HERBAGE PRODUCTION OF LEGUMINOUS CROPS IN SUMMER RICE FALLOWS

BY

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THESIS
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1994

Dedicated for the memory of my loving
brother Sivaprasad

DECLARATION

I hereby declare that this thesis entitled "Herbage production of leguminous crops in summer rice fallows" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Herbage production of leguminous crops in summer rice fallows" is a record of research work done independently by Kum. RAJASREE, G. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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RAJASREE, G.

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LIST OF ABBREVIATIONS

CEC - Cation exchange capacity

EC - Electrical conductivity

% - Percentage

Cm - Centimeter

Kg - Kilogram

Rs - Rupees

KAU - Kerala Agricultural University

TNAU - Tamil Nadu Agricultural University

AICRP - All India Co-ordinated Research Project

DAS - Days After Sowing

BH - Before harvest

R.H - Relative humidity

LAI - Leaf Area Index

ha - Hectare

t - tonnes

CSRC - Cropping Systems Research Centre

RGR - Relative growth rate

RBD - Randomised Block Design

N - Nitrogen

P - Phosphorus

K - Potassium

Ca - Calcium

Mg - Magnesium

INTRODUCTION

INTRODUCTION

The success of modern agriculture largely depends on the availability of energy. Under pressure of population and shortage of energy, emphasis shall be laid on techniques that can increase agricultural production without expending large quantities of energy. Legumes are crucial to the balance of nature as they have the ability to fix atmospheric nitrogen and thus save the energy that would be expended for nitrogenous fertilizers. As palatable and proteinacious fodder crops, they have pivotal roles in animal production systems.

Livestock population in India is the largest in the world, but the production of milk and other livestock products is the lowest. This could be ascribed to acute shortage of nutritious green forage especially in summer. Considering the importance of livestock in Indian Agriculture, the present position of forage availability, its requirement and the competition between food and fodder crops for cultivated land, a viable alternative is growing of fodder crops in summer rice fallows. Leguminous short duration crops like cowpea and *Sesbania rostrata*, a popular green manure crop which has high potential as fodder crop due to its biomass productivity can come up well in summer rice fallows where the moisture is not sufficient to raise other crops and the fields are usually left fallow. Cultivation of these leguminous catch crops for fodder purpose in summer rice fallows, not only provides protein rich nutritious forage during the lean summer months, but also has beneficial effects on soil characteristics, nutrient supply and yields of the subsequent rice crop.

The biomass productivity and successful performance as fodder crops in summer rice fallows may vary with the genotypes and varieties. Cowpea varieties CO-5 and C-152 are well known for their fodder production capacity under irrigated and rainfed conditions. But their performance as fodder crops in summer rice fallows needs further investigation. Much studies have not been conducted on the fodder production potential of cowpea variety Karnataka local. Similarly the fodder production potential of *Sesbania rostrata* in summer rice fallows also has to be studied further in comparison with the cowpea varieties. It is not only vital to identify the most suitable forage legume for summer rice fallows, but their residual effects on the subsequent rice crop also needs scientific investigations. When paddy fields dry in summer and the soil system shifts from the submerged conditions to the one similar to dry uplands, the availability of phosphorus decreases (Ponnamperuma, 1964). Phosphorus is considered to be very essential for the luxuriant growth of legumes, better nodulation, higher enzymatic activity and nitrogen fixation (Whyte _et_ _al_., 1953). Phosphorus application has been found to enhance the growth attributes like plant height, number of leaves and branches in crops like cowpea and _Sesbania rostrata_. The phosphorus levels at which these legumes give optimum fodder yields in summer rice fallows are to be found out for enhancing their production.

Encouraging results are available on the beneficial effects of liming acid soils through its influence on soil pH, availability of other nutrient elements such as phosphorus and the stimulatory action on nodulation. The yields of these crops and their response to phosphorus will again vary with the application of lime in summer rice fallows where the soil system is changing from the neutral submerged situations to the dry state accompanied by a fall in pH in acidic soils of Kerala.

It is in the light of the above facts, the present study was taken up with the following major objectives.

1. To study the comparative fodder production potential of 3 varieties of cowpea and Sesbania rostrata and to select the best legume for fodder production in summer rice fallows.

2. To investigate the individual effect of lime and phosphorus and their combination on the fodder attributes of leguminous crops grown in summer rice fallows.

3. To find out the residual effect of combined application of lime and phosphorus to the leguminous crops on the yield of the succeeding rice crop.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

An investigation was carried out at Cropping Systems Research Centre, Karamana to find out the fodder production potential of four legumes under lime and phosphorus application in summer rice fallow condition and also to determine their residual effect on the succeeding crop of paddy.

The relevant literature available on the subject are reviewed hereunder. Wherever sufficient literature is not available on the crops tried in this experiment, results of experiments conducted on related crops are also cited.

2.1 Influence of lime on growth attributes, yield and quality of fodder legumes

Lime is considered essential for the growth of meristematic tissues and as co-factor or an activator of a number of enzymes. Lime supplies calcium which is essential for the growth and modulation of nitrogen into organic constituents especially protein.

2.1.1 Influence of lime on growth attributes

Various growth attributes of fodder legumes are influenced by liming.

2.1.1.1 Height of the plant

In a field experiment with different legumes including cowpea, Rose (1963) found that application of lime at the rate of 680 kg per hectare increased the plant height significantly over control.

Bhattacharya (1971) observed that the application of lime significantly increased the plant height in horsegram.

Viswanathan et al. (1980) reported that when the rate of application of lime was increased from 250 kg ha^{-1} to 500 kg ha^{-1}, plant height in cowpea was enhanced from 91.70 to 94.90 cm. In fodder cowpea, application of 600 kg lime along with 30 kg nitrogen resulted in maximum height of plants (Ramanagowda, 1981).

Yost et al. (1985) reported that in Sesbania cannabina, plant height increased from 58 to 140 cm on liming. In a trial on biomass production of Sesbania rostrata, Murali (1989) recorded a maximum plant height of 168.23 cm with the application of 500 kg lime.

Adhikari et al. (1989) reported that plant height of cowpea was greatest with the application of 3 tonnes of lime.

In general liming resulted in increased plant height as evident from various trials.

2.1.1.2 Number of leaves

In Stylosanthes gracilis, application of 500 kg lime per hectare was found to increase the number of leaves (Mariyappan 1978).

Viswanathan *et al*. (1980) observed that in cowpea, number of leaves per plant was increased from 16.30 to 18.00 when lime rate was increased from 250 to 500 kg ha^{-1}, while the number of leaves recorded a decreasing trend when rate of application of dolomite was increased from 400 to 800 kg ha^{-1}.

Ramanagowda (1981) reported that application of higher levels of lime markedly enhanced the number of leaves in fodder cowpea.

Thus the number of leaves per plant was increased by liming in different legumes.

2.1.1.3 Nodulation

Rose (1963) reported that application of lime at the rate of 680 kg ha^{-1} produced maximum number of nodules in cowpea, groundnut, Sesbania speciosa and Sesbania aculeata.

Ramanagowda (1981) reported that application of 600 kg lime per hectare improved the nodulation in cowpea and in Rabi season, better nodulation was recorded than in Kharif.

Manguiat et al. (1987a) reported that nitrogen fixing efficiency of stem nodules of Sesbania rostrata increased on liming.

Adhikari et al. (1989) recorded maximum number of nodules in cowpea due to the application of 3 tonnes of lime per hectare.

Murali (1989) obtained significant influence due to liming on nodulation of Sesbania rostrata. Application of 300 kg lime produced maximum root nodules (72.85/plant) and stem nodules (26.41/plant).

Alva et al. (1990) reported that in Vigna unguiculata combination of low pH and low calcium content delayed the nodulation and strongly depressed the nodule number and nodule weight.

Though liming generally influenced the nodulation positively as indicated by the results cited, Munns and Fox (1977) reported that liming did not produce significant increase in the nodule efficiency of cowpea or groundnut though the yields were increased by 30 per cent.

2.1.1.4 Leaf : stem ratio

Results of a trial conducted by Mariyappan (1978) indicated that lime application and different levels of phosphorus had no effect on the leaf : stem ratio of <u>Stylosanthes</u> <u>gracilis</u>.

In agronomic investigations on soybean, Sheelavantar (1980) reported that lime application along with the seed in the form of pellet increased the leaf weight significantly over no lime treatment.

Hence, the lime application was found to have varied influence on leaf : stem ratio of legumes.

2.1.1.5 Leaf area index

Lime application was found to influence the leaf area index of legumes favourably.

Ramanagowda (1981) reported that application of 600 kg lime per hectare along with 30 kg nitrogen positively influenced the leaf area index of fodder cowpea and was more in C-152 variety.

2.1.1.6 Number of branches

Bhattacharya (1971) observed that the application of lime significantly increased the number of branches per plant in horsegram.

Elkins _et al_. (1976) reported that in a soil with pH 4.9,number of branches per plant in soybean was increased significantly by liming.

Application of lime at the rate of 600 kg per hectare produced significantly more number of branches over 300 kg lime which inturn was superior to no lime treatment in fodder cowpea (Ramanagowda, 1981).

Though generally application of lime positively influenced the number of branches per plant, Mariyappan (1978) observed that number of branches per plant was not significantly affected by lime application in _Stylosanthes gracilis_.

2.1.2 _Influence of lime on yield of fodder crops_

2.1.2.1 Green fodder yield

Alfalfa which requires neutral soil pH produced 20 times higher green matter yield with lime application in a number of soils (Adams and Pearson, 1967).

In a field experiment on podsolic soil, application of lime at the rate of two to five tonnes per hectare as basal dressing increased the lucerne yields from 1.84 t ha^{-1} to 5.25 ha^{-1} and 6.15 t ha^{-1} over a period of nine years (Skvortsov and Erokhina, 1972).

Bouton et al. (1981) observed that alfalfa yield was increased with lime application in acid soils.

Ramanagowda (1981) reported highest green matter yield with the application of 600 kg lime in fodder cowpea which was significantly superior to the 300 kg lime level which in turn was superior to no lime treatment.

Manguiat et al. (1987a) reported that increasing soil pH from 5.4 to 6.8 by lime application significantly improved the green matter yield of Sesbania rostrata.

Adhikari et al. (1989) reported that application of 3 tonnes of lime per hectare produced maximum fresh weight in cowpea.

In an experiment on biomass production of Sesbania rostrata in rice fallows, Murali (1989) reported a green matter production of 18.85 t ha^{-1} with the application of 500 kg lime along with 30 kg P_2O_5.

Lime application significantly increased the green fodder yield of legumes as evident from various trials.

2.1.2.2 Dry fodder yield

Adams and Lowther (1970) noted that liming of soil having pH 4.9 increased the dry matter yield of clover significantly.

In an experiment in the acid soils of Malaysia, Chew and Vivekanandan (1975) reported that the application of lime at the rate of two tonnes per acre increased the dry matter content of soybean.

In a pot culture experiment, Cheng (1976) reported that addition of lime increased the dry matter yield of fodder legumes by 57.137 percent. Dry matter yields increased from 2.53 to 4.12 g per pot due to the addition of 800 kg $CaCO_3$ per hectare.

Ramanagowda (1981) observed that application of 600 kg lime produced significantly higher dry matter yield of fodder cowpea than the other levels of lime, and application of 300 kg lime was superior to no liming.

Manguiat et al. (1987a) from Philippines reported that increasing the soil pH from 5.4 to 6.8 by lime application significantly improved the dry matter yield of Sesbania rostrata. In another trial on biomass production of Sesbania rostrata, Murali (1989) reported that a maximum dry matter yield of 6.05 t ha^{-1} was obtained with the application of 500 kg lime.

Bansaridas et al. (1990) found that in an acid alfisol, dry matter yield of greengram was significantly increased under limed condition. Though liming generally improved the dry matter production of legumes, contrary results were also reported. Kruger et al. (1990) reported that in a very acid soil (pH 4.0) neither phosphorus or lime application had any significant effect on dry matter production of sub-tropical legumes.

2.1.3 Influence of lime on quality of fodder

2.1.3.1 Protein content

Rose (1963) observed that application of lime at the rate of 680 kg ha^{-1} increased the nitrogen content of plant parts in an experiment with cowpea, groundnut, *Sesbania speciosa* and *Sesbania aculeata*.

Elpete (1972) reported that the uptake of nitrogen by legumes was increased significantly by liming acid soils where the soil pH was raised from 6.0 to 7.0.

Application of lime ranging from 0 to 22 t ha^{-1} increased the nitrogen content in cowpea (Munns and Fox, 1977).

Ramanagowda (1981) reported that application of lime and nitrogen increased the protein content of fodder cowpea.

Stamford and Costa (1985) found that lime with a high magnesium content increased the nitrogen accumulation and dry matter yield of *Vigna unguiculata*.

Puttaswamy (1988) reported that protein content of cowpea was maximum when 2.5 tonnes of lime was applied in acid soils.

In a trial on biomass production of Sesbania rostrata, Murali (1989) reported that increasing levels of lime increased the nitrogen content of plant with maximum content obtained under 500 kg lime level.

In an experiment with greengram, total nitrogen in shoot and total uptake of nitrogen was increased by liming while total nitrogen in root remained unaffected (Sarkar and Debnath, 1990).

Thus liming had a positive influence on the nitrogen content of plant parts and increased the protein content in legumes.

2.1.3.2 Phosphorus content

Robson et al. (1970) reported that phosphorus uptake by annual legume was increased significantly by the application of lime.

Cheng (1976) reported that addition of lime along with phosphorus and potassium increased dry matter content of pasture legumes with a phosphorus concentration of 0.21 per cent.

Haynes and Ludecke (1981) in an experiment with two pasture legumes, lotus (Lotus pedunculatus Cav.) and white clover (Trifolium repens L.) observed that phosphorus uptake and yield of both the legumes increased with lime and phosphorus addition and with increasing lime additions, available phosphorus indices decreased.

Ramanagowda (1981) reported that application of lime along with nitrogen enhanced the phosphorus content of fodder cowpea.

Murali (1989) found that highest level of lime application (500 kg ha^{-1}) gave the highest plant phosphorus content of 0.67 per cent in Sesbania rostrata.

Bansaridas et al. (1990) observed that phosphorus uptake by greengram (Vigna radiata L.) increased significantly by liming, in an acid alfisol.

In an experiment with greengram, Sarkar and Debnath (1990) reported that the total phosphorus content in root and shoot, as well as total uptake of phosphorus increased by liming in all the three varieties tested.

Liming generally improved the phosphorus content of legumes as shown by various trials.

2.1.3.3 Potassium content

In an experiment with tropical and sub-tropical legumes, Andrew and Johnson (1976) observed that increase in calcium concentration in the nutrient solution decreased the potassium concentrations in plant tops.

Santos *et al*. (1976) reported that liming decreased potassium content in the plant but the decrease was smaller at higher rate of application.

Decreased potassium content in fodder cowpea with the application of lime along with nitrogen was reported by Ramanagowda (1981).

Murali (1989) obtained maximum potassium content of 1.72 per cent in *Sesbania rostrata* when no lime was applied. Increasing levels of lime decreased the potassium content of plant.

Although the common trend was decrease in potassium content with lime application, opposing results were also reported by some workers.

Cheng (1976) reported that addition of 800 kg calcium carbonate per hectare increased the potassium concentration of pasture legumes in an old Rubber land soil of Serdang series.

