1978) who found significant reduction in leaf : stem ratio of hybrid napier and guinea grass with increased N application.

Protein content in forage crops is of prime importance since it is considered as the building block of any living system. Crude protein content of the grass was significantly influenced by planting geometries and higher crude protein content was recorded when paired row system of planting was followed (Table 6, Fig. 4). This may be probably because of the efficient utilization of natural resources, which would have resulted in increased dry matter production thereby increasing the crude protein content. This is in line with the results of Sasireka (1992) in hybrid napier. Protein content of the grass significantly increased when hybrid napier was intercropped with lablab bean. This may be due to the beneficial effect of legume association on the grass. It is a well established fact that legume transfer nitrogen to the associated non-legume through various ways such as excretion of nitrogenous compounds, release of N from decaying leaves, roots and root nodules (Russell, 1973). The present findings are in agreement with the results of Balbatti (1980) and Mahander Singh *et al.* (1984) in hybrid napier and Tripathi *et al.* (1997) in maize. Significant increase in crude protein content of the crop was noticed with increased level of N. Since N is the chief constituent of protein, its application would naturally increase the protein content. Similar results were reported by Little *et al.* (1970) and Balbatti (1980). The interaction between planting geometries x N was significant and higher crude protein content was recorded for paired row planting x 100 per cent N.

The crude fibre content determines the digestibility of the forage and it is an important crieteria for evaluation of any forage material. Crude fibre content of the grass was not influenced by planting geometries, but a comparatively lower content was recorded under paired row planting (Table 6, Fig. 4). The better availability of N under paired row planting made the plant more succulent thereby resulting in decreased fibre content. Fibre content of the grass is seen influenced to some extent by inclusion of legume in the cropping system and to a greater extent by nitrogen application. Minimum values were recorded in the plots in which lablab bean was raised. It might be inferred that these plots produced plant material of more succulence thereby leading to a reduced fibre content. Lowest fibre content was recorded when 100 per cent N was applied. With higher content of N in the plant, the carbohydrates are utilized more for synthesis of protoplasm rather than for thickening of cell wall, resulting in reduced fibre content as reported by Tiwana *et al.*(1975). The present results are in agreement with the findings of Thomas (1975) and Balbatti (1980) in hybrid napier. An inverse relationship between crude protein and crude fibre contents as reported by Balbalti (1980) was also noticed. This inverse relationship is further substantiated by a significant negative correlation between crude protein and crude fibre contents.

Fig 4 Effect of treatments on the crude protein and crude fibre contents of hybrid napier



P1 - Normal row planting
P2 - Paired row planting
I1 - Cowpea
I2 - Lablab bean
N1 - 50 % N
N2 - 75 % N
N3 - 100 % N

When protein content is higher and fibre and drymatter contents are lower, the fodder will be more digestible and would give more digestible energy. Any step to increase the protein content will naturally result in decreased content of crude fibre.

5.1.4. **Nutrient content and nutrient uptake by grass**

Among the nutrients, nitrogen occupies an important role in providing succulence, vegetative growth and palatability of fodder crops. Forage materials must contain adequate quantities of calcium to meet the demand of animal metabolism and growth. Both phosphorus, potassium, calcium and magnesium are largely required by the animals in their active stages of growth and in advanced stage of pregnancy. Hence mineral contents and their uptake by forage crops occupy very important roles in determining the quality of the feed.

In the present study, nitrogen content and its uptake exhibited differential response to various treatments (Table 7). The content and uptake of nitrogen were higher under paired row system of planting. This might be due to the minimum competition with in the grass coupled with high dry matter production which ultimately resulted in increased nutrient content and uptake. The present result is in conformity with the findings of Sasireka (1992) in hybrid napier. Significant increase in the content and uptake of nitrogen due to legume intercropping was noticed and the highest value was obtained when lablab bean was raised as the intercrop. This might be due to the higher rate of nitrogen fixing and transferring capacity of lablab bean. Whitney *et al.* (1967)

found that, of the total nitrogen fixed by *Centrosema pubescense*, 6 - 11 per cent was transferred to grasses grown in association. The role of legume crops in increasing the content and uptake of nitrogen in maize has been reported by Ghosh and Singh (1996). A definite increasing trend in the content and uptake of N was noticed with the addition of inorganic nitrogen and was maximum when 100 per cent N was applied. The increase in the content and uptake of nitrogen could be attributed to the promotion of vegetative growth and increased protein content due to better availability of N. The interaction between planting geometries and N was significant and the maximum content and uptake of N was recorded for paired row planting x 100 per cent N.

Planting geometries had no significant influence on the content and uptake of phosphorus, eventhough slightly higher values were obtained when paired row system of planting was followed (Table 8). This is in accordance with the findings of Singh and Patil (1984) who reported that the content and uptake of phosphorus was higher in buffel and *Stylosanthes hamata* cv. *verano* association with alternate single row planting, but paired row planting reduced the degree of competition and resulted in a comparable value as that of single row planting. Content and uptake of phosphorus were increased when the grass was grown mixed with legume and was higher with lablab bean due to complementary effect of legume on the grass. Mixtures of *Cenchrus ciliaris*, annual fodder and grain legumes exhibited higher content and uptake of phosphorus than pure sward (Mahander Singh and Singh, 1986; Rai, 1986). Application of nitrogen was helpful in enhancing the content and uptake of phosphorus and the maximum was recorded when 100 per cent N was applied.

Increased nitrogen content resulted in increased absorption of phosphorus which in turn increased the phosphorus content and its uptake as reported by Tisdale and Nelson (1975).

Comparatively higher values for the content and uptake of potassium were recorded when paired row system of planting was followed (Table 9). This may be attributed to more availability of space between paired rows and least competition between plants for nutrients (Singh and Patel, 1984). There was no significant influence on potassium content due to intercropping, however more uptake was recorded when lablab bean was raised as the intercrop. This fits in with the results of Jayakumar (1988) in guinea grass. The content and uptake of potassium were maximum when supplied with 100 per cent N, due to increased availability of N. The interaction between planting geometries and N was significant and normal row planting x 75 per cent N recorded the maximum uptake of potassium.

It was seen that calcium content of the grass and its uptake were greatly influenced by planting geometries and paired row planting recorded higher values solely due to the enhanced growth in response to more availability of space (Table 10). Calcium content and its uptake increased when the grass was grown in association with legume due to the beneficial effect of legume. Improvement in calcium content and calcium uptake by guinea grass was observed by Tulen (1976) and reported 25 per cent increase in calcium content by legume intercropping. Similar results were reported by Shanmughasundaram (1980) who observed that there was a definite improvement in the content and uptake of calcium in 1:1 and 2 : 1 mixtures of NB - 21 and lucerne than pure stand of the grass (NB - 21). An increasing trend in the content and uptake of calcium was noticed with N application and was maximum when 100 per cent N was applied. This might be due to the increase in CEC of the soil as a result of higher nitrogen availability resulting in higher content and uptake of calcium (Bear, 1968.)

Paired row system of planting recorded higher values for the content and uptake of magnesium. Raising of intercrops also enhanced the content and uptake of magnesium and was higher when lablab bean was raised (Table 11). The increased availability of nitrogen due to increased CEC of the soil in response to legume intercropping, according to Bear (1968), can be attributed to this. Application of nitrogen resulted in increased content and uptake of magnesium and was maximum when 100 per cent N was applied. Balsako (1977) noticed higher magnesium content and uptake in grasses due to increased application and availability of nitrogen

5.2. **Studies on intercrops** (cowpea and lablab bean)

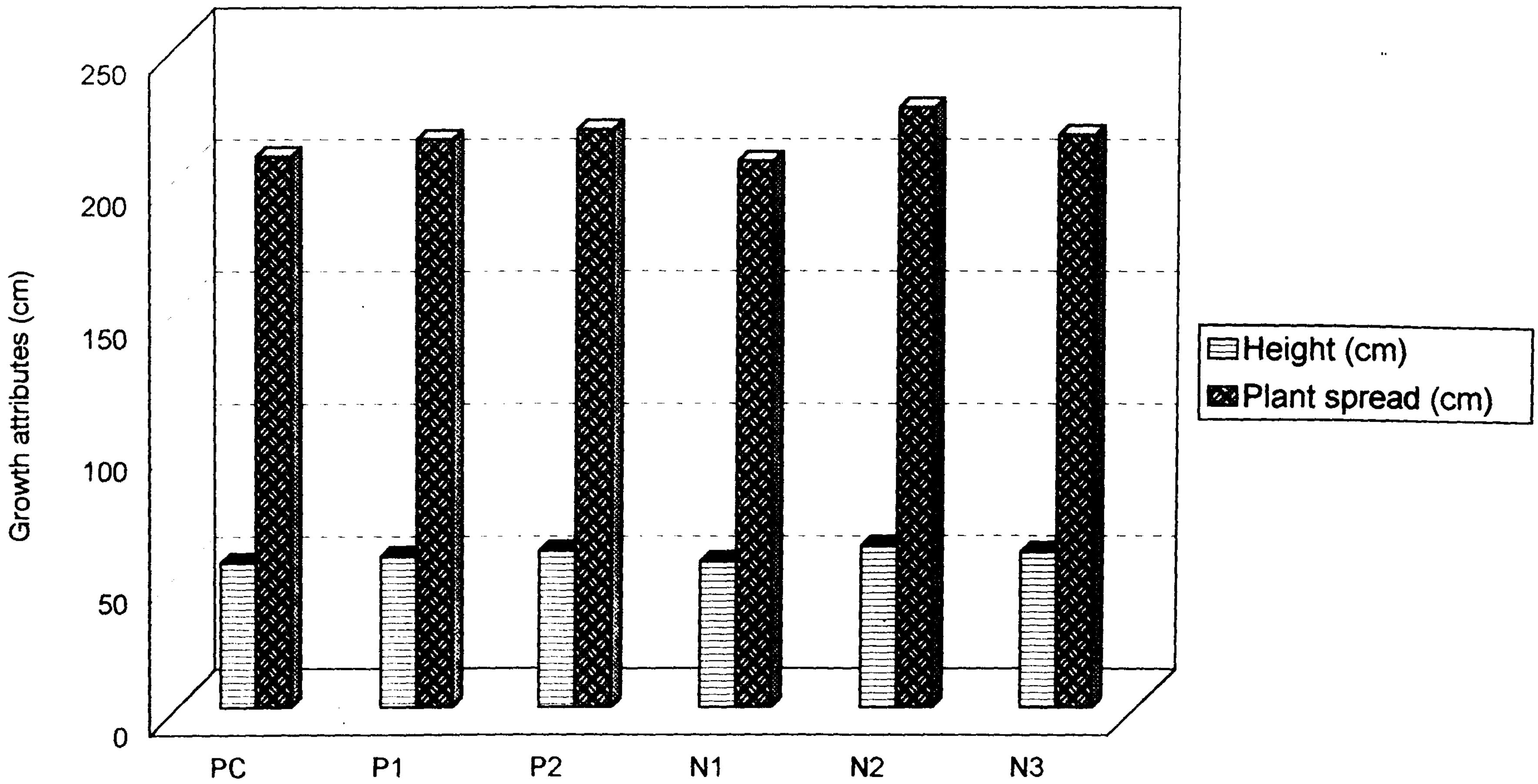
5. 2. 1. **Growth components of intercrops**

It is evident from the data that various treatments had significant impact on the growth components of legume intercrops grown in association with grass.