In another experiment on the effect of liming acid soils on growth and uptake of nutrients by greengram, Sarkar and Debnath (1990) observed that total potassium content in shoot and total uptake of potassium were significantly increased by liming in one variety of greengram.

Results of various trails indicated the varied influence of lime on the potassium content of legumes.

2.1.3.4 Calcium content

Chatterjee <u>et</u> <u>al</u>. (1972) reported an appreciable increase in the content and uptake of calcium by soybean due to liming at the rate of two tonnes per hectare.

Karki <u>et</u> <u>al</u>. (1974) found that the calcium content of soybean crop was increased by lime application.

Andrew and Johnson (1976) in an experiment on growth and chemical composition of some tropical and subtropical pasture legumes reported that increasing calcium concentration of the nutrient solution markedly increased the calcium concentrations in the tops of all species of legumes but in the roots only a minor extent.

Ramanagowda (1981) reported that in fodder cowpea, maximum calcium content was recorded with the application of 600 kg lime in combination with 30 kg nitrogen.

Tripathi and Hazra (1986) noted that liming acid soils increased the forage yield as well as calcium content of berseem and lucerne.

Murali (1989) reported that increasing levels of lime application increased the calcium content of plant in Sesbania rostrata. Maximum calcium content of 1.27 per cent was obtained with the application of 500 kg lime per hectare.

2.1.3.5 Magnesium content

In a field trial with pigeonpea, Dalal and Quilt (1977) observed that calcium carbonate applied at the rate of 1.25 and 2.50 tonnes ha^{-1} increased the magnesium content in plants.

Mandal et al. (1979) reported that the uptake of magnesium by soybean was increased significantly by the application of lime.

Tripathi and Hazra (1986) observed that liming increased the magnesium content of the forage in berseem and lucerne.

Opposite results of decrease in magnesium content on liming were also reported by some workers.

Habeebullah _et al_. (1977) observed that lime applied to groundnut at the rate of 200 kg ha^{-1} decreased the magnesium content while it increased the calcium content.

Similar results were reported by Ramanagowda (1981) where highest magnesium content in fodder cowpea plants was noticed with the application of 10 kg nitrogen without lime and the lowest with the application of 600 kg lime in combination with 30 kg nitrogen.

Murali (1989) also reported similar results in a trial on _Sesbania rostrata_ where magnesium content of plant decreased from 0.29 to 0.22 per cent when liming was increased from 0 to 500 kg ha^{-1}.

Liming influenced the magnesium content of legumes either positively or negatively as evident from the cited examples.

2.2 Influence of phosphorus on growth attributes, yield and quality of fodder

Legumes show good response to the addition of phosphorus. The beneficial effects of phosphatic fertilization are manifested in luxuriant growth of legumes, better nodulation, better enzymatic activity, higher nitrogen fixation and addition of organic matter, Whyte _et al_. (1953).

2.2.1 Influence of phosphorus on growth attributes

2.2.1.1 Plant height

Deshpande and Bathkal (1965) observed significant increase in height of mung (Phaseolus aureus Raxb.) with the application of 40 kg and 60 kg P_2O_5 ha^{-1} over control. The height increased from 21.5 cm in control to 25.0 cm and 26.2 cm with 40 kg and 60 kg P_2O_5 ha^{-1} respectively.

Panda (1972) in an experiment with greengram observed an increase in plant height with increasing levels of phosphorus. Reddy (1975) also obtained similar results in greengram.

Geethakumari (1981) reported that in fodder cowpea, plant height significantly increased with increasing levels of phosphorus and at flowering stage, application of 50 kg P_2O_5 ha^{-1} recorded the maximum plant height.

In a trial on biomass production of Sesbania rostrata, Murali (1989) observed that a maximum plant height of 135.56 cm was obtained with the application of 30 kg P_2O_5 per hectare.

In another experiment with fodder cowpea, Thakuria and Luikham (1991 a) reported that phosphorus application at 50 kg P_2O_5 ha^{-1} influenced the plant height over the other levels.

Some scientists reported the non significant effect of phosphorus in increasing the plant height.

Maharana and Das (1973) observed that effect of phosphorus was not significant in increasing the plant height in cowpea. Subramanian et al. (1977) also obtained similar results wherein phosphorus application had no influence on plant height of cowpea.

Subramanian (1978) reported that in blackgram, plant height was not influenced by phosphorus levels.

Negative influence of phosphorus application on plant height was reported by Kesavan and Morachan (1973) where the successive addition of phosphorus gradually reduced the plant height in soybean though the difference was not significant.

Phosphorus application was found to influence the plant height in legumes differently in different field experiments.

2.2.1.2 Number of leaves

Garg et al. (1970) found an increase in the number of leaves in cowpea with an increase in level of phosphorus.

Tarila and Ormrod (1977) reported that increasing levels of phosphorus enhanced the leaf number in cowpea.

In a trial with fodder cowpea under phosphorus nutrition, Geethakumari (1981) observed that leaf number was significantly increased by phosphorus application and maximum number of leaves was obtained by the application of 50 kg P_2O_5 ha^{-1}.

In another experiment on the response of three cowpea varieties to 4 levels of phosphorus, Jain *et al*. (1986) observed that phosphorus application significantly influenced the number of leaves in cowpea at 60 kg P_2O_5 ha^{-1}.

Although phosphorus application generally increased the number of leaves, contradictory results were obtained by Mariyappan (1978) who reported that levels of phosphorus had no influence in increasing the number of leaves in *Stylosanthes gracilis*.

2.2.1.3 Nodulation

Pandey (1969) reported that in gram, plants with the application of nitrogen or phosphorus produced higher number of nodules per plant than untreated plants.

Sahu and Behera (1972) in an experiment with cowpea, groundnut and greengram reported that phosphorus application in combination with *Rhizobium* inoculation increased the nodulation.

Application of phosphorus or Rhizobium inoculation was found to increase the nodulation in blackgram and horsegram (Sahu, 1973).

Sharma and Garg (1973) observed that the number and weight of nodules per plant in cowpea increased with increasing rates of phosphorus upto 111 kg P_2O_5 ha^{-1}. Rao and Mader (1975) reported a slight increase in nodule number in soybean and higher nodule weights of 1.46 and 1.44 g were recorded with the application of 90 kg and 45 kg P_2O_5 ha^{-1} which were at par with each other.

Sairem et al. (1985) reported that phosphorus application and inoculation with Rhizobium lead to an increase in number and dry weight of nodules per plant in cowpea. The number of nodules per plant was maximum at 90 kg P_2O_5 ha^{-1}.

Muthuswamy et al. (1986) observed increased mean nodule number per plant from 5.48 to 5.74 due to phosphorus application.

Manguiat et al. (1987 b) reported that in Sesbania rostrata best growth and stem nodulation was obtained with the application of 60 kg P_2O_5 ha^{-1} while for root nodulation 30 kg P_2O_5 ha^{-1} was sufficient.

Kumar and Verma (1988) reported that when phosphate levels were increased from 30 kg P_2O_5 ha^{-1} to 90 kg P_2O_5 ha^{-1}, the effective nodule count was 11.00 per plant at 30 DAS and 2.19 per plant at 50 per cent flowering in blackgram.

Mali and Mali (1991) obtained improved dry weight of nodules and nitrogen accumulation in nodules by phosphatic fertilization in cowpea.

Thakuria and Luikham (1991 b) reported that application of phosphorus significantly increased the nodule number and dry weight of nodule per plant. Nodulation increased significantly upto 50 kg P_2O_5 ha^{-1} at all the sampling dates except at first sampling (15 DAS) where the increase was significant at 25 kg P_2O_5 ha^{-1}.

Although the general trend of phosphorus fertilization on nodulation was positive, Reddy (1975) reported that there was no significant difference in the number of effective nodules due to phosphorus application at any of the three stages of sampling in greengram. Murali (1989) also reported that in Sesbania rostrata, phosphorus application did not increase both root and stem nodulation.

Phosphatic fertilization influenced the nodulation of legumes as indicated by various trials.

2.2.1.4 Leaf : stem ratio

De Gesus (1977) recorded maximum leafiness in stylosanthes with the application of combinations of moderate levels of nitrogen and phosphorus.

Results of a trial on Stylosanthes gracilis indicated an increasing trend in leaf : stem ratio with increased levels of phosphorus upto 120 kg ha^{-1} (Mariyappan, 1978).

Pillai (1986) reported that application of phosphorus significantly increased the leaf : stem ratio of Stylosanthes guianensis both in open and shaded conditions.

Phosphorus application improved the leaf : stem ratio as a general trend.

2.2.1.5 Leaf area index

Results of a trial on peas proved that application of phosphorus increased the leaf area index (Omel'chenkov, 1970).

Roy and Mishra (1975) reported that leaf area index of soybean was increased upto the level of 39 kg P_2O_5 ha^{-1} and then decreased.

Tarila and Ormrod (1977) reported that increasing levels of phosphorus increased the leaf area in cowpea.

Rollin Bhaskar (1979) observed that leaf area index of greengram was significantly increased by the application of 12.5 to 50.0 kg P_2O_5 ha^{-1} over no phosphorus application which resulted in higher dry matter production.

Geethakumari (1981) reported a linear increase in leaf area index with increased application of phosphorus during early stage of growth in cowpea, but at later stages maximum leaf area index was obtained with the application of 50 kg P_2O_5 ha^{-1}.

Halepyati and Sheelavantar (1989) in an experiment with Sesbania rostrata reported that application of phosphorus increased the supply of nitrogen for the biological activity of the plant, increased the cell division and expansion of each resulting in higher leaf area.

Phosphorus application favoured the leaf area index generally. On the contrary, Subramanian (1978) reported that leaf area index was not influenced by phosphorus levels, in blackgram.

2.2.1.6 Number of branches

Panda (1972) reported that in greengram var. Pusa baisakhi phosphorus application increased the number of branches per plant.

Jain et al. (1986) observed that application of 60 kg P_2O_5 ha^{-1} increased the number of branches in cowpea grown under 4 levels of phosphorus.

In an experiment with Stylosanthes hamata, Khara et al. (1990) reported that phosphorus application at the rate of 17.5 kg ha^{-1} significantly increased the number of primary branches.

The beneficial effect of phosphorus application on fodder attributes of cowpea which increased the number of branches per plant was reported by Singh and Singh (1991).

Though the number of branches was positively influenced by the phosphorus application as evident from the results of various trials, opposing results were obtained by some workers. Mariyappan (1978) observed that in Stylosanthes gracilis phosphorus application had no influence on number of branches per plant.

2.2.2 Influence of phosphorus on yield of fodder crops

2.2.2.1 Green fodder yield

Garg et al. (1970) reported that incremental doses of phosphorus increased the green fodder yield significantly upto 37 kg P_2O_5 ha^{-1} in cowpea. Positive influence of phosphatic fertilization on the green matter production of cowpea was also reported by Sharma et al. (1974).

In a trial with cowpea, Dubey et al. (1975) reported that the fresh fodder yields of cowpea were increased by the application of 100 kg P_2O_5 ha^{-1}.

The beneficial influence of phosphorus fertilization in cowpea was reported by Faroda and Tomer (1976) who observed that 17 kg P_2O_5 ha^{-1} and 34 kg P_2O_5 ha^{-1} which did not differ from each other were significantly superior to the control in terms of green matter production per hectare.

Sandhu et al. (1976) observed that in cowpea, production of green fodder was significantly affected by phosphorus application and the application of 25 kg P_2O_5 ha^{-1} gave a significant increase, there being no additional increase in yield when the level of phosphorus was raised to 50 or 75 kg P_2O_5 ha^{-1}.

In a trial on the fodder production potential of legumes, Singh and Trivedi (1981) observed that application of 120 kg P_2O_5 ha^{-1} either in the form of single superphosphate or triple superphosphate produced maximum green forage.

In an experiment on biomass production of Sesbania rostrata, Murali (1989) reported maximum green matter yield of 15.85 t ha^{-1} with the application of 30 kg P_2O_5 ha^{-1}.

In a study on the influence of phosphorus on yield and quality of fodder cowpea, Thakuria and Luikham (1991 a) reported that the green fodder yields were significantly affected by phosphorus supply. Application of 50 kg P_2O_5 ha^{-1} showed a significant superiority over control and 25 kg P_2O_5 ha^{-1} was on a par with 75 kg P_2O_5 ha^{-1}.

Green fodder yield of legumes increased with the application of phosphorus. However, no effect on green matter yield of cowpea by increased application of phosphorus was noticed by Sundaram et al. (1974).

2.2.2.2 Dry fodder yield

Rao and Patel (1975) reported the beneficial influence of phosphorus application on dry matter production over no phosphorus application in cowpea.

Application of both 17 and 34 kg P_2O_5 ha^{-1} which did not differ from each other was significantly better than control in terms of dry matter production per hectare and dry matter accumulation in individual plants of cowpea (Faroda and Tomer, 1976).

Sandhu et al. (1976) reported that production of dry fodder was significantly affected by phosphorus application in cowpea. Application of 25 kg P_2O_5 ha^{-1}gave a significant increase, while no additional increase was observed in yield when the level of phosphorus was raised to 50 or 75 kg P_2O_5 ha^{-1}.

Halepyati and sheelavantar (1989) observed that application of 100 per cent P_2O_5 dose of rice to Sesbania rostrata produced the highest dry matter followed by application of 50 per cent P_2O_5 dose of rice to Sesbania rostrata.

Results of a trial conducted by Murali (1989) on biomass production of Sesbania rostrata indicated that with the application of 30 kg P_2O_5 ha^{-1}, a maximum dry matter yield of 5.08 t ha^{-1} was obtained.

Raj and Patel (1991) observed that the dry fodder yield of cowpea was significantly influenced by phosphorus application. Maximum dry fodder yield of 7.62 t ha^{-1} was obtained with the application of 80 kg P_2O_5 ha^{-1}.

Results of an experiment conducted by Thakuria and Luikham (1991 b) in fodder cowpea indicated that the dry fodder yield was significantly affected by phosphorus application. Application of 50 kg P_2O_5 ha^{-1} was superior to control and 25 kg P_2O_5 ha^{-1} was on a par with 75 kg P_2O_5 ha^{-1}.

Contrary results have been reported by Kruger et al. (1990) that the phosphorus application did not influence dry matter production of sub-tropical pasture legumes.

2.2.3 Influence of phosphorus on fodder quality

2.2.3.1 Crude protein

In a trial on phosphate manuring of legumes, Sen and Bains (1956) observed that manurial treatments in general and phosphatic fertilizer application in particular improved the quality of cowpea hay in respect of nitrogen content.

Omueti and Oyenuga (1970) and Gill et al. (1972) reported an increase in protein content of cowpea fodder due to phosphorus application.

Sahu (1973) reported that inoculation or phosphatization increased the nitrogen content in shoot and root of blackgram and horsegram.

Bhagwandas et al. (1975) found that the application of phosphorus at the rate of 40 kg P_2O_5 ha^{-1} increased the crude protein yield from 4.19 to 4.92 quintals ha^{-1} and it was increased to 5.32 quintals ha^{-1} at 80 kg P_2O_5 ha^{-1} in fodder cowpea.

Results of trial undertaken by Faroda and Tomer (1975) revealed that in fodder cowpea application of 17 kg and 34 kg P_2O_5 ha^{-1} were significantly better than control in respect of nitrogen percentage and total uptake of nitrogen.