Height, spread and branching habit of the legumes were significantly influenced by planting geometries and were maximum when paired row system of planting was practiced (Table 12, 13, 14, Fig. 5, 6). Hybrid napier grass possesses a bushy habit which gives sufficient space for the growth of legumes in between them. Paired row planting would have provided ample space between paired rows of the grass and might have resulted in increased growth, height and more number of branches of the intercrops. Similar results were also reported by Daulay *et al.* (1972) in green gram grown mixed with bunch grass. Application of nitrogen to the grass resulted in increased plant height, spread and branching habit of the undersown legume intercrops. Height, spread and number of branches of the intercrops were maximum when supplemented with 75 per cent N. Some of the applied nitrogen to the grass might have turned to be useful to the intercrops and thus the effect is manifested as reported by Balbatti (1980). It was seen that application of 100 per cent N to the crop resulted in reduced growth due to the inactivity of nitrogen fixing bacteria at higher levels of N. The interaction between planting geometries and N levels of lablab bean was significant and the maximum height was recorded for paired row planting x 75 per cent N. Similarly the interaction between planting geometries and N levels of cowpea was significant and the maximum number of branches were produced for paired row planting x 75 per cent N.

Root growth was also seen to have been influenced by planting geometries and N levels (Table 18, 19). More availability of space among paired rows of the grass facilitated the growth of component legume intercrops and resulted in better spread and depth of roots under paired row system of planting. Nitrogen application favourably influenced the growth of roots and best results were obtained when 100 per cent N was applied. It could be

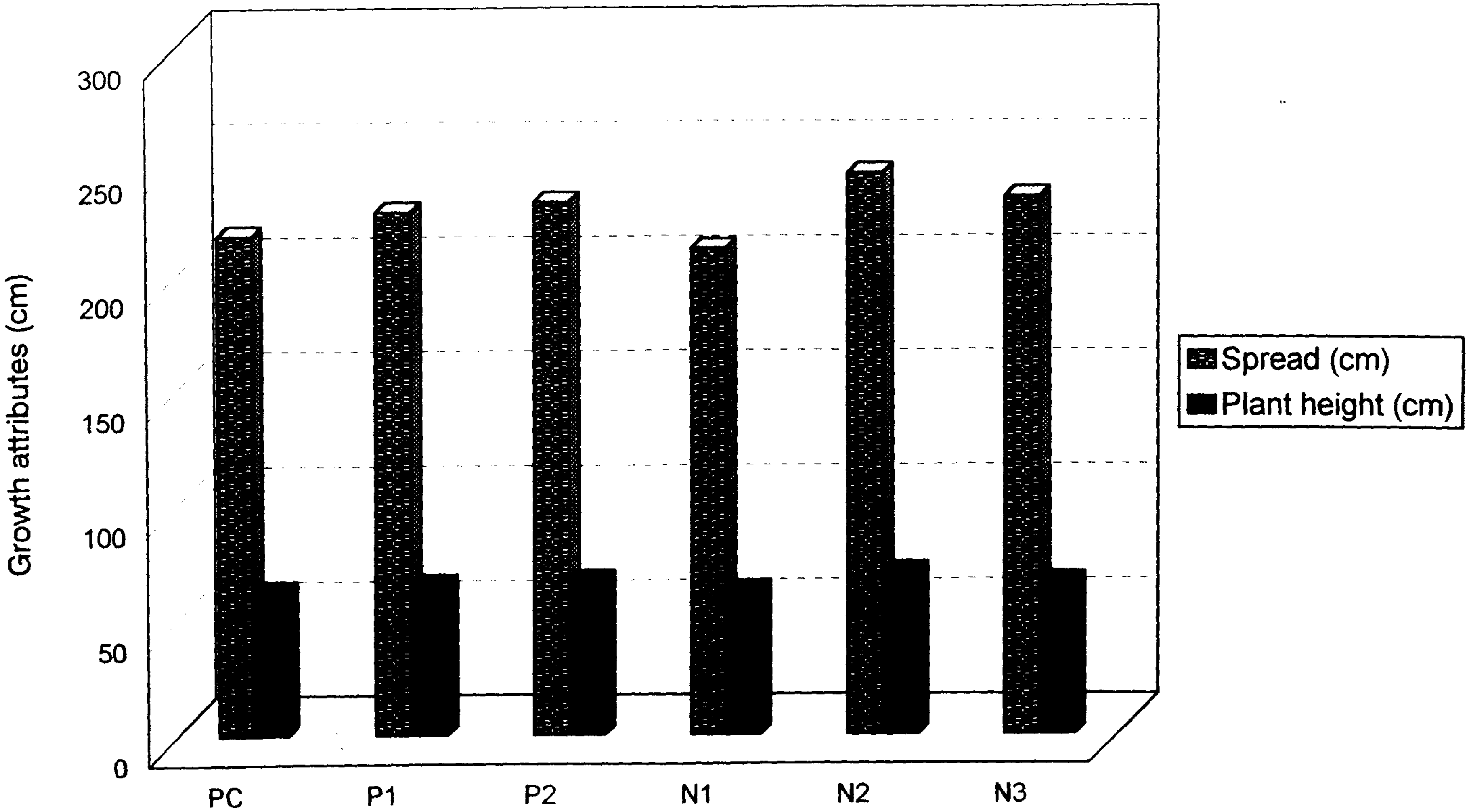
Fig. 5 Effect of treatments on the height and spread of cowpea



PC - Pure crop
P1-Normal row planting
P2 - Paired row planting

N1- 50 % N
N2 - 75 % N
N3 - 100 % N

Fig. 6 Effect of treatments on plant height and spread of lablab bean



PC - Pure crop
P1-Normal row planting
P2 - Paired row planting

N1- 50 % N
N2 - 75 % N
N3 - 100 % N

inferred that nitrogen application might have promoted the absorption of phosphorus which is essential for proper growth and development of roots. Better absorption of phosphorus ultimately resulted in better growth of roots thereby recording higher values for spread and depth of legume roots (Balbatti, 1980).

5.2.2. **Yield of intercrops**

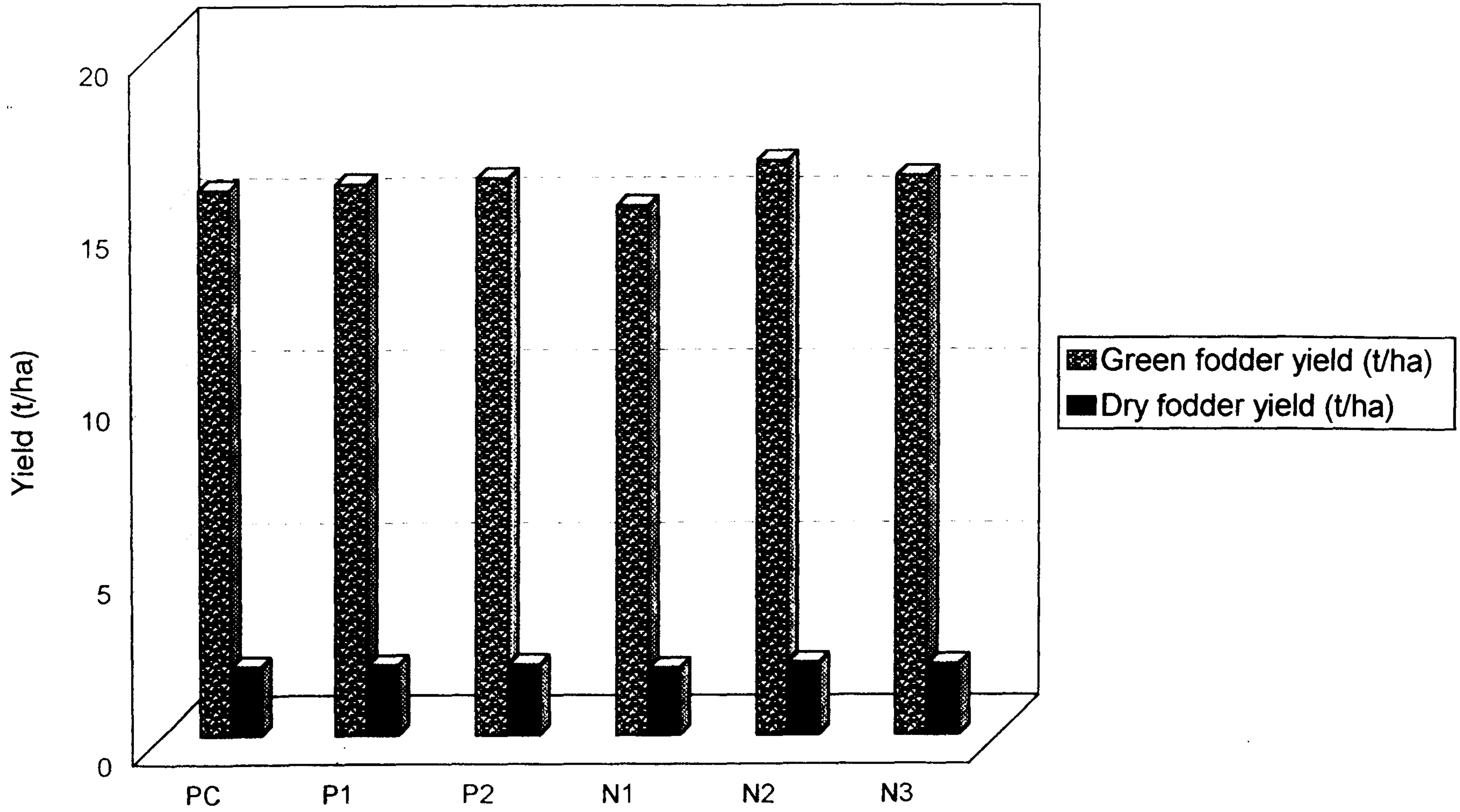
Results showed that planting geometries had significant influence on green and dry fodder yields of legumes (Table 16, 17, Fig. 7, 8). Paired row planting of the base crop enhanced the growth and yield of legumes by providing more space. Present results are in accordance with the findings of Palaniappan *et al.* (1975) who reported that paired row planting of the crop facilitates better growth of intercrops since the space between paired rows is more than that available in sole stand of hybrid napier. With regard to intercrops, lablab bean produced the maximum green and dry fodder yields. The higher green fodder yield of lablab bean might be due to the increased plant height, spread and number of branches of the crop throughout its growth. The uptake of NPK by this crop was also higher which promoted the growth and finally resulted in increased green fodder yield. Higher drymatter yield due to higher green fodder production was quite natural as expected. Similar increased green and dry fodder yields were reported by Singh and Relwani (1978) and Mercy George (1981) for velvet bean grown in association with maize. Higher green and dry fodder yields were obtained at comparatively higher levels of N. The higher green and dry fodder yields at higher levels of N might be due to an adequate and balanced supply of the nutrient required for plant growth which in turn might have caused a favourable effect on nodulation in legumes and for an increased growth and dry matter production of the grass and consequently towards an overall increase in green and dry fodder yields of these crops. This is in conformity with the work of Thimmegowda and Shivaraj (1994) in various fodder crops.

5. 2. 3. **Quality aspects of intercrops**

The different planting geometries did not influence the leaf : stem ratio of the legumes (Table 15). Lablab bean recorded higher leaf : stem ratio. The higher number of leaves in lablab bean resulting from increased vegetative growth in response to N application would have resulted in higher leaf : stem ratio. The stem of lablab bean being thicker and leaves more succulent when compared to cowpea resulted in higher leaf : stem ratio as reported by Mercy George (1981).