Progressive increase in protein content of *Stylosanthes gracilis* with increasing levels of phosphorus upto 120 kg ha^{-1} was reported by Mariyappan (1978). Increasing the phosphorus levels beyond 120 kg ha^{-1} showed a decline in protein content.

In a trial conducted by Murali (1989) on biomass production of *Sesbania rostrata*, phosphorus application increased the nitrogen content of plant and application of 30 kg P_2O_5 ha^{-1} recorded a nitrogen content of 2.05 per cent.

Beneficial effect of phosphorus application on the crude protein content of cowpea plants was reported by Thakuria and Luikham (1991 a). In their trial, crude protein content and yield were significantly higher at 50 kg P_2O_5 ha^{-1}.

Though the general influence of phosphorus application on crude protein content was positive, some workers have obtained contradictory results. Rao and Subramanian (1990) reported that phosphorus application in combination with zinc sulphate decreased the nitrogen accumulation in leaves and stems. Othman *et al*. (1991) observed that though phosphorus concentration in plant tops, roots and nodules increased with phosphorus supply, nitrogen concentration in these plant tissues were unaffected by phosphorus supply in cowpea.

2.2.3.2 Phosphorus content

Sen and Bains (1956) reported improved quality of the cowpea hay in respect of phosphorus content due to phosphorus application.

Results of a trial on fodder cowpea revealed that application of 17 kg and 34 kg P_2O_5 ha^{-1} significantly increased the plant phosphorus per cent and total uptake of phosphorus over the control (Faroda and Tomer, 1975).

Maloth and Prasad (1976) reported increased uptake and accumulation of phosphorus due to phosphorus application in cowpea. Uptake of phosphorus was approximately doubled on applying 50 kg P_2O_5 ha^{-1}.

Results of a trial on Stylosanthes gracilis indicated that phosphorus application at the rate of 120 kg ha^{-1} was superior resulting in higher phosphorus content and the levels of 40 kg and 80 kg P_2O_5 ha^{-1} were on a par (Mariyappan, 1978).

In a trial on biomass production of Sesbania rostrata, Murali (1989) reported that phosphorus application at the rate of 30 kg ha^{-1} resulted in a plant phosphorus content of 0.65 per cent compared to 0.57 per cent for no application.

Singh and Hiremath (1990) reported that in mungbean phosphate fertilization significantly increased the phosphorus content of plant parts.

Othman _et al_. (1991) reported that phosphorus concentration in plant tops, roots and nodules increased with phosphorus supply in cowpea.

In a trial on fodder cowpea, Thakuria and Luikham (1991 a) observed significantly higher phosphorus content (0.32 per cent) in plants with the application of 50 kg P_2O_5 ha^{-1}.

Phosphorus application generally increased the phosphorus content of plant parts in legumes as evident from various trials.

2.2.3.3 Potassium content

Faroda and Tomer (1975) reported that total uptake and accumulation of potassium in fodder cowpea was significantly increased by the application of 17 and 34 kg P_2O_5 ha^{-1}.

Result of an experiment conducted by Mariyappan (1978) indicated that increasing levels of phosphorus significantly increased the potassium content of *Stylosanthes gracilis*.

In a trial on the biomass production of *Sesbania rostrata*, Murali (1989) reported that phosphorus application at the rate of 30 kg ha^{-1} recorded highest potassium content of 1.69 per cent.

Phosphorus application generally influenced the potassium content of legumes positively. Contrary results were also reported by some workers. Faroda and Tomer (1975) found that phosphorus application had no effect on the potassium content of fodder cowpea.

2.2.3.4 Calcium content

Omueti and Oyenuga (1970) and Gill *et al*. (1972) reported increase in the calcium content of cowpea fodder due to phosphorus application.

Faroda and Tomer (1975) noted that application of 17 kg and 34 kg P_2O_5 significantly increased the uptake and accumulation of calcium in fodder cowpea over the control.

Mariyappan (1978) observed that in unlimed condition calcium content of plants increased with increase in the levels of phosphorus upto 120 kg ha^{-1} in *Stylosanthes gracilis*.

Pillai (1986) reported increased calcium content of *Stylosanthes guianensis* by phosphorus application in open and shaded conditions.

Phosphorus application increased the calcium content of *Sesbania rostrata* and the application of 30 kg P_2O_5 recorded a calcium content of 1.04 per cent in plant (Murali, 1989).

Calcium content in legumes was favourably influenced by phosphorus application as a general trend. On the contrary, Faroda and Tomer (1975) found that phosphorus application did not influence the calcium content in fodder cowpea.

2.2.3.5 Magnesium content

In a trial with *Stylosanthes gracilis*, Mariyappan (1978) observed that effect of phosphorus was significant in increasing the magnesium content of fodder and 120 kg P_2O_5 ha^{-1} was superior to other levels.

Some workers have reported that the phosphorus application had no effect on magnesium content in fodder legumes. In an experiment on biomass production of Sesbania rostrata, Murali (1989) reported that the phosphorus application did not influence magnesium content of plants.

2.3 Varietal difference

2.3.1 Growth attributes

In a field trial on five varieties of cowpea in red sandy loam soils of Vellayani, Nair (1966) observed that varieties differed significantly with regard to plant height at maturity.

Bhat (1979), while working on production potential of three cowpea varieties viz., C-152, Chinese red and New Era at Dharward observed that the variety Chinese red produced significantly more number of green leaves, RGR, stem weight, leaf weight and total dry matter than the other two varieties.

While analysing the growth and yield factors of three mung varieties, Saini and Das (1979) noted appreciable varietal differences in leaf area index.

In a trial with different fodder cowpea varieties, maximum length of the vine (279.73 cm) was recorded in the variety UPC-287 and the minimum length in C-1 variety (82.51 cm). Highest leaf:stem ratio was recorded in the variety JC-1 and the lowest ratio in MPKV-1 (Singh et al. 1979).

Subramanian et al. (1987) reported that CO-5 variety of fodder cowpea was superior to CO-1 variety in all the yield attributes and this variety had a plant height of 93.0 cm and leaf:stem ratio of 3.3. Number of leaves and number of branches were 12.1 and 2.4 respectively.

Growth attributes of legumes varied according to the genetic characters of the variety.

2.3.2 Fodder yield

2.3.2.1 Green fodder yield

In a field trial, Jacquinot (1967) observed that cowpea variety S-8-23 yielded significantly higher green matter yield as compared to three other fodder cowpea varieties.

In an experiment with six cowpea varieties, Ranjhan et al. (1967) reported that Russian Giant and T_2 Lobia gave significantly higher green matter yield.

Restuceia (1968) tested six fodder cowpea varieties during summer and observed that green matter yield differed significantly among the varieties.

Dhanram et al. (1971) noted that fodder cowpea CV-10 gave the highest green matter yield and was most suitable for multiple cut.

Ranjhan et al. (1972) observed varietal differences in green matter yield from a comparative trial with four Australian cowpea varieties and variety Russian Giant as the check.

Sundaram et al. (1974) reported that variety CO-1 was superior to EC-4216 with regard to green matter yield.

Faroda and Tomer (1976) obtained different green matter yields in three different varieties of fodder cowpea.

In a trial with eighteen fodder cowpea varieties, Rao and Sampath (1976) observed that the green matter yield ranged between 20.0 and 40.5 tonnes per hectare.

Tripathi et al. (1977) observed that of the four cowpea varieties tried, the variety HFC 42-1 out yielded all other varieties in green fodder yield. On an average 14.0, 7.3 and 7.5 per cent higher green fodder yield was recorded with HFC 42-1 variety over Russian Giant, EC 4216 and FOS varieties respectively.

In a trial under AICRP at Vellayani with 26 varieties of fodder cowpea, variety C-152 recorded 20 tonnes ha^{-1} of green fodder yield (AICRP, 1984).

Subramanian et al. (1987) reported that fodder cowpea variety CO-5 has a green fodder yield potential of 18.16 t ha^{-1} in 50-55 days which was 32.74 per cent higher than that of CO-1.

In an evaluation trial conducted under AICRP on forage crops at TNAU with 12 varieties of fodder cowpea, variety CO-5 recorded 35.42 t ha^{-1} of green fodder yield (AICRP, 1990).

Varietal difference influenced the green fodder yield as evident from various trials.

2.3.2.2 Dry fodder yield

In an experiment with three fodder cowpea varieties viz., CV-10 EC-4216 and FOS-1, Faroda and Tomer (1976) reported that the dry matter yield differed significantly among the varieties and ranged between 3.68 and 4.28 tonnes per hectare. Rao and Sampath (1976) conducted a field experiment with eighteen cowpea varieties and found that variety CL-1 gave the highest dry fodder yield of 6.05 t ha^{-1}.

Singh et al. (1976) reported the superiority of fodder cowpea variety HFC-42-1 over FOS-1. HFC 42-1 produced 4.7 tonnes of dry fodder while FOS-1 produced 4.54 tonnes of dry fodder.

Tripathi _et_ _al_. (1977) reported that the cowpea variety HFC 42-1 out yielded all other varieties in dry matter yield. On an average 15.0, 14.3 and 16.9 per cent higher dry matter yield were recorded with HFC 42-1 variety over Russian Giant, EC-4216 and FOS-1 variety of fodder cowpea respectively.

In a comparative study involving fourteen fodder cowpea varieties, the dry fodder yield ranged between 1.05 and 5.04 tonnes per hectare (Akinola and Davis, 1978).

Deshmukh _et_ _al_. (1980) reported that variety IGFRI-978 gave significantly higher dry matter yield than varieties EC-4216, IGFRI-457 AND IGFRI-450.

Nawargaonkar _et_ _al_. (1980) conducted an experiment with four fodder cowpea varieties and observed that dry matter yield ranged from 2.82 to 5.03 tonnes per hectare in different varieties.

Subramanian _et_ _al_. (1987) reported a dry matter production of 2.66 t ha^{-1} in fodder cowpea variety CO-5 in an yield performance trial.

Dry matter production of different varieties differed significantly according to their production potential as indicated by the results of the trials mentioned above.

2.3.3 Quality of fodder

Fodder varieties differ in their quality characters.

Ranjhan et al. (1972) reported a crude protein content of 19.3 per cent in Russian Giant variety of fodder cowpea compared to 15-17 per cent in Australian varieties.

In a trial with fourteen cowpea varieties, Das et al. (1975) observed that the variety FOS-42-1 recorded the highest crude protein content.

Results of a field trial conducted by Faroda and Tomer (1975) indicated that cowpea variety No.10 recorded maximum nitrogen content and total uptake of nitrogen, phosphorus, potassium and calcium while variety EC-4216 was found to contain higher amount of potassium and calcium.

In a study on chemical composition of fodder cowpea varieties, Rao and Sampath (1976) noticed that crude protein content ranged from 16.12 to 20.58 per cent and the phosphorus content ranged from 0.37 to 0.41 per cent.

Singh et al. (1976) reported slightly higher crude protein content in cowpea variety HFC 42-1 over FOS-1.

Singh et al. (1979) reported that the crude protein content of different cowpea varieties varied from 1.57 to 8.54 quintals ha^{-1}.

Results of a trial conducted by Subramanian et al. (1987) indicated the superior quality of fodder cowpea variety CO-5 which recorded a crude protein content of 20.00 per cent, calcium content of 2.8 per cent and phosphorus content of 0.14 per cent.

Fodder cowpea variety CO-5 recorded a crude protein yield of 1573 kg ha^{-1} in an evaluation trial conducted at TNAU (AICRP, 1990).

Reports from AICRP centre, Rajendranagar indicated that Sesbania rostrata had a high crude protein content (32.00 %), good digestibility and satisfactory cattle acceptance as a green fodder in combination with cereal fodders (AICRP, 1991).

2.4 Residual effect of growing leguminous crops on the yield of succeeding rice crop

De et al. (1983) reported that the previous seed crops of mungbean, cowpea and blackgram increased the grain and straw yields of subsequent rice crop. The legumes increased the yield components such as number of productive tillers per m^2, panicle length, number of grains per panicle etc.

Takahashi et al. (1986) reported that the utilization of Sesbania sp. as a preceding crop in upland rice resulted in increased plant height, tillers per m^2, LAI and dry weight. Rice yield was highest following Sesbania sp.

Narwal and Malik (1989) observed that the local cultivar of tall wheat yielded more when sown after fallow or legumes than after non legumes and produced more earbearing tillers and more grains per ear.

Rai and Sinha (1990) observed that the residual effect of guar and cowpea on the yield of succeeding wheat crop was well marked and the trend of increase in wheat yield as a result of phosphorus application to the preceding crop was very much apparent.

Patel and Saraf (1991) reported that the ameliorative effects of legumes on the soil is considered to be the most important factor in improving cereal production. In their trial, application of irrigation, phosphorus and weed control treatments to summer cowpea produced favourable effect on yield and nutrient uptake by succeeding sorghum crop.

Sharma et al. (1991) reported that the inclusion of legumes in crop rotation benefits the succeeding wheat crop mainly because of the improvement in nitrogen status of soil.

These studies indicate that the forage legumes and residues from pulse crops can supply nitrogen to the succeeding rice crop, improve soil physical and chemical properties in a rice based cropping system. However, contradictory results have also been obtained by Shashidhara et al. (1987) who reported that legumes for fodder purpose had little influence on the succeeding crop of finger millet.

MATERIALS AND METHODS

MATERIALS AND METHODS

Leguminous fodder crops were raised in summer rice fallow during March - May and thereafter a bulk crop of paddy was raised as dry sown crop during May- August to study the residual effect.

3.1 Experimental site

The field experiment was conducted at Cropping Systems Research Centre, Karamana, Thiruvananthapuram. Location is situated at 8°5'N latitude and 76°9'E longitude and at an altitude of 29 m above mean sea level.

3.1.1 Soil

Soil of the experimental site is a riverine alluvium, acidic in reaction, low in CEC, medium in organic carbon, medium in available nitrogen, phosphorus and potassium. Soil samples were collected from 0-30 cm depth and a composite sample was used for ascertaining the chemical properties.

3.2 Season

The experiment was carried out during 22nd February-10th August, 1992.

Leguminous crops as per the treatments were raised and harvested in summer during 6th March-6th May. Succeeding bulk crop of paddy variety, Hriswa (culture 24-20) was raised in the first crop season during May 25th - August 10th to study the residual effect.

Table 1. Physico-chemical properties of soil at the experimental site.