Crude protein content of legumes remained almost unchanged under different planting geometries, however a slightly increasing trend was noticed under paired row planting which facilitated better growth of the crop by providing more space among paired rows of the grass (Table 20). Lablab bean being more aggressive and competitive, resulted in better growth, higher N content and simultaneously recorded higher crude protein content. Protein content of the legumes were increased when fertilizer N was applied to the crops. It may be mentioned in this context that the extra nitrogen given to the crop did not increase the dry matter yield of the legumes. Probably this N

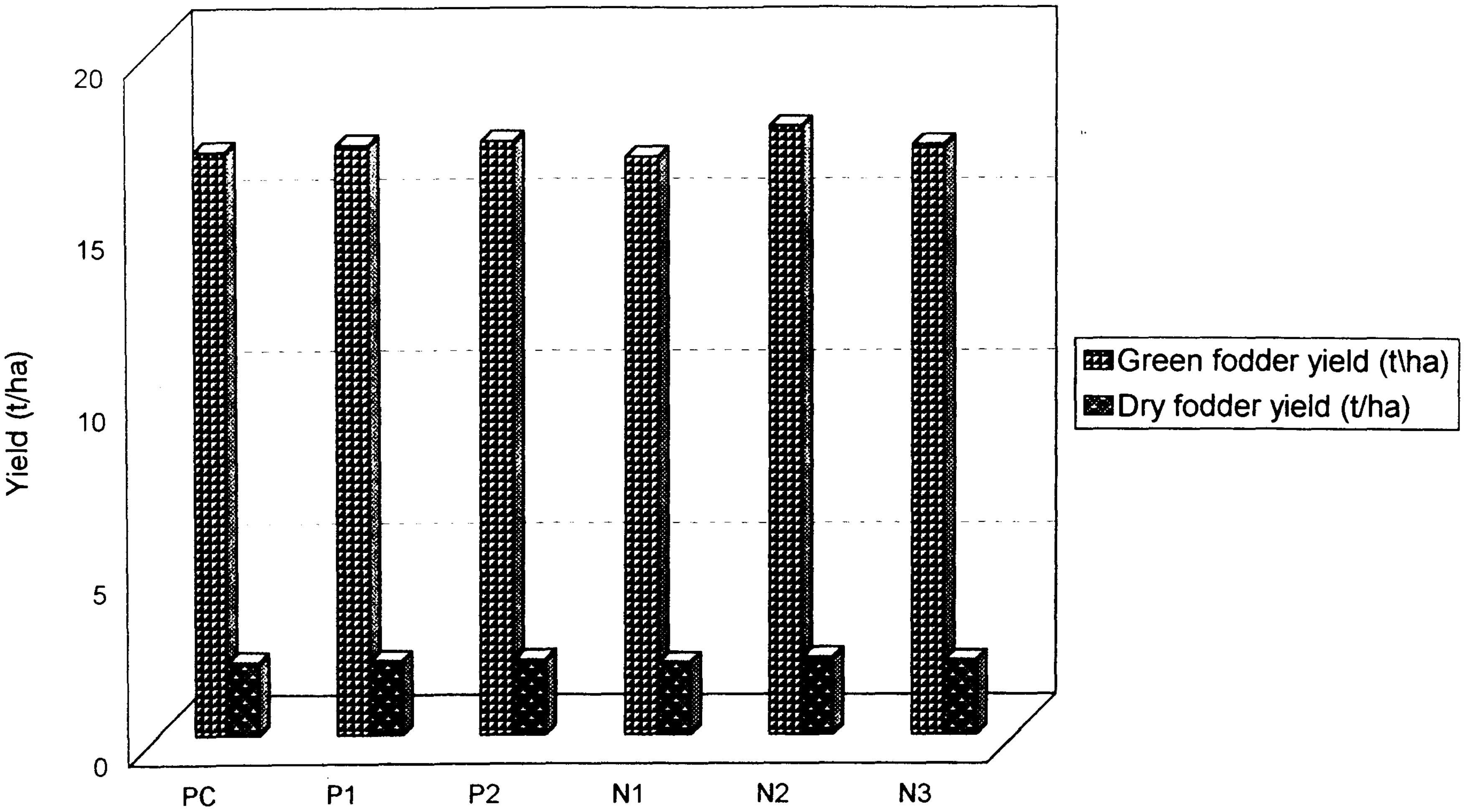
Fig. 7 Effect of treatments on green and dry fodder yields of cowpea



PC - Pure crop
P1-Normal row planting
P2 - Paired row planting

N1- 50 % N
N2 - 75 % N
N3 - 100 % N

Fig. 8 Effect of treatments on green and dry fodder yields of lablab bean



PC - Pure crop
P1-Normal row planting
P2 - Paired row planting

N1- 50 % N
N2 - 75 % N
N3 - 100 % N

might have been utilised mainly for increasing the protein yield. Similar observation was recorded by Balbatti (1980).

The results showed that planting geometries had no significant influence on crude fibre content of the legumes (Table 21). Cowpea recorded comparatively higher crude fibre content. The utilization of carbohydrates for thickening the cell wall and elongation of stem might be more in cowpea than lablab bean and this might have produced more crude fibre content. Succulence in plants can be induced to a limited extent by supplying nitrogen. With increase in succulence, the fibre content decreases correspondingly. Since nitrogen is the principal nutrient element in providing succulency to plants, higher content of nitrogen might have resulted in lower crude fibre content, as there exists a negative correlation between nitrogen and crude fibre contents. The present result is in line with the findings of Mercy George (1981) and Chandini and Pillai (1983).