1.a Physical composition

Parameters	Content in soil (%)	Method used
Coarse sand fine sand	74.28	Bouyoucas hydrometer (Bouyoucas, 1962)
Silt	8.74	
Clay	17.87	
Soil texture	Sandy loam	

1.b Chemical composition of the soil at the experimental site

Constituent	Content in soil	Rating	Method
1. pH	5.3	Acidic	pH meter with glass electrodes (Jackson, 1973)
2. EC (dS m^{-1})	0.016	Safe	Conductivity bridge
3. CEC (c mol(P^+) kg^{-1})	6.84		Buchner funnel method (Jackson, 1973)
4. Organic carbon (%)	0.72	Medium	Walkley and Black's rapid filtration method (Jackson, 1973)
5. Available N (kg ha^{-1})	313.00	Medium	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
6. Available P_2O_5 (kg ha^{-1})	40.00	Medium	Bray colourimetric method (Jackson, 1973)
7. Available K_2O (kg ha^{-1})	215.00	Medium	Ammonium acetate method (Jackson, 1973)
8. Available Ca (kg ha^{-1})	189.30		Ammonium acetate method (Jackson, 1973)
9. Available Mg (kg ha^{-1})	131.50		Ammonium acetate method (Jackson, 1973)

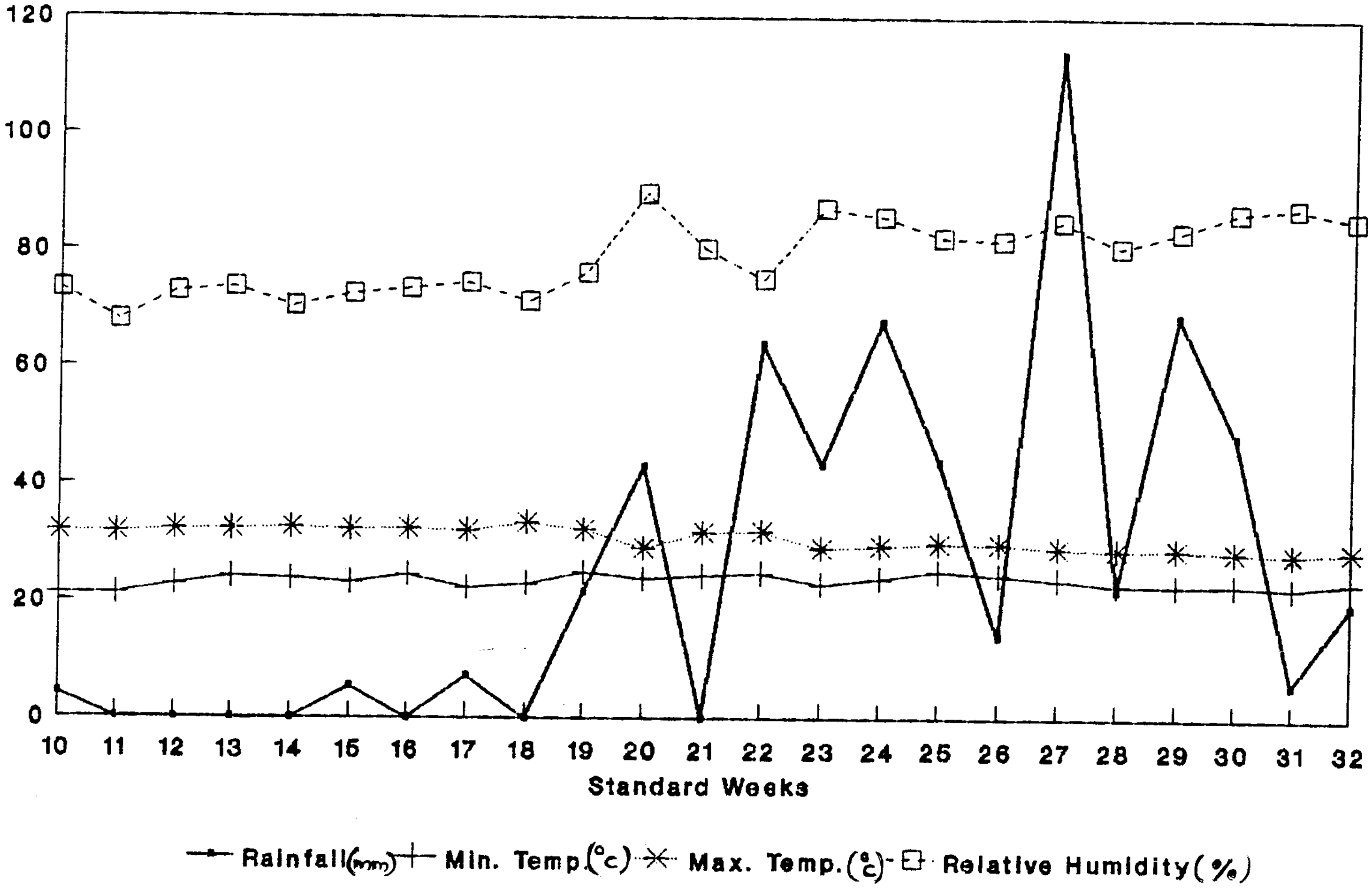


Fig. 1. Weather condition during the cropping period
(6th March 1992 to 10th August 1992)

3.3 Weather conditions

Data on weather conditions like temperature, rain fall and relative humidity were obtained from Thiruvananthapuram Observatory. Weather condition was satisfactory for proper growth and establishment of the crop. The average values of climatic parameters for the cropping period are given in Appendix I. Mean maximum and minimum temperature ranged from 28.22°C to 33.40°C and 21.20°C to 25.25°C respectively. The mean relative humidity ranged from 67.86 per cent to 89.71 per cent. The total rainfall received during the cropping period was 592.40 mm. in 161 days.

3.4 Cropping history of the field

Bulk crop of paddy was raised prior to the commencement of experiment in the second crop season during 1991.

3.5 Materials

3.5.1 Seeds

Seeds of cowpea variety C-152 and <u>Sesbania rostrata</u> were obtained from Cropping Systems Research Centre (CSRC), Karamana. Department of Forage Crops, Tamil Nadu Agricultural University, Coimbatore supplied the seeds of CO-5 variety of cowpea. Karnataka local seeds were obtained from the Krishi Vigyan Kendra, Manjeswar. Seeds of rice variety, Hriswa (culture 24-20) was used to raise the bulk crop after fodder crops and was obtained from CSRC, Karamana. Description of varieties are given below:

3.5.1.1 C-152

This variety was identified and developed from the germplasm at pulse off-season nursery at Coimbatore. The foliage is green in medium fertile and dark green in high fertile soils. It is largely recommended as a grain crop for cultivation in rice fallows. Studies under AICRP on forage crops, Vellayani showed its suitability for fodder purpose also.

3.5.1.2. CO-5

A high yielding fodder cowpea mutant isolated from the M-5 generation of CO- 1 cowpea seeds irradiated with 30 Kr gamma rays. This mutant has recorded an average green matter yield of 18-16 t ha^{-1} in 50-55 days and was released as CO-5 fodder cowpea in 1986 from the Tamil Nadu Agricultural University.

3.5.1.3 Karnataka local

A popular and promising variety of cowpea from Karnataka which was introduced to Kerala, a few years back for cultivation as a grain crop in summer rice fallows. This variety is season bound in nature and high green matter yield has been reported from summer season crop.

3.5.1.4 Sesbania rostrata

A green manure crop with high biomass production capacity. This plant produces nodules both on the stem and roots.

3.5.1.5 Hriswa (culture 24-20)

This is an early duration rice culture evolved from a cross between T-140 and IR-8. Its duration is 75-85 days during summer season and gives comparable yield with other short duration varieties of 90-100 days. This variety has bold grains and red kernels.

3.5.2 Fertilizers

Mussoriephos containing 20 per cent P_2O_5 was used as the source of phosphorus. Urea (45.6% N) and muriate of potash (59.81% K_2O) were used as sources of nitrogen and potassium respectively. Quick lime (neutralising value Of 164.0) was used as a source of lime. The Rhizobium cultures for the seed treatment of cowpea and Sesbania rostrata and liquid Rhizobium culture for seedling spraying of Sesbania rostrata were obtained from the Department of Plant Pathology, College of Agriculture, Vellayani.

PLATE - 1. A GENERAL VIEW OF THE EXPERIMENT

3.6. Methods

3.6.1 Treatment

Combinations of three cowpea varieties and Sesbania rostrata with three levels of phosphorus and three levels of lime constituted the treatment.

A. Lime doses (main treatment)

L_0 - No lime

L_1 - 125 kg ha^{-1}

L_2 - 250 kg ha^{-1}

B. Phosphorus doses (main treatment)

P_0 - No phosphorus

P_1 - 30 kg P_2O_5 ha^{-1}

P_2 - 60 kg P_2O_5 ha^{-1}

C. Crops (sub-treatment)

V_1 - Cowpea variety CO-5

V_2 - Cowpea variety C-152

V_3 - Cowpea variety Karnataka local

V_4 - Sesbania rostrata

3.6.2 Treatment combinations

$l_0p_0v_1$	$l_0p_1v_1$	$l_0p_2v_1$
$l_0p_0v_2$	$l_0p_1v_2$	$l_0p_2v_2$
$l_0p_0v_3$	$l_0p_1v_3$	$l_0p_2v_3$
$l_0p_0v_4$	$l_0p_1v_4$	$l_0p_2v_4$
$l_1p_0v_1$	$l_1p_1v_1$	$l_1p_2v_1$
$l_1p_0v_2$	$l_1p_1v_2$	$l_1p_2v_2$
$l_1p_0v_3$	$l_1p_1v_3$	$l_1p_2v_3$
$l_1p_0v_4$	$l_1p_1v_4$	$l_1p_2v_4$
$l_2p_0v_1$	$l_2p_1v_1$	$l_2p_2v_1$
$l_2p_0v_2$	$l_2p_1v_2$	$l_2p_2v_2$
$l_2p_0v_3$	$l_2p_1v_3$	$l_2p_2v_3$
$l_2p_0v_4$	$l_2p_1v_4$	$l_2p_2v_4$

3.6.3 Layout and design

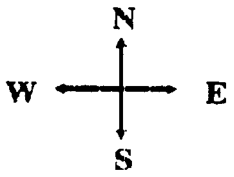
The experiment was laid out in split plot experiment in RBD with 3 replications. The layout plan is as given in Fig 2.

Treatment combinations - 36

Replications - 3

Total number of plots - 108

Fig. 2. Layout Plan



BLOCK - I						BLOCK - II						BLOCK - III					
$l_1p_0v_1$	$l_1p_0v_2$	$l_2p_1v_4$	$l_2p_1v_2$	$l_0p_0v_1$	$l_0p_0v_3$	$l_1p_0v_4$	$l_1p_0v_2$	$l_0p_0v_4$	$l_0p_0v_3$	$l_2p_1v_1$	$l_2p_1v_3$	$l_2p_2v_4$	$l_2p_2v_1$	$l_0p_2v_2$	$l_0p_2v_3$	$l_1p_1v_2$	$l_1p_1v_1$
$l_1p_0v_4$	$l_1p_0v_3$	$l_2p_1v_1$	$l_2p_1v_3$	$l_0p_0v_4$	$l_0p_0v_2$	$l_1p_0v_1$	$l_1p_0v_3$	$l_0p_0v_1$	$l_0p_0v_2$	$l_2p_1v_4$	$l_2p_1v_2$	$l_2p_2v_2$	$l_2p_2v_3$	$l_0p_2v_4$	$l_0p_2v_1$	$l_1p_1v_4$	$l_1p_1v_3$
$l_0p_2v_3$	$l_0p_2v_1$	$l_1p_1v_2$	$l_1p_1v_4$	$l_2p_2v_3$	$l_2p_2v_1$	$l_0p_2v_2$	$l_0p_2v_1$	$l_2p_2v_3$	$l_2p_2v_4$	$l_1p_1v_2$	$l_1p_1v_4$	$l_1p_0v_3$	$l_1p_0v_2$	$l_1p_2v_1$	$l_1p_2v_3$	$l_2p_0v_1$	$l_2p_0v_4$
$l_0p_2v_2$	$l_0p_2v_4$	$l_1p_1v_3$	$l_1p_1v_1$	$l_2p_2v_4$	$l_2p_2v_2$	$l_0p_2v_3$	$l_0p_2v_4$	$l_2p_2v_2$	$l_2p_2v_1$	$l_1p_1v_3$	$l_1p_1v_1$	$l_1p_0v_1$	$l_1p_0v_4$	$l_1p_2v_2$	$l_1p_2v_4$	$l_2p_0v_3$	$l_2p_0v_2$
$l_1p_2v_4$	$l_1p_2v_1$	$l_2p_0v_2$	$l_2p_0v_3$	$l_0p_1v_2$	$l_0p_1v_1$	$l_1p_2v_4$	$l_1p_2v_3$	$l_0p_1v_1$	$l_0p_1v_4$	$l_2p_0v_2$	$l_2p_0v_3$	$l_2p_1v_4$	$l_2p_1v_3$	$l_0p_0v_1$	$l_0p_0v_3$	$l_0p_1v_2$	$l_0p_1v_3$
$l_1p_2v_3$	$l_1p_2v_2$	$l_2p_0v_4$	$l_2p_0v_1$	$l_0p_1v_4$	$l_0p_1v_3$	$l_1p_2v_2$	$l_1p_2v_1$	$l_0p_1v_3$	$l_0p_1v_2$	$l_2p_0v_4$	$l_2p_0v_1$	$l_2p_1v_2$	$l_2p_1v_1$	$l_0p_0v_4$	$l_0p_0v_2$	$l_0p_1v_1$	$l_0p_1v_4$

TREATMENTS

I. LIME (Main Treatment)
1. l_0 - zero
2. l_1 - 125 kg ha^{-1}
3. l_2 - 250 kg ha^{-1}

II. PHOSPHORUS (Main Treatment)
1. p_0 - zero
2. p_1 - 30 kg P_2O_5 ha^{-1}
3. p_2 - 60 kg P_2O_5 ha^{-1}

III. CROPS (Sub Treatment)
1. v_1 - Cowpea var. **CO-5**
2. v_2 - Cowpea var. **C-152**
3. v_3 - Cowpea var. **Karnataka** local
4. v_4 - ***Sesbania rostrata***

DESIGN : SPLIT PLOT IN RBD

REPLICATIONS : 3

TOTAL NUMBER OF PLOTS : 108

PLOT SIZE : 3 x 3 m

SPACING : 30 x 10 cm

SITE OF THE EXPERIMENT : CROPPING SYSTEMS RESEARCH CENTRE, KARAMANA

3.6.4 Spacing and plot size

A spacing of 30 cm between the rows and 10 cm between the plants in a row was adopted.

Gross plot size - 3 x 3 m

Net plot size - 2.5 x 1.5 m

Area for periodical destruction to study nodule count - 2.5 x 0.90 m

3.7 Details of cultivation

3.7.1 Lime application

Lime was applied in plots as indicated in the treatments, one week prior to sowing and properly mixed with the soil.

3.7.2 Fertilizer application

Entire quantity of mussoriephos was applied at the time of sowing as per the treatments. Uniform doses of N and K as urea and MOP were given at the time of sowing as per the package of practice recommendations of the Kerala Agricultural University.

3.7.3 Seed treatment

Seeds of all the three cowpea varieties were treated with rhizobium culture Bradyrhizobium sp. and Sesbania rostrata seeds were treated with a mixed culture of Rhizobium (KAUS 5 and 6) prior to sowing on 5-3-1992. Cultures were obtained from Department of Plant Pathology, College of Agriculture, Vellayani. Seeds were first dipped in a 10 per cent sugar solution and then in Rhizobium culture and dried in shade.

3.7.4 Sowing

The treated seeds were sown in lines at a spacing of 30 cm, with 10 cm spacing between plants by dibbling two seeds per hill on 6-3-1992. Sesbania was sown by placing 5-6 seeds at each hill. At the end of sowing, soil was compacted between rows.

3.7.5 After cultivation

Seed germination was satisfactory. Ten days after the emergence of seedlings thinning was done by retaining one plant at each hill. Sesbania plants were sprayed with Rhizobium culture on 6-4-1992 to enhance the stem nodulation.