5.2.4 **Nutrient content and nutrient uptake by legumes**

From the data it became clear that the effect of various treatments on the content and uptake of nutrients were different (Table 22, 23). Nitrogen content and its uptake were higher when paired row system of planting was undertaken, due to the efficient utilization of space between paired rows of base crop which might have resulted in better growth and higher content of nutrients. Lablab bean recorded higher values for the content and uptake of nitrogen than cowpea. This differential response might be due to the varietal characters of the legumes as reported by Mercy George (1981). Fertilizer levels influenced the content and uptake of nitrogen and was maximum at 75 per cent N application. Non-significant response for the N levels on nitrogen content of legumes beyond this level might be due to the positive response of hybrid napier and negative response of legumes towards increased level of N as suggested by Ahmed and Gunasena (1979).

Planting geometries had no significant effect on the content and uptake of phosphorus in legume intercrops (Table 24, 25). The highest P content and uptake was noticed in lablab bean. Lablab bean produced higher quantity of fodder which necessitated higher uptake of phosphorous. Nitrogen levels had no role in influencing the content and uptake of phosphorous. In the initial stage, the applied nitrogen might have increased the phosphorus content and uptake in legumes as reported by Omueti and Oyenuga (1970). At the stage of harvest, the dry matter yield was higher and hence the dilution effect would have resulted in a lower phosphorus content and uptake in legume intercrops (Mercy George, 1981).

From a critical study of the values, it could be seen that planting geometries had no significant effect on the content and uptake of potassium in legume intercrops (Table 26, 27). The highest potassium content and uptake were recorded by cowpea. Cowpea might have absorbed more potassium in the very early stages than lablab bean and might have used it for its vegetative growth. Higher content and uptake of potassium was recorded at comparatively higher levels of N. Higher doses of application of fertilizers might have resulted in luxury consumption which in turn helped to increase the potassium content and uptake as reported by Mercy George (1981).

Calcium content and its uptake remained unchanged under different planting geometries (Table 28, 29). Content and uptake of calcium were higher in cowpea. But at the time of harvest, legumes did not show any significant difference in the calcium content. Such a non significant response for calcium content of legumes when grown in association with fodder maize was reported by Singh and Relwani (1978). The higher two levels of N resulted in higher content and uptake of calcium in legumes. Hutton (1970) and Mercy George (1981) reported that higher doses of N and P favoured the uptake of calcium in leguminous crops. The results obtained in the present investigation are in conformity with the above findings.

As in the case of phosphorus, potassium and calcium and the content and uptake of magnesium were not influenced significantly by planting geometries (Table 30, 31). Cowpea was found to contain more magnesium than lablab bean. Varying N levels had differential response to the content and uptake of magnesium and not much significant influence was seen. Jokinen (1979) reported that the magnesium content and uptake of fodder crops were low without magnesium fertilization. The present result is in agreement with the above finding.

5. 3. Physico-chemical properties of the soil after completion of the experiment

5. 3. 1. Physical properties

Significant differences in the physical properties of the soil was noticed after completion of the experiment. Reduction in bulk density of the soil was observed. This in accordance with the findings of White *et al.* (1976) who reported that the bulk density of the soil was reduced due to pasture cultivation. Adoption of grass-legume mixture favourably influenced the porosity of the soil as put forward by Page and Willard (1946) who found that the porosity of the soil was increased due to grass cropping. Water holding capacity of the soil was also found increased by grass cropping due to the addition of organic matter resulting from the decomposition of plant parts as reported by Anderson and Gantzer (1989).

5.3.2. Chemical properties

5.3.2.1 Available nitrogen

It was seen that in plots where paired row system of planting was undertaken they had a higher N content than that of normal row planting (Table 32). Being a grass crop of perennial nature, the earlier developed roots might have decomposed and helped to add to the organic matter content thereby contributing to a consequent increase in the N content of the soil. Increase in organic matter content of the soil due to increased root growth of hybrid napier was reported by Thomas (1978) and Balbatti (1980). Available N content of the soil was higher in presence of legume intercrops than when grass was grown alone. This increased nitrogen content may be attributed to the nitrogen fixation of the legume and quicker humification of the residues such as roots, root nodules, leaves etc. These results are in support of the findings of Krishnaraj (1976), Myers (1976) and Balbatti (1980) who reported an increase in the N content of the soil by intercropping legume. Intercropping with supplementation of inorganic nitrogen further increased the available N content of the soil. The data showed that the root growth was increased due to application of inorganic nitrogen in conjunction with intercropping. These treatments received the benefit of legume intercropping and that of applied nitrogen, with the result that there was more N content in soil after the experiment.

5. 3.2.2 **Available phosphorus content**

Planting geometries had no significant influence on the available phosphorus content of the soil (Table 33). Lablab bean when raised as intercrop resulted in higher phosphorus content due to increased absorption of phosphorus. Similar increase in phosphorus content of the soil was reported by Garg *et al.*(1970). Supplementation of N might have stimulated the process of biological nitrogen fixation. This process might have resulted in increased absorption of phosphorus indirectly, thereby resulting in higher content of phosphorus.

5.3.2.3. **Available potassium content**

Higher content of potassium was recorded in plots where paired row system of planting was undertaken (Table 34). This may be due to better availability of space among paired rows of the grass and its efficient utilization which has resulted in enhanced growth and higher content of potassium in soil. Legumes and their interaction with N levels significantly influenced the available K content of the soil. Higher value of available K was recorded in plots where lablab bean was grown as the intercrop besides supplementing with 100 per cent N and was on par with those where cowpea was raised.

It was seen that the soil reaction remained unchanged by adoption of grass-legume mixture. This is in conformity with the findings of Sahasranaman et al. (1976) who didnot find any change in soil reaction after five years of intercropping of fodder crops in coconut garden.