3.7.6 General condition of the crop

General condition of the crop was satisfactory, throughout the period. Plant protection measures as per the Kerala Agricultural University package of practices were taken to control aphids during the early stage of crop growth (24 DAS).

3.8 Harvest

Harvesting was done on 6-5-1992 at 50 per cent flowering stage by cutting the stem at the soil surface. The border area was first harvested and removed. Then the net plot area was harvested separately and weight of the green matter/plot recorded.

3.9 Cultivation details of succeeding paddy crop

A bulk crop of paddy was raised retaining the same experimental lay out of leguminous crops in the first crop season. Seeds of the variety, Hriswa (culture 24-20) was sown in rows at 15 cm apart with a plant to plant spacing of 10 cm as a dry sown crop on 26-5-1992. Plant protection measures were taken as per the Kerala Agricultural University package of practices. Crop was harvested on 10-8-1992. Two rows were left from each side of the plot as border rows and were harvested and removed first. Later, net plot was separately harvested and removed. Grain and fresh straw yield of each plot were recorded separately and from the fresh straw yield, dry straw yield was computed.

3.10 Plant sampling and growth studies

Five plants were randomly tagged in the net plot area to record the biometric observations viz. plant height, number of leaves and number of branches at 15 DAS, 30 DAS and at 50 per cent flowering and also to study the leaf : stem ratio and LAI

Different biometric observations made were the following:

3.10.1 Plant height

Height of the plant was recorded three times at 15 DAS (on 21-3-1992), 30 DAS (6-4-1992) and 50 per cent flowering (6-5-1992). Height was measured from the first basal node to the tip of the growing point.

3.10.2 Number of leaves

The number of fully opened leaves was counted from all the random plants at 15 DAS, 30 DAS and 50 per cent flowering.

3.10.3 Leaf area index (LAI)

Leaf area per plant was read in the Leaf Area Meter and was expressed as cm^2 per plant. From this leaf area, the leaf are index was worked out by the following formula suggested by Watson (1947).

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

3.10.4 Number of branches

Branches on the random plants were counted 15 DAS, 30 DAS and at 50 per cent flowering and the number noted.

3.10.5 Nodule number

Plants were carefully uprooted from the rows selected for destructive sampling, at 15 DAS, 30 DAS and at 50 per cent flowering. Nodule counts were made after washing the nodules. For Sesbania rostrata, root and stem nodules were counted and noted separately each time.

3.10.6 Leaf : stem ratio

Five plants were uprooted carefully from each plot. Each plant was separated into leaves and stem and were sundried first and then dried to a constant weight in hot air oven, at 68 - 70°C. Dry weight of stem and leaves were recorded separately for each plant after oven drying and the ratio was calculated.

3.10.7 Date of flowering

Date of appearance of first flower was noted in each plot and days to flower was calculated.

3.11 Yield

3.11.1 Green fodder yield

Green matter yield from the net plot area was recorded as kg per plot immediately after harvest and from this value, the yield per hectare was calculated.

3.11.2 Dry fodder yield

Five plants were uprooted from each plot and the fresh weight was recorded immediately. This plant material was first dried in sun and then dried to a contant weight in hot air oven at 68-70°C. Dry matter content was recorded accurately for each treatment and the dry fodder yield per hectare was computed.

3.12 Plant analysis

Plant samples were first dried in shade and subsequently in an oven and powdered well. One half of a gram of plant sample was digested using digestion mixture (K_2SO_4 & $CuSO_4$) and 20 ml of concentrated H_2SO_4. After digestion, the volume was made upto 50 ml and the sample thus prepared was used to estimate the nitrogen and phosphorus contents of plant.

3.12.1 Crude protein content

Total nitrogen content of the plant was estimated by modified microkjeldahl method as given by Jackson (1973). Crude protein content was calculated by multiplying the nitrogen content by the factor 6.25 (Simpson *et al*., 1965).

3.12.2 Total phosphorus content

Total P content was determined by the Vando-molybdophosphoric yellow colour method (Jackson, 1973) and read in a spectronic - 2000 spectrophotometer.

3.12.3 Total potassium content

Total K content in plant was estimated by Atomic absorption spectrophotometry, after wet digestion of the sample using di-acid mixture as suggested by Perkin-Elmer Corporation (1982).

3.12.4 Total calcium content

Total Ca content in plant was estimated by Atomic absorption spectrophotometry, after wet digestion of the sample using di-acid mixture as suggested by Perkin-Elmer Corporation (1982).

3.12.5 Total Magnesium content

Total Mg content in plant was estimated by Atomic absorption spectrophotometry, after wet digestion of the sample using di-acid mixture as suggested by Perkin-Elmer Corporation (1982).

3.12.6 Crude protein yield

Crude protein yield per hectare was calculated by multiplying the crude protein content of plant with the dry matter produced by the crops per hectare at harvest.

3.13 Uptake studies

The total uptake of nitrogen, phosphorus, potassium, calcium and magnesium by the fodder crops, during crop growth period was calculated as the product of the content of these nutrients in plant samples and the respective dry weights and expressed as kg ha^{-1}.

3.14 Soil Analysis

A composite soil sample was collected prior to the conduct of experiment and analysed to determine, physical composition, pH, available N, available P_2O_5, available K_2O, available Ca, available Mg, organic carbon %, CEC, and EC. After the harvest of fodder crops, soil samples were taken from each plot separately and analysed to determine available N, available P_2O_5, available K_2O, available calcium and available Mg.

3.14.1 Available N

Available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956).

3.14.2 Available P_2O_5

Available P_2O_5 was estimated by Bray colourimetric method (Jackson, 1973) and readings were taken in a Spectronic-20 spectrophotometer.

3.14.3 Available K_2O

Available K_2O was estimated spectrophotometrically using Atomic Absorption Spectrophotometer (Perkin-Elmer model).

3.14.4 Available Ca and available Mg

Available Ca and available Mg were estimated spectrophotometrically using Atomic-Absorption Spectrophotometer (Perkin-Elmer model).

3.15 Economics of cultivation

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

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

$$\text{Benefit-cost ratio} : \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.16 Statistical Analysis

Data generated from the experiment were subjected to analysis of variance (ANOVA) for split-splot design in RBD.

RESULTS

RESULTS

4.1. Growth Attributes

4.1.1 Plant height

Effects of lime, phosphorus and leguminous crops on plant height are shown in Table 2.

Increase in lime levels increased the plant height significantly and maximum height (86.04 cm) was recorded with the application of 250 kg lime per hectare at the third stage of observation. Figure 3 further explains this trend.

Taller plants were produced with the application of 60 kg P_2O_5 at the last stage of observation whereas phosphorus application did not influence the plant height at 15 DAS and 30 DAS.

Plant height recorded with different legumes varied significantly at all the three stages of observation. At 15 DAS cowpea variety C-152 recorded more plant height (17.27 cm) and Sesbania rostrata recorded the minimum (11.76 cm). Sesbania rostrata produced taller plants at 30 DAS than all other legumes while at the third stage of observation, this crop recorded almost two times more height than other cowpea varieties, (122.47 cm). Cowpea variety CO-5 produced taller

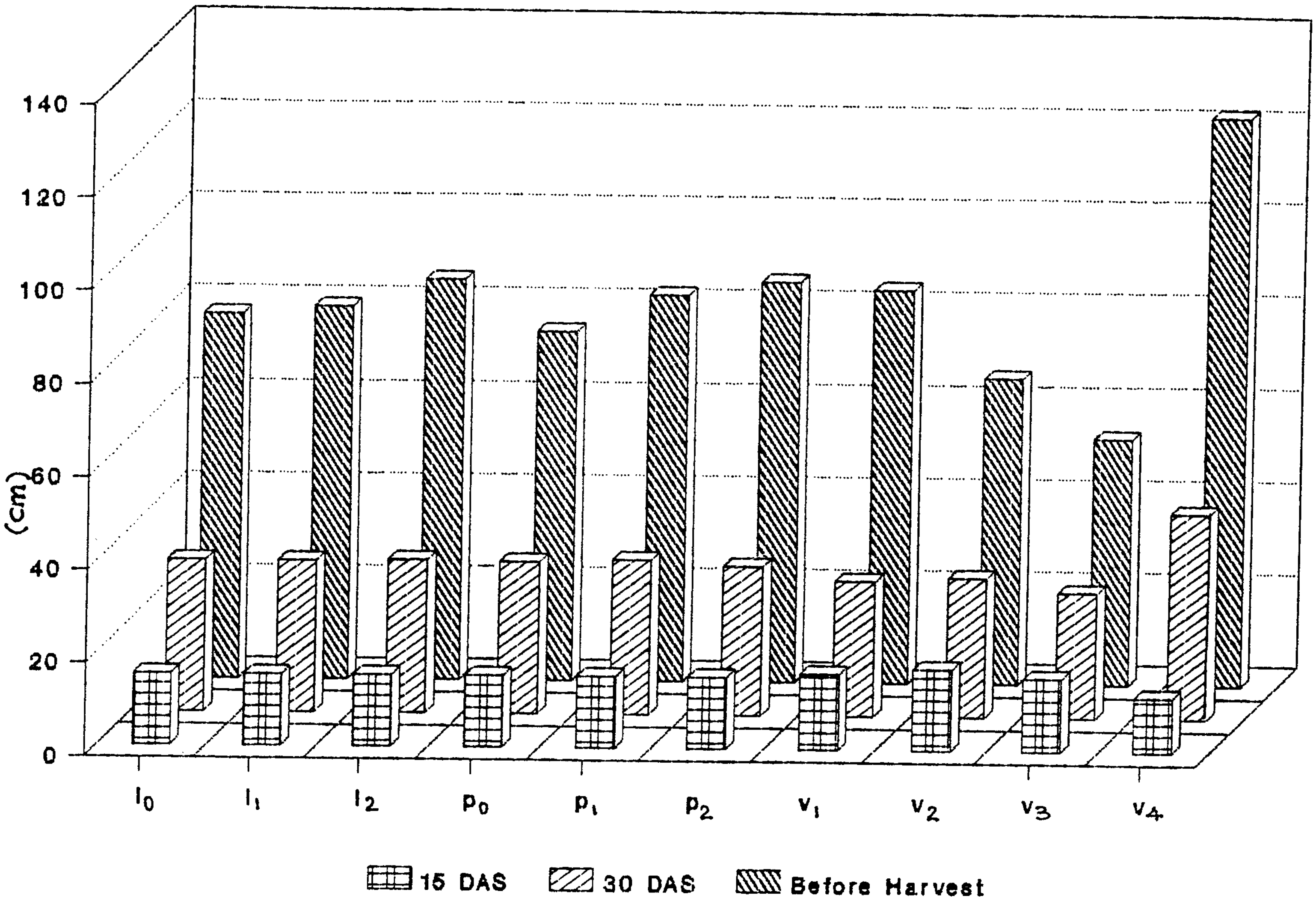


Fig. 3. Plant height

Table 2. Effect of lime, phosphorus and crops on growth parameters of fodder legumes

Treatment	Leaf/ stem ratio	LAI	Days to flowering	No. of leaves /plant			Height of the plant			No. of branches /plant	
				15DAS	30DAS	BH	15DAS	30DAS	BH	30DAS	BH
Lime (kg ha^{-1})											
0 (l_0)	1.24	7.18	39.00	3.78	10.31	24.69	15.10	32.34	78.21	0.89	3.25
125 (l_1)	1.12	7.24	41.00	3.82	10.86	24.81	15.30	32.48	80.11	0.84	3.17
250 (l_2)	0.90	10.75	42.00	3.86	10.27	38.07	15.11	32.69	86.04	0.84	4.33
$F_{2,16}$	1.29^{ns}	42.37^{**}	13.68^{**}	0.20^{ns}	1.15^{ns}	1002.63^{**}	0.50^{ns}	0.039^{ns}	94.15^{**}	0.074^{ns}	273.77^{**}
Phosphorus (P_2O_5 kg ha^{-1})											
0 (P_0)	1.27	6.62	40.00	3.76	10.47	22.94	15.24	32.38	75.07	0.77	3.34
30 (P_1)	1.09	8.16	41.00	3.88	10.46	30.46	15.17	33.09	83.11	0.82	3.48
60 (P_2)	0.89	10.38	42.00	3.82	10.51	34.17	15.10	32.03	86.19	0.99	3.92
$F_{2,16}$	1.65^{ns}	36.34^{**}	4.05^{*}	0.43^{ns}	0.0096^{ns}	554.41^{**}	0.18^{ns}	0.36^{ns}	186.28^{**}	1.05^{ns}	59.69^{**}
CD L/P	-	0.94	1.06	-	-	0.73	-	-	1.26	-	0.12
SEd	0.21	0.44	0.50	0.13	0.44	0.34	0.23	1.26	0.59	0.16	0.06
Crops											
Co-5 (V_1)	1.21	6.95	51.00	2.97	8.10	18.67	16.11	29.03	84.48	1.17	3.33
C-152 (V_2)	1.31	9.93	44.00	2.97	7.44	24.19	17.27	29.89	65.83	1.22	3.70
Karnataka Local (V_3)	1.12	6.23	34.00	2.93	8.56	20.02	15.53	26.92	53.05	0.98	2.97
Sesbania rostrata (V_4)	0.71	10.44	33.00	6.41	17.82	53.87	11.76	44.17	122.47	0.07	4.33
$F_{3,54}$	2.39^{ns}	30.21^{**}	505.96^{**}	374.12^{**}	161.18^{**}	3996.70^{**}	129.69^{**}	53.50^{**}	3648^{**}	24.79^{**}	89.72^{**}
CD	--	1.09	1.05	0.25	1.10	0.75	0.59	3.05	1.42	0.31	0.17
SEd	0.24	0.55	0.53	0.13	0.55	0.38	0.30	1.53	0.71	0.16	0.09

* - Significant at 5% level   ** - Significant at 1% level   ns - not significant

Table 3. Interaction effect of lime and crops (l x v) on growth parameters of fodder legumes

Treatment	Leaf/ stem ratio	LAI	Days to flowering	No. of leaves/plant			Height of the plant			No. of branches/plant	
				15DAS	30DAS	BH	15DAS	30DAS	BH	30DAS	BH
l_0v_1	1.55	5.09	50	2.91	8.40	14.44	16.27	29.57	76.58	1.11	2.36
l_0v_2	1.62	9.96	41	2.87	7.76	22.76	17.04	29.33	66.20	1.51	3.93
l_0v_3	1.32	5.31	33	3.09	7.87	17.16	15.66	28.20	56.96	0.96	3.02
l_0v_4	0.47	8.38	32	6.24	17.20	44.40	11.42	42.24	113.12	0.00	3.69
l_1v_1	0.83	6.27	51	3.00	7.82	17.51	15.97	27.97	85.68	1.16	3.11
l_1v_2	1.43	9.00	44	2.93	7.20	21.96	17.67	30.26	61.41	0.93	3.20
l_1v_3	1.05	5.58	34	2.93	9.79	17.78	15.70	25.86	51.20	1.09	2.56
l_1v_4	1.16	8.09	34	6.42	18.64	42.00	11.87	45.83	122.17	0.20	3.82
l_2v_1	1.25	9.50	51	3.00	8.09	24.07	16.11	29.54	91.18	1.24	4.51
l_2v_2	0.87	10.83	47	3.11	7.36	27.84	17.11	30.08	69.88	1.22	3.98
l_2v_3	0.97	7.80	34	2.78	8.02	25.13	15.23	26.71	51.00	0.89	3.33
l_2v_4	0.51	14.85	34	6.56	17.62	75.22	11.98	44.42	132.11	0.00	5.49
$F_{6,54}$	1.35^{ns}	4.43^{**}	2.79^{*}	0.84^{ns}	1.05^{ns}	258.48^{**}	0.61^{ns}	0.54^{ns}	47.62^{**}	1.02^{ns}	25.75^{**}
CD	--	1.88	1.82	-	-	1.29	-	-	2.46	-	0.30
SEd	0.42	0.94	0.91	0.22	0.95	0.65	0.52	2.65	1.23	0.27	0.15

* - Significant at 5 % level ** - Significant at 1% level

ns - Not significant

Table 4. Interaction effect of phosphorus and crops (p x v) on growth parameters of fodder legumes

Treatment	Leaf/ stem ratio	LAI	Days to flowering	No. of leaves/plant			Height of the plant			No. of branches/plant	
				15DAS	30DAS	BH	15DAS	30DAS	BH	30DAS	BH
P_0V_1	1.35	6.07	49	2.91	8.64	17.22	16.29	27.64	80.42	1.07	3.6
P_0V_2	1.37	7.93	43	2.84	7.42	19.98	17.56	30.76	57.28	0.93	3.6
P_0V_3	1.18	6.45	34	2.93	8.80	18.69	15.32	26.92	46.73	1.07	3.16
P_0V_4	1.19	6.02	33	6.36	17.02	35.89	11.79	44.21	115.83	0.00	3.02
P_1V_1	1.31	6.70	52	3.11	7.49	17.82	15.71	31.90	87.57	1.02	3.11
P_1V_2	1.38	9.65	44	3.02	7.11	24.29	17.31	28.97	66.20	1.31	3.69
P_1V_3	1.19	5.32	33	2.93	8.44	20.47	15.67	27.13	56.91	0.96	2.78
P_1V_4	0.48	10.97	33	6.47	18.78	59.24	11.98	44.34	121.78	0.00	4.36
P_2V_1	0.96	8.08	51	2.89	8.18	20.98	16.34	27.53	85.44	1.42	3.27
P_2V_2	1.17	12.20	45	3.04	7.78	28.29	16.96	29.94	74.01	1.42	3.82
P_2V_3	0.97	6.91	34	2.93	8.43	20.91	15.60	26.71	55.51	0.91	2.98
P_2V_4	0.46	14.33	34	6.40	17.67	66.49	11.50	43.94	129.79	0.20	5.62
$F_{6,54}$	0.40^{ns}	7.20^{**}	1.58^{ns}	0.21^{ns}	0.95^{ns}	237.36^{**}	0.72^{ns}	0.57^{ns}	13.79^{**}	0.76^{ns}	42.18^{**}
CD	--	1.88	-	-	-	1.29	-	-	2.46	-	0.30
SEd	0.42	0.94	0.91	0.22	0.95	0.65	0.52	2.65	1.23	0.27	0.15

** Significant at 1% level   ns- Not significant.

Table 5. Interaction effect of lime and phosphorus (l x p) on growth parameters of fodder legumes

Treatment	Leaf/ stem ratio	LAI	Days to flowering	No. of leaves/plant			Height of the plant			No. of branches/plant	
				15DAS	30DAS	BH	15DAS	30DAS	BH	30DAS	BH
l_0p_0	1.16	4.51	39	3.48	10.40	18.02	15.00	31.08	62.39	0.78	3.35
l_0p_1	1.49	9.48	39	4.03	10.50	31.02	15.45	33.55	87.13	0.98	3.32
l_0p_2	1.07	7.56	40	3.82	10.02	25.03	14.84	32.38	85.13	0.92	3.08
l_1p_0	1.68	5.89	40	3.77	10.98	22.23	15.18	33.13	78.63	0.73	3.47
l_1p_1	0.94	8.03	40	3.73	10.78	29.12	14.97	34.10	86.05	0.78	3.58
I_1p_2	0.72	7.78	42	3.97	10.83	23.08	15.75	30.21	75.67	1.02	2.47
l_2p_0	0.97	9.46	41	4.03	10.03	28.58	15.53	32.94	84.18	0.78	3.22
l_2p_1	0.85	6.98	42	3.88	10.08	31.23	15.08	31.61	76.17	0.70	3.55
l_2p_2	0.88	15.80	42	3.67	10.70	54.38	14.71	33.52	97.78	1.03	6.22
$F_{4,16}$	1.46^{ns}	29.83^{**}	0.34^{ns}	2.20^{ns}	0.37^{ns}	451.69^{**}	2.69^{ns}	1.19^{ns}	223.75^{**}	0.30^{ns}	309.40^{**}
CD	--	1.63	-	-	-	1.26	-	-	2.19	-	0.202
SEd	0.37	0.77	0.86	0.23	0.76	0.594	0.394	2.19	1.03	0.28	0.095

* - Significant at 5% level

** - Significant at 1% level

ns - Not significant

plants than C-152 and Karnataka local recorded the lowest plant height (53.05 cm) at the final stage of observation.

l x v interaction could influence the plant height only during the last stage of observation. In all legumes except cowpea variety Karnataka local, a significant increase in plant height was noticed on applying highest level of lime, (Table 3).

p x v interaction did not influence the plant height at early stages of growth. But at the final stage of growth all crops recorded maximum height with the application of 60 kg P_2O_5 except cowepa variety Karnataka local and CO-5 which responded only upto 30 kg P_2O_5, (Table 4).

At the final stage of observation combination of highest level of lime and phosphorus produced taller plants (97.78 cm) than all other combinations. 125 kg lime + 30 kg P_2O_5 resulted in more plant height (86.05 cm) than 250 kg lime + 30 kg P_2O_5 treatment which recorded a height of 76.17 cm, (Table 5).

4.1.2 Number of leaves per plant

Table 2 indicates that the different levels of lime did not influence the number of leaves per plant at 15 DAS and 30 DAS. However, number of leaves per plant was significantly increased to 38.07 with the highest dose of lime application just before harvest. Application of 125 kg lime was on a par with control.

The number of leaves per plant was not significantly influenced by different levels of phosphorus at 15 DAS and 30 DAS. Application of 60 kg P_2O_5 produced more number of leaves (34.17) compared to 30 kg P_2O_5 treatment (30.46) which in turn was significantly superior to the control as evident from Table 2 at the final stage of observation.

The number of leaves produced by different legumes varied significantly at all the three stages of observation. However there was no significant difference among cowpea variety CO-5, C-152 and Karnataka local in number of leaves produced per plant at 15 DAS. Sesbania rostrata produced more number of leaves than all other legumes at all the three stages of observation (Figure 4). At the second stage of observation cowpea variety Karnataka local produced more number of leaves (8.56) than C-152 (7.44) which in turn was on a par with variety CO-5 (8.10). Just before harvest cowpea variety C-152 produced significantly more number of leaves (24.19) than the variety Karnataka local (20.02) which in turn was superior to CO-5 which produced only 18.67 leaves per plant.

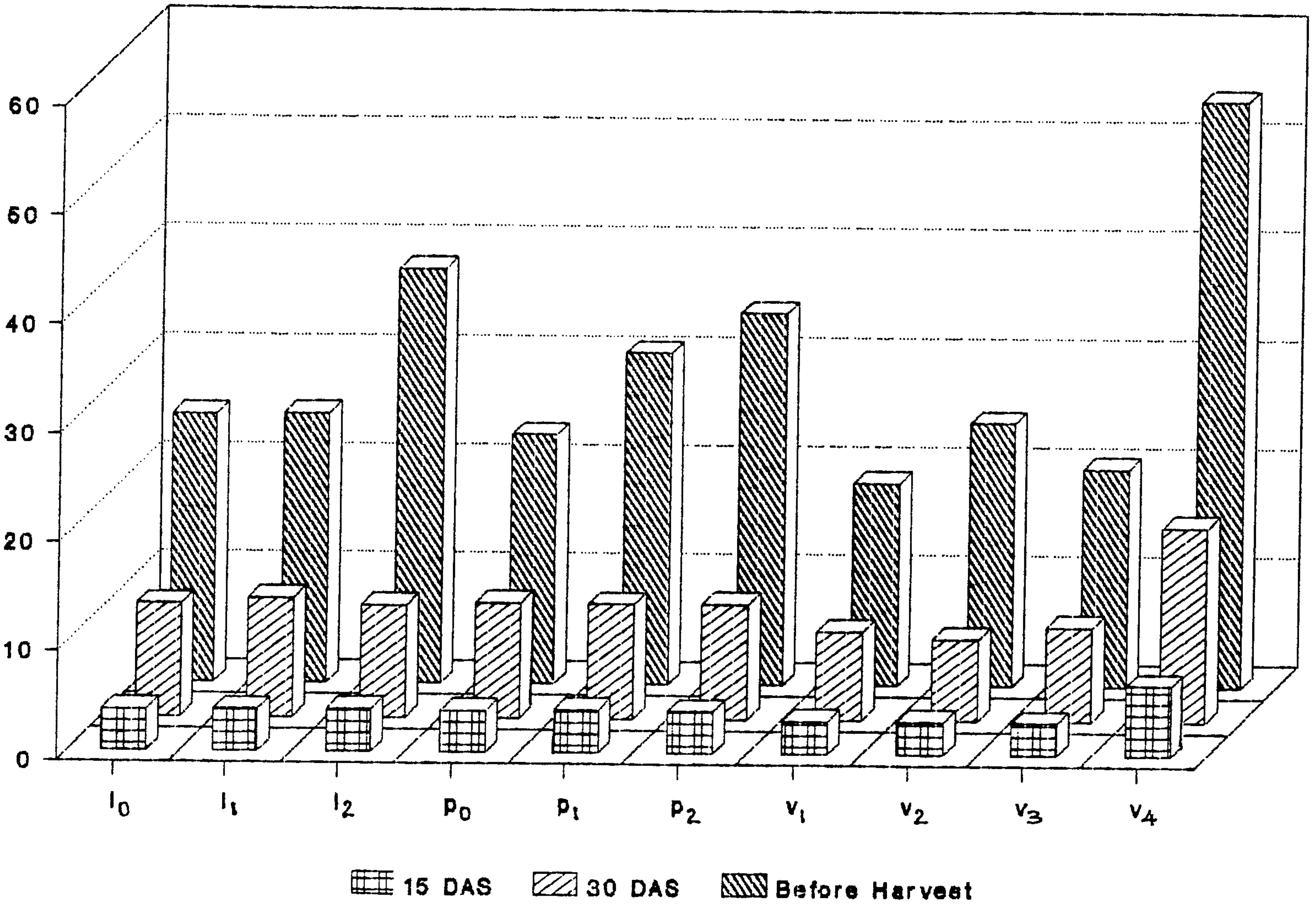


Fig. 4. Number of leaves per plant

l x v interaction did not significantly influence the number of leaves per plant at 15 DAS and 30 DAS. However increasing levels of lime from 0 to 250 kg significantly increased the number of leaves produced by all the fodder legumes, (Table 3). Sesbania rostrata produced maximum number of leaves (75.22) by the application of 250 kg lime at the final stage of observation.

p x v interaction had no significant influence on the number of leaves per plant at 15 DAS and 30 DAS, but at the third stage, maximum number of leaves was produced with the application of highest dose of phosphorus in all legumes except Karnataka local cowpea which responded only upto 30 kg P_2O_5, (Table 4).

l x p interaction was not significant at the first two stages of observation but it influenced the number of leaves per plant just before harvest. 250 kg lime + 60 kg P_2O_5 combination produced maximum number of leaves (54.38) followed by 250 kg lime + 30 kg P_2O_5 treatment. Application of 125 kg lime + 30 kg P_2O_5 combination produced significantly more number of leaves (29.12) than 125 kg lime + 60 kg P_2O_5 combination (23.08), (Table 5).

4.1.3 Leaf area index

Effect of lime, phosphorus and crops on LAI are shown in Table 2. Leaf area index increased with increasing

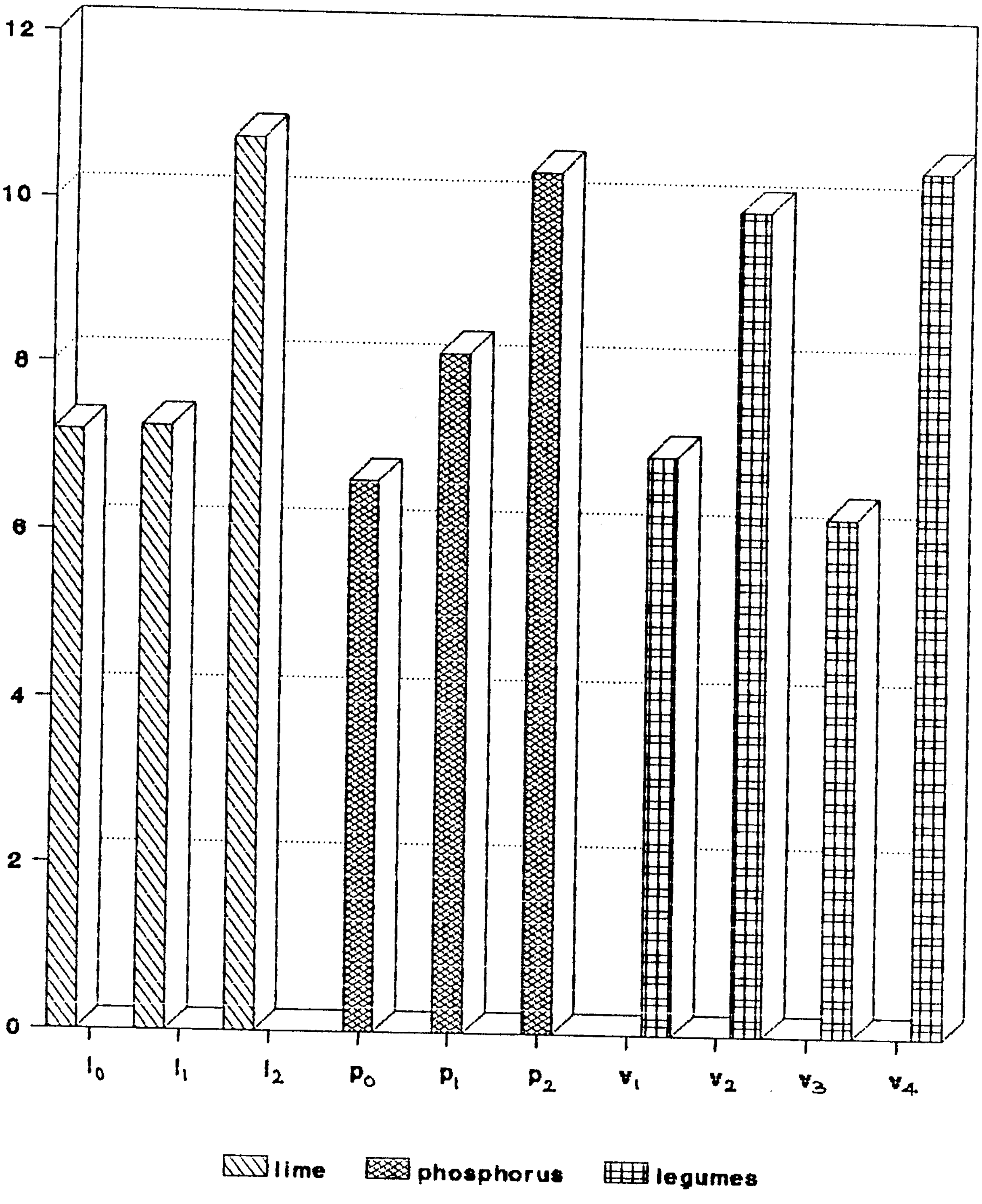


Fig. 5. Leaf Area Index

levels of lime and maximum value (10.75) was obtained with the application of 250 kg lime, which was significantly superior to 125 kg lime which produced a LAI of 7.24.