5. 4. Effect of intercropping on biosuitability parameters

5. 4. 1. Aggressivity

Higher aggressivity values were recorded where paired row system of planting was followed (Table 35). This might be due to the availability of more space between paired rows of the base crop which made the plant more competitive to acquire more sunlight, water etc. Lablab bean competed more with the base crop and performed better which might be the reason for higher aggressivity values. It could be concluded that supplementation of inorganic N along with legume intercropping resulted in the absorption of more N which recorded better vegetative growth and higher aggressivity values.

5. 4. 2. Land Equivalent Ratio (LER)

The highest LER was recorded with paired row planting of grass x lablab bean and supplemented with 100 per cent N, showing the increased biological efficiency or intercropping advantage of the grass- legume association (Table 36). However, in the present study the intercropping advantage or biological efficiency was over estimated by LER. LER gives a valid estimate of biological efficiency when each of the following two conditions are met, viz, When all intercrop components have equal production cycle durations and when planting and harvesting of the intercrop coincide with planting and harvesting of the requisite monoculture checks. If the conditions are not met, LER gives inflated values of biological efficiency because crop duration does not enter into intercrop vs monoculture comparison.

The present study revealed that LER value was maximum when all other factors remained congenial ie., paired row planting of the grass with inclusion of lablab bean as the intercrop along with supplementation of 100 per cent N.

5.5. Economics of intercropping

The data clearly shows that intercropping of grass with legume was significantly superior to sole cropping of hybrid napier (Table 37). The growth and yield of the sole crop of grass was poor and resulted in the minimum profit of Rs. 25630. Addition of nitrogen besides legume intercropping resulted in overall increased growth and yield of fodder. In response to increased yield, the maximum profit of Rs. 46579 was recorded when hybrid napier was grown mixed with lablab bean and supplemented with 100 per cent N.

SUMMARY

SUMMARY

An investigation was carried out in the Instructional Farm attached to the College of Agriculture, Vellayani during 1995-96 for a continuous period of ten months. The objective of the investgation was to find out the comparative fodder production efficiency of two high yielding legume intercrops for hybrid napier as influenced by planting geometries and nitrogen levels. The planting geometries of the base crop were paired row planting and normal row planting. The intercrops tried were cowpea and lablab bean. The different nitrogen levels were 50, 75 and 100 percent N (for both crops). The experiment was laid out in Factorial Randomised Block Design with three replications. The results of the study are summarised below:-

The height of hybrid napier as well as legume intercrops were higher under paired row system of planting. Inorganic nitrogen application besides legume intercropping enhanced the height and tiller production of the grass and was maximum when lablab bean was raised as the intercrop and supplemented with 100 percent N.

The height and spread of legume intercrops increased due to inorganic nitrogen application and was maximum when 75 percent N was applied.

Leaf : stem ratio of both hybrid napier and legume intercrops were not influenced by planting geometries. Leaf : stem ratio decreased with application of nitrogen in grass and increased with the same in legumes.

The leaf area index of the grass was maximum when paired row system of planting was undertaken. Legume intercropping and supplementation of

inorganic nitrogen promoted the leaf area index of the grass. Maximum LAI was recorded when lablab bean was raised as the intercrop, besides application of 100 percent N.

Green and dry fodder yields of the grass were maximum under paired row system of planting. The yields were maximum when lablab bean was raised as the intercrop and supplemented with 100 percent N.

With regard to green and dry fodder yields of intercrops, the yields were higher under paired row planting. In the case of intercrops, yields were higher with lablab bean and the maximum was recorded when 75 percent N was applied.

Root spread and root depth of fodder crops were maximum under paired row system of planting. Raising of lablab bean and supplementation of 100 percent N facilitated better root spread and depth of grass and recorded the maximum values. In the case of intercrops, lablab bean performed better and root growth was maximum when 100 percent N was applied.

Crude protein content of hybrid napier was higher under paired row system of planting. The maximum content of crude protein was recorded when lablab bean was raised as the intercrop and supplemented with 100 percent N.

Planting geometries had no significant effect on the crude fibre content of fodder crops. Crude fibre content of the grass decreased when lablab bean was raised as the intercrop and the lowest content was recorded when 100 percent N was applied. With regard to intercrops, lablab bean recorded lower content of crude fibre and best performance was noticed when 100 percent N was applied.

The content and uptake of nitrogen in hybrid napier was higher when paired row system of of planting was undertaken. Highest values were recorded when lablab bean was grown, besides supplemented with 100 percent N. Lablab bean recorded higher content and uptake of N when 75 percent N was applied.

Phosphorus content and phosphorus uptake by the crops remained unchanged under different planting geometries. Intercropping with lablab bean and application of 100 percent N resulted in maximum content and uptake of phosphorus in grass. With regard to intercrops lablab bean performed better when 100 percent N was applied. Planting geometries, N levels and legume intercropping had no significant role on the content and uptake of potassium in grass. Among the intercrops cowpea recorded higher content and uptake of potassium when 100 percent N was applied.

Paired row system of planting recorded higher content and uptake of calcium in hybrid napier. Raising lablab bean as the intercrop and supplementation of 100 percent N recorded highest values. Cowpea recorded higher content and uptake of calcium in the case of intercrops when 100 percent N was applied.

Magnesium content and its uptake in grass remained almost same under different planting geometries. Highest value was recorded with intercropping with lablab bean in addition to application of 100 percent N. cowpea recorded higher content and uptake of magnesium. N had no significant influence on the content of magnesium in cowpea.

The status of N, P and K after completion of experiment was higher in plots where paired row system of planting was undertaken. The plots where lablab bean was raised as the intercrop, recorded higher N, P and K contents. The content of N and K was maximum with 100 percent N and that of P with 75 percent N application.

Similarly higher aggressivity and land equivalent ratio were obtained when paired row system of planting was followed. Legume intercropping and supplemented with inorganic N were helpful in maximising the values. Highest values were obtained when lablab bean was raised and supplemented with 100 percent N.