Table 2 indicates an increase in phosphorus level leading to a linear increase in leaf area index and maximum leaf area index (10.38) was recorded with the application of 60 kg P_2O_5.

Cowpea varieties CO-5 and Karnataka local recorded significantly lesser leaf area index in comparison with cowpea variety C-152 and Sesbania rostrata. Maximum leaf area index (10.44) was recorded with Sesbania rostrata which was on a par with C-152, (Table 2 and Figure 5).

l x v interaction significantly influenced the leaf area index of CO-5 cowpea variety, Karnataka local cowpea and Sesbania rostrata where maximum LAI was recorded with the application of 250 kg lime, (Table 3).

Leaf area index was significantly influenced by p x v interaction. Cowpea variety CO-5 produced significantly higher LAI (8.08) at the highest level of phosphorus (60 kg P_2O_5) than the control which was on a par with 30 kg P_2O_5. Cowpea variety C-152 and Sesbania rostrata also recorded maximum LAI with the application of highest level of phosphorus which were 12.2 and 14.33 respectively.

However, the cowpea variety Karnataka local did not exhibit any significant difference in LAI with increasing levels of phosphorus (Table 4).

It is clear from Table 5 that the LAI of different fodder legumes were influenced by l x p interaction. Maximum LAI was produced with the application of 250 kg lime + 60 kg P_2O_5 treatment (15.80) compared to 250 kg lime + 30 Kg P_2O_5 (6.98).

4.1.4 Leaf : stem ratio

Lime or phosphorus did not produce significant influence on leaf : stem ratio of fodder legumes, (Table 2). Varietal difference was also not observed to influence the leaf: stem ratio. None of the interactions were found to influence the leaf: stem ratio, (Tables 3, 4 and 5).

4.1.5. Number of branches

Effect of lime, phosphorus and crops on number of branches are shown in Table 2.

Increasing levels of lime did not influence the number of branches at 30 DAS, but more branches were produced (4.33) with the application of 250 kg lime at the last stage of observation.

Application of highest dose of P_2O_5 produced maximum number of branches (3.92) followed by the next lower dose.

There was significant difference in the number of branches produced by different legumes at both 30 DAS and before harvest. Cowpea varieties CO-5, C-152 and Karnataka local did not differ from each other in branching character at 30 DAS. Sesbania rostrata produced lesser number of branches (0.07) than all other legumes at the initial stage of observation, but more branching was noticed in this legume (4.33 branches per plant) at the final stage of observation. Cowpea variety C-152 produced more number of branches (3.70) than variety CO-5 (3.33) which in turn was superior to Karnataka local which produced only 2.97 branches per plant at the last stage of observation.

l x v interaction produced significant variation in branching only during the last stage of observation (Table 3). In all legumes except cowpea variety C-152 maximum number of branches were obtained with the application of 250 kg lime. In C-152 liming reduced the branching compared to the control though it was improved at the highest dose of application.

Table 4 indicates that p x v interaction also influenced the number of branches only during the final stage of observation. Number of branches increased with the application of 60 kg P_2O_5 in cowpea variety C-152 and Sesbania rostrata whereas in Karnataka local cowpea branching was reduced at higher levels of phosphorus application compared to the control.

l x p interaction significantly influenced the number of branches per plant (Table 5) at the final stage of observation. Application of 250 kg lime + 60 kg P_2O_5 produced highest number of branches (6.22) which was significantly superior to 250 kg lime + 30 kg P_2O_5 combination. 125 kg lime + 60 kg P_2O_5 treatment produced lesser number of branches (2.47) compared to 125 kg lime + 30 kg P_2O_5 (3.58).

4.1.6 Days to flower

Days taken for flowering significantly increased from 39 to 41, when the lime level was increased from 0 to 125 kg. However further increase in lime level did not produce any significant variation in flowering, (Table 2).

It is clear from Table 2 that the application of 60 kg P_2O_5 resulted in more days for flowering compared to control, but there was no significant difference between the days for flowering at 30 kg P_2O_5 and 60 kg P_2O_5 levels.

Cowpea variety CO-5 took more days for flowering (51 days) than all other legumes. Likewise more days were taken for flowering in case of cowpea variety C-152 (44) compared to Karnataka local (34) and Sesbania rostrata (33), (Table 2).

l x v interaction influenced the number of days taken for flowering (Table 3). Cowpea varieties CO-5 and Karnataka local took equal days for flowering under 125 kg lime and 250 kg lime treatments. Cowpea variety C-152 required more days for flowering (47 days) with 250 kg lime application. Compared to control, Sesbania rostrata took more days to flower (34 days) when 125 kg lime was applied; however the next higher dose did not produce any significant variation in flowering.

4.1.7 Nodulation

Results of the single effect of lime, phosphorus and legumes and their interaction effects on root nodulation of legumes and stem nodulation of Sesbania rostrata are given below.

4.1.7 a Root nodulation

Number of root nodules per plant was not influenced by different levels of lime at 15 DAS, 30 DAS and just before harvest.

Table 6. Effect of lime, phosphorus and crops on root nodulation of fodder legumes

Factor	Number of root nodules/plant 15 DAS	Number of root nodules/plant 30 DAS	Number of root nodules/plant before harvest
Lime (kg ha^{-1})			
0 (L_0)	2.06 (1.75)	7.11 (2.85)	11.46 (3.53)
125 (L_1)	2.09 (1.76)	7.07 (2.84)	11.96 (3.60)
250 (L_2)	2.24 (1.80)	6.78 (2.79)	12.38 (3.66)
$F_{2,16}$	0.16^{ns}	0.13^{ns}	1.35^{ns}
Phosphorus (P_2O_5 kg ha^{-1})			
0 (P_0)	2.26 (1.81)	6.59 (2.76)	13.41 (3.80)
30 (P_1)	1.99 (1.73)	6.56 (2.75)	10.18 (3.34)
60 (P_2)	2.17 (1.78)	7.88 (2.98)	12.27 (3.64)
$F_{2,16}$	0.33^{ns}	2.39^{ns}	16.16^{**}
CD L/P	---	---	0.17
SEd	0.096	0.12	0.08
Crops			
CO-5 (V_1)	2.52 (1.88)	8.74 (3.12)	13.15 (3.76)
C-152 (V_2)	4.29 (2.30)	10.09 (3.33)	18.58 (4.42)
Karnataka Local (V_3)	2.04 (1.74)	8.75 (3.12)	14.86 (3.98)
Sesbania rostrata (V_4)	0.36 (1.17)	2.02 (1.74)	3.88 (2.21)
$F_{3,54}$	36.99^{**}	61.91^{**}	229.81^{**}
CD	0.22	0.26	0.18
SEd	0.11	0.13	0.09

** - Significant at 1% level

ns - not significant ( ) - transformed mean

Table 7. Interaction effect of lime and crops (l x v) on root nodulation of fodder legumes

Treatment	Number of root nodules/plant 15 DAS	Number of root nodules/plant 30 DAS	Number of root nodules/plant before harvest
l_0v_1	2.59 (1.90)	10.15 (3.34)	13.53 (3.81)
l_0v_2	3.71 (2.17)	8.28 (3.05)	14.14 (3.89)
l_0v_3	2.12 (1.77)	8.24 (3.04)	12.31 (3.65)
l_0v_4	0.38 (1.18)	2.87 (1.97)	6.56 (2.75)
l_1v_1	2.42 (1.85)	9.16 (3.19)	15.90 (4.11)
l_1v_2	4.48 (2.34)	11.25 (3.50)	19.77 (4.56)
l_1v_3	1.79 (1.67)	8.50 (3.08)	12.76 (3.71)
l_1v_4	0.39 (1.18)	1.56 (1.60)	3.08 (2.02)
l_2v_1	2.56 (1.89)	7.01 (2.83)	10.32 (3.36)
l_2v_2	4.69 (2.39)	10.87 (3.45)	22.28 (4.82)
l_2v_3	2.23 (1.80)	9.52 (3.24)	20.05 (4.59)
l_2v_4	0.30 (1.14)	1.72 (1.65)	2.44 (1.86)
$F_{6,54}$	0.29^{ns}	2.26^{ns}	23.53^{**}
CD	---	---	0.31
SEd	0.19	0.23	0.16

** - Significant at 1% level

ns - not significant ( ) - transformed mean

Table 8. Interaction effect of phosphorus and crops (p x v) on root nodulation of fodder legumes

Treatment	Number of root nodules/plant 15 DAS	Number of root nodules/plant 30 DAS	Number of root nodules/plant before harvest
p_0v_1	3.33 (2.08)	7.91 (2.99)	13.73 (3.84)
p_0v_2	4.60 (2.37)	10.90 (3.45)	18.91 (4.46)
p_0v_3	1.71 (1.65)	8.65 (3.11)	19.05 (4.48)
p_0v_4	0.27 (1.13)	1.18 (1.48)	4.79 (2.41)
p_1v_1	2.17 (1.78)	8.39 (3.07)	11.26 (3.50)
p_1v_2	3.80 (2.19)	9.66 (3.27)	19.62 (4.54)
p_1v_3	2.33 (1.83)	7.87 (2.98)	11.32 (3.51)
p_1v_4	0.24 (1.11)	1.86 (1.69)	2.31 (1.82)
p_2v_1	2.12 (1.77)	9.97 (3.31)	14.60 (3.95)
p_2v_2	4.47 (2.34)	9.73 (3.28)	17.23 (4.27)
p_2v_3	2.09 (1.76)	9.76 (3.28)	14.60 (3.95)
p_2v_4	0.59 (1.26)	3.20 (2.05)	4.76 (2.40)
$F_{6,54}$	0.91^{ns}	1.01^{ns}	5.75^{**}
CD	---	---	0.31
SEd	0.19	0.23	0.16

** - Significant at 1% level

ns - not significant

( ) - transformed mean

Table 9. Interaction effect of lime and phosphorus (l x p) on root nodulation of fodder legumes

Treatment	Number of root nodules/plant 15 DAS	Number of root nodules/plant 30 DAS	Number of root nodules/plant before harvest
l_0p_0	2.00 (1.73)	5.76 (2.60)	11.12 (3.48)
l_0p_1	2.04 (1.74)	6.34 (2.71)	10.21 (3.35)
l_0p_2	2.17 (1.78)	9.43 (3.23)	13.03 (3.75)
l_1p_0	2.46 (1.86)	7.82 (2.97)	14.01 (3.87)
l_1p_1	1.62 (1.62)	6.69 (2.77)	8.89 (3.14)
l_1p_2	2.22 (1.80)	6.78 (2.79)	13.29 (3.78)
l_2p_0	2.31 (1.82)	6.27 (2.70)	15.26 (4.03)
l_2p_1	2.31 (1.82)	6.65 (2.77)	11.51 (3.54)
l_2p_2	2.13 (1.77)	7.50 (2.92)	10.59 (3.40)
$F_{4,16}$	0.44^{ns}	1.97^{ns}	7.54^{**}
CD	---	---	0.298
SEd	0.17	0.21	0.14

** - Significant at 1% level

ns - not significant

( ) - transformed mean

Similarly different levels of phosphorus did not significantly influence the root nodulation during 15 DAS and 30 DAS. However during the last stage of observation increasing levels of phosphorus from 0 to 30 kg decreased the root nodules from 13.41 to 10.18 but further increase in the phosphorus level increased the number of root nodules, but was still lower than the control, (Table 6).

There was significant difference in the root nodulation of different legumes during all the stages of observation (Table 6). At 15 DAS cowpea variety C-152 produced maximum number of root nodules (4.29) than all other legumes, followed by variety CO-5 and Karnataka local. Sesbania rostrata produced lesser number of root nodules (0.36) at this stage. At 30 DAS also cowpea variety C-152 was superior to all other varieties in root nodulation (10.09 nodules/ plant) while Sesbania rostrata recorded the lowest number of nodules (2.02). At the third stage of observation cowpea variety C-152 produced highest number of root nodules (18.58) followed by Karnataka local (14.86) and Sesbania rostrata recorded the lowest number of root nodules (3.88).

Table 7 shows that l x v interaction influenced the root nodulation of legumes only during the last stage of observation. In cowpea variety CO-5, application of 125 kg lime increased the root nodulation from 13.53 to 15.90 nodules per plant, while it was depressed with the application of 250 kg lime. In C-152 and Karnataka local, there was a linear increase in root nodulation with increase in levels of lime. Increasing levels of lime significantly reduced the root nodulation in Sesbania rostrata.

Root nodulation was significantly influenced by p x v interaction only during the last stage of observation (Table 8). In cowpea variety CO-5, Karnataka local, and Sesbania rosrata root nodulation decreased significantly with the application of 30 kg P_2O_5. However nodulation improved with the application of 30 kg P_2O_5 in C-152 and decreased from 19.62 to 17.23 nodules per plant when level of phosphorus was further raised to 60 kg P_2O_5.

As shown in Table 9, l x p interaction significantly affected the root nodulation only during the final stage of observation. Maximum number of root nodules (15.26) were produced by the application of 250 kg lime + 0 kg P_2O_5 while lowest number of root nodules (8.89) were produced with the application of 125 kg lime + 30 kg P_2O_5.

4.1.7 b Stem nodulation

Increase in lime levels decreased the number of stem nodules significantly at each level, (Table 10).

Increase in phosphorus levels from 0 to 30 kg significantly decreased the number of stem nodules in

Table 10. Effect of lime and phosphorus on stem nodulation of <u>Sesbania</u> <u>rostrata</u>

	P_0 (0)	P_1 (30kg)	P_2 (60kg)	Mean (L)
L_0 (0)	31.12 (5.67)	19.42 (4.52)	20.83 (4.67)	23.53 (4.95)
L_1 (125 kg)	32.73 (5.81)	0.13 (1.06)	30.12 (5.58)	16.21 (4.15)
L_2 (250 kg)	26.31 (5.23)	7.61 (2.93)	0.06 (1.03)	8.39 (3.06)
Mean (P)	29.99 (5.57)	7.05 (2.84)	13.15 (3.76)	

F (L) = 25.78** CD (L) = 0.56 SE (L) = 0.19

F (P) = 55.31** CD (P) = 0.56 SE (P) = 0.19

F (LxP) = 29.59** CD (LxP) = 0.97 SE (LxP) = 0.32

** - Significant at 1% level

ns - not significant ( ) - transformed mean

Sesbania rostrata from 29.99 to 7.05, however nodulation was improved by the next higher dose of phosphorus (60 kg P_2O_5) but was still lower than the control.

Application of higher dose of lime along with higher dose of phosphorus significantly decreased the stem nodulation in Sesbania rostrata.

4.2 Yield

4.2.1 Green fodder yield

Different levels of lime application did not significantly influence the green fodder yield, (Table 11).