Intercropping hybrid napier with fodder legumes and supplementation of N enhanced fodder production and the maximum net profit of Rs. 46579 was obtained when the grass was raised under paired row planting with lablab bean as the intercrop and supplemented with 100 percent N. Pure crop of hybrid napier recorded the lowest yield and resulted in the minimum net profit of Rs. 25630.

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APPENDIX

APPENDIX - I

Values of simple correlation coefficients

	Hybrid napier		Cow pea		Lablab bean	
Plant character	Green fodder yield	Dry fodder yield	Green fodder yield	Dry fodder yield	Green fodder yield	Dry fodder yield
Plant height	0.9562**	0.9602**	0.8637**	0.8707**	0.9510**	0.8674**
Tiller count	0.9605**	0.9018**	-	-	-	-
Plants spread	-	-	0.9428**	0.9518**	0.9119**	0.8572**
Number of branches	-	-	0.8123**	0.8138**	0.8855**	0.8173**
Leaf : stem ratio	-0.7463**	-0.8663**	0.6725**	0.6760**	0.3746	0.4341*
Leaf area index	0.8496**	0.7742**	-	-	-	-
Root depth	0.7985**	0.8661**	0.5217*	0.5238*	0.6838**	0.6643**
Root spread	0.9388**	0.8876**	0.6581**	0.6520**	0.4793*	0.4934*
Crude protein content	0.8291**	0.9207**	0.9758**	0.9785**	0.9694**	0.9007**
Crude fibre content	-0.8245**	-0.9123**	-0.5155*	-0.5093*	-0.5095*	-0.5250*
Nitrogen content	0.8283**	0.9230**	0.9736**	0.9767**	0.9672**	0.8803**
Nitrogen uptake	0.9313**	0.9977**	0.9900**	0.9915**	0.9815**	0.9233**
Phosphorus content	-0.0696	-0.1094	0.0120	0.0014	0.1618	0.2045
Phosphorus uptake	0.8785**	0.9161**	0.5135*	0.5040*	0.3386	0.4027
Potassium content	-0.3931*	-0.2817	0.2313	0.2284	0.0362	0.0184
Potassium uptakd	0.9155**	0.9900**	0.7258**	0.7547**	0.2627	0.3762
Calcium content	-0.6282**	-0.5819**	-0.2298	-0.2237	-0.4001	-0.3323
Calcium uptake	0.8773**	0.9547**	0.6083**	0.6137**	0.1519	0.2873
Magnesium content	-0.5414**	-0.4473**	0.1095	0.0973	-0.1024	-0.0722
Magnesium uptake	0.8465**	0.9256**	0.6586**	0.6631**	0.4245	0.4369*

** Significant at 1% level ($P < 0.01$)

* Significant at 5% level ($P < 0.05$)

INTENSIVE FODDER PRODUCTION THROUGH LEGUME INTERCROPPING IN HYBRID NAPIER

By

JAYAKUMAR, G.

ABSTRACT OF THESIS
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ABSTRACT

A field experiment was conducted at the Instructional farm, Vellayani during 1995-96 for studies on intensive fodder production through legume intercropping in hybrid napier. It was aimed to evaluate the performance of hybrid napier as influenced by planting geometries, intercrops and nitrogen levels. The experiment was laid out in factorial Randomised Block Design. The abstract of the results is given below.

1. The growth parameters of both the base crop as well as intercrops were influenced significantly by planting geometries and nitrogen levels. Both hybrid napier as well as intercrops recorded the maximum value when paired row system of planting was undertaken. With regard to hybrid napier, maximum values were recorded when supplemented with 100 percent N. However the intercrops recorded the maximum values when 75 percent N was applied.
2. Leaf : stem ratio of both hybrid napier and intercrops were not influenced by planting geometries. Leaf : stem ratio decreased with application of N in grass and increased with the same in legumes.
3. Green and dry fodder yields of grass were maximum under paired row system of planting. The yields were maximum when lablab bean was grown as intercrop and supplemented with 100 percent N. But in the case of intercrops, the yields were higher for lablab bean under paired row system of planting besides supplementing with 75 percent N.
4. Root growth of fodder crops was maximum under paired row system of

planting. Growing lablab bean as the intercrop besides supplementation of 100 percent N enhanced the root spread and root depth of the grass and recorded the maximum values. With regard to intercrops, lablab bean had better root growth and was maximum when 100 percent N was applied.

5. In the case of hybrid napier, highest value for crude protein and lowest value for crude fibre were recorded under paired row system of planting. The maximum and minimum values for crude protein and crude fibre respectively were obtained when 100 percent N was applied. With regard to intercrops, maximum value for crude protein and minimum value for crude fibre were recorded by lablab bean when 75 and 100 percent N respectively were applied.
6. The content and uptake of N, P, K, Ca and Mg were higher in both the crops under paired row system of planting. Higher values were recorded by hybrid napier when lablab bean was grown as the intercrop. Both the base crop and intercrops recorded higher values for the content of nutrients when 100 percent N was applied.
7. Adoption of grass-legume mixture improved the physico-chemical properties of the soil. Bulk density was reduced and porosity increased. The status of N, P and K were higher in plots where paired row system of planting was undertaken. The content of nutrients were higher when lablab bean was grown as the intercrop and supplemented with 100 percent N.
8. Aggressivity and LER values were maximum under paired row system of planting. Lablab bean when raised as the intercrop besides supplementation of 100 percent N recorded the maximum values.

9. Maximum net profit of Rs. 46579 was obtained when hybrid napier was grown under paired row system of planting with lablab bean as the intercrop and supplemented with 100 % N whereas the minimum profit of Rs. 25630 was recorded by the pure crop of hybrid napier.