Similarly phosphorus application also had no significant influence on the green fodder yield of legumes.

Table 11 shows that highest green fodder yield (31.19 t ha^{-1}) was recorded by cowpea variety C-152 which was on a par with CO-5 (30.66 t ha^{-1}). Sesbania rostrata ranked third in green matter production (26.67 t ha^{-1}) while Karnataka local cowpea variety recorded the lowest green fodder yield of 15.39 t ha^{-1}. Figure 6 further explains the variation in green fodder yield of different legumes.

Green fodder yield was not significantly affected by l x v, p x v and l x p interactions, (Tables 12, 13 and 14).

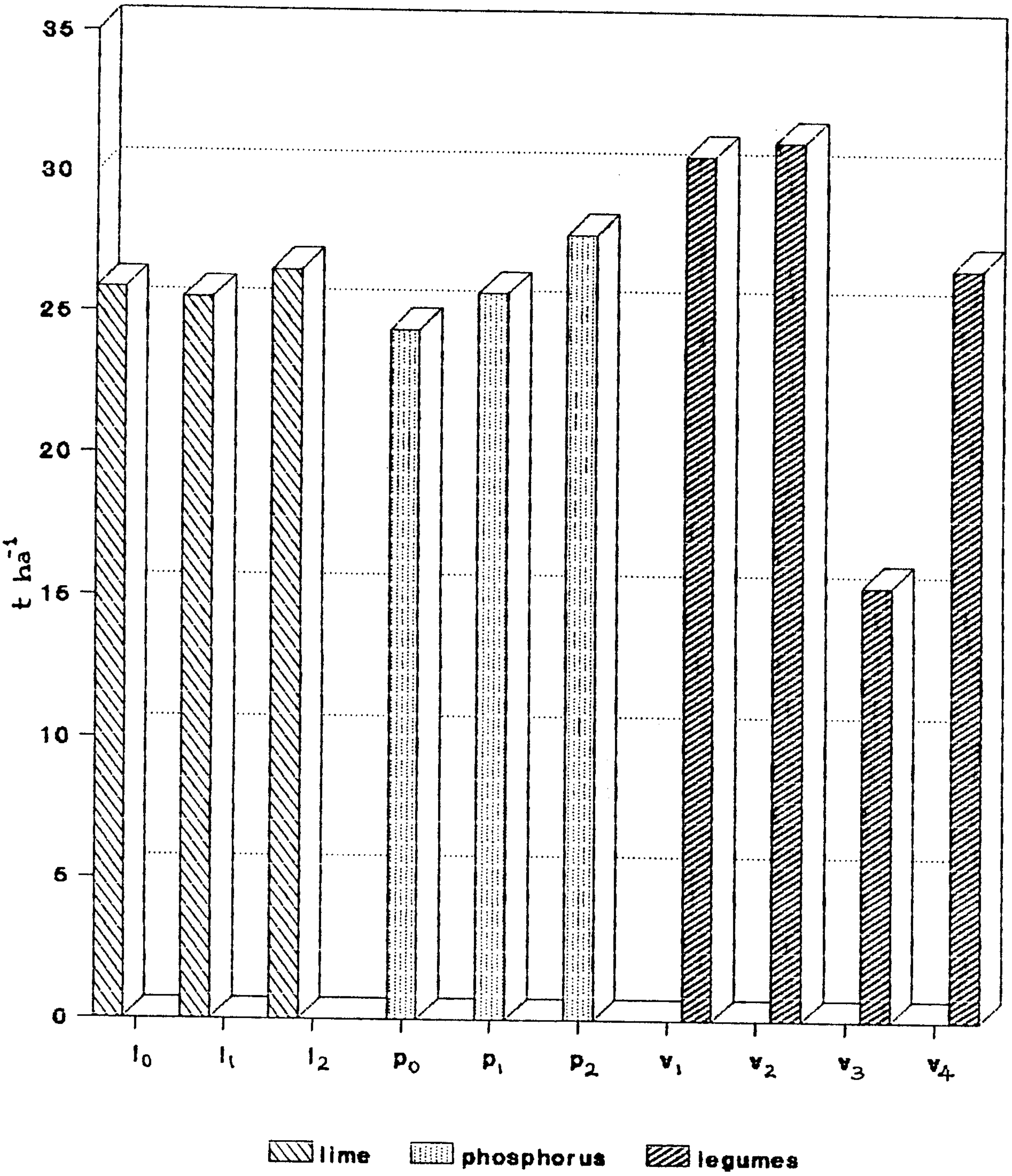


Fig. 6. Green fodder yield

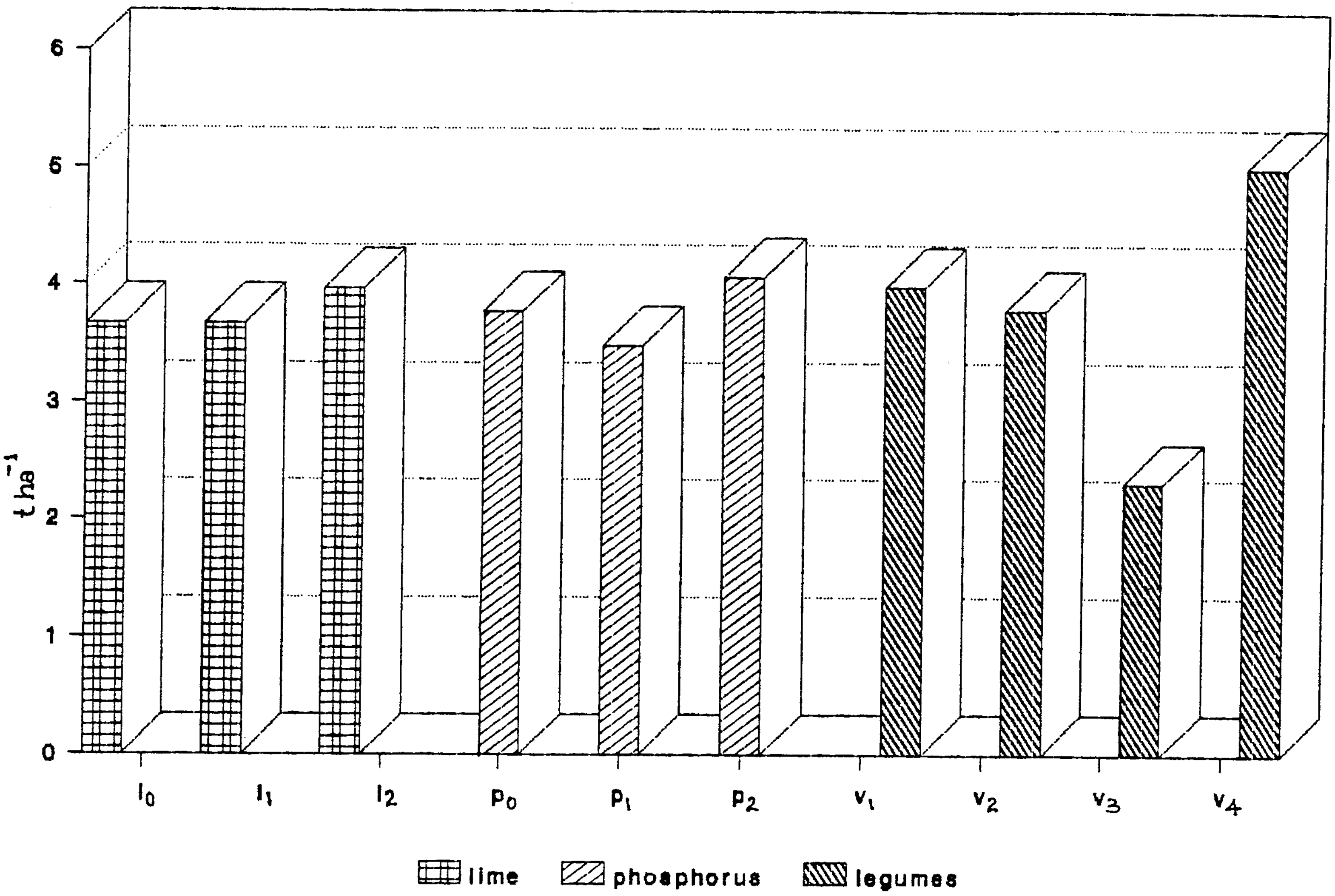


Fig. 7. Dry fodder yield

Table 11. Effect of lime, phosphorus and crops on yield of fodder legumes

Factor	Green fodder yield t ha^{-1}	Dry fodder yield t ha^{-1}	Crude protein yield kg ha^{-1}
Lime (kg ha^{-1})			
0 (L_0)	25.86	3.66	722.10
125 (L_1)	25.52	3.66	738.14
250 (L_2)	26.54	3.97	850.60
$F_{2,16}$	0.097^{ns}	0.23^{ns}	0.54^{ns}
Phosphorus (P_2O_5 kg ha^{-1})			
0 (P_0)	24.38	3.77	717.13
30 (P_1)	25.71	3.47	736.83
60 (P_2)	27.84	4.06	856.89
$F_{2,16}$	1.10^{ns}	0.61^{ns}	0.62^{ns}
SEd	2.35	0.53	135.38
Crops			
CO-5 (V_1)	30.66	3.98	693.30
C-152 (V_2)	31.19	3.78	778.76
Karnataka Local (V_3)	15.39	2.31	386.18
Sesbania rostrata (V_4)	26.67	4.99	1222.88
$F_{3,54}$	40.37^{**}	8.37^{**}	18.96^{**}
CD	3.28	1.08	225.09
SEd	1.64	0.54	112.55

** - Significant at 1% level ns - not significant

Table 12. Interaction effect of lime and crops (l x v) on yield of fodder legumes

Treatment	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})	Crude protein yield (kg ha^{-1})
l_0v_1	30.99	3.84	602.24
l_0v_2	29.63	3.24	662.29
l_0v_3	15.31	2.34	404.53
l_0v_4	27.53	5.23	1219.36
l_1v_1	31.36	4.28	781.19
l_1v_2	33.09	3.88	740.85
l_1v_3	13.09	1.92	310.79
l_1v_4	24.57	4.57	1119.71
l_2v_1	29.63	3.82	696.47
l_2v_2	30.86	4.23	933.15
l_2v_3	17.78	2.68	443.22
l_2v_4	27.90	5.17	1329.58
$F_{6,54}$	0.97^{ns}	0.36^{ns}	0.41^{ns}
SEd	2.84	0.94	194.94

ns - Not significant

Table 13. Interaction effect of phosphorus and crops (p x v) on yield of fodder legumes

Treatment	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})	Crude protein yield (kg ha^{-1})
p_0v_1	29.26	4.33	695.73
p_0v_2	30.86	4.36	847.84
p_0v_3	13.46	2.09	317.84
p_0v_4	23.95	4.30	1007.09
p_1v_1	30.62	3.71	644.26
p_1v_2	32.84	3.28	688.20
p_1v_3	13.95	1.81	327.67
p_1v_4	25.43	5.09	1287.20
p_2v_1	32.10	3.90	739.92
p_2v_2	29.88	3.71	800.25
p_2v_3	18.77	3.03	513.03
p_2v_4	30.62	5.58	1374.36
$F_{6,54}$	1.08^{ns}	0.67^{ns}	0.62^{ns}
SEd	2.84	0.94	194.94

ns - Not significant

Table 14. Interaction effect of lime and phosphorus (l x p) on yield of fodder legumes

Treatment	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})	Crude protein yield (kg ha^{-1})
l_0p_0	21.95	3.18	529.86
l_0p_1	26.02	3.48	798.27
l_0p_2	29.63	4.33	838.19
l_1p_0	22.13	3.26	540.02
l_1p_1	27.59	3.61	728.72
l_1p_2	26.85	4.11	945.67
l_2p_0	29.07	4.87	1081.50
l_2p_1	23.52	3.33	683.51
l_2p_2	27.04	3.73	786.80
$F_{4,16}$	1.34^{ns}	1.12^{ns}	1.72^{ns}
SEd	4.08	0.91	234.49

ns - Not significant

4.2.2 Dry fodder yield

Dry fodder yield was not significantly influenced by different levels of lime and phosphorus application.

Different legumes showed significant variation in their dry fodder production as evident from Table 11. Sesbania rostrata produced maximum dry fodder (4.99 t ha^{-1}) followed by cowpea variety CO-5 (3.98 t ha^{-1}) which was on a par with the cowpea variety C-152 (3.78 t ha^{-1}), Karnataka local variety was the most inferior in dry fodder production (Figure 7).

None of the interactions were found to be significant, (Tables 12, 13 and 14).

4.2.3 Crude protein yield

Crude protein yield was not significantly influenced by the application of different levels of lime or phosphorus, (Table 11).

Crude protein yield was highest in Sesbania rostrata (1222.88 kg ha^{-1}) followed by cowpea variety C-152 (778.76 kg ha^{-1}) which was on a par with variety CO-5, which recorded a crude protein yield of 693.30 kg ha^{-1}. Karnataka local variety cowpea recorded the lowest crude protein yield (386.18 kg ha^{-1}) which was only a quarter of that of Sesbania rostrata and half of the crude protein yield of CO-5 and C-152, (Table 11).

None of the interactions were found to significantly influence the crude protein yield of fodder legumes, (Tables 12, 13 and 14).

4.3 Fodder quality

4.3.1 Crude protein content

Effects of lime, phosphorus and legumes on the crude protein content are shown in Table 15.

Increase in levels of lime increased the crude protein content significantly with the maximum protein content (20.62 %) obtained with the application of 250 kg lime.

Increase in phosphorus levels enhanced the crude protein content of plant significantly, although there was only a marginal increase in crude protein content from 20.06 to 20.53 per cent when phosphorus level was increased from 30 to 60 kg P_2O_5.

Table 15. Effect of lime, phosphorus and crops on nutrient contents of fodder legumes

Factor	Crude protein %	P%	K%	Ca%	Mg%
Lime (kg ha^{-1})					
0 (L_0)	17.94	0.30	1.52	1.02	0.28
125 (L_1)	19.86	0.24	1.65	1.14	0.26
250 (L_2)	20.62	0.32	1.71	1.14	0.23
$F_{2,16}$	1156.39^{**}	56.32^{**}	110.49^{**}	6.95^{**}	57.53^{**}
Phosphorus (P_2O_5 kg ha^{-1})					
0 (P_0)	17.83	0.31	1.54	1.09	0.26
30 (P_1)	20.06	0.29	1.70	1.08	0.25
60 (P_2)	20.53	0.26	1.64	1.14	0.25
$F_{2,16}$	1257.94^{**}	23.36^{**}	74.95^{**}	1.78^{ns}	0.10^{ns}
CD L/P	0.12	0.02	0.03	0.08	0.01
SEd	0.06	0.01	0.014	0.04	0.005
Crops					
CO-5 (V_1)	17.25	0.26	1.76	1.10	0.25
C-152 (V_2)	19.96	0.27	1.59	1.03	0.25
Karnataka Local (V_3)	16.84	0.26	1.42	0.99	0.25
Sesbania rostrata (V_4)	23.84	0.36	1.74	1.28	0.26
$F_{3,54}$	9166.51^{**}	71.96^{**}	284.98^{**}	18.14^{**}	3.07^{*}
CD	0.095	0.016	0.026	0.086	0.01
SEd	0.048	0.008	0.013	0.043	0.005

** - Significant at 1% level

ns - not significant

* - Significant at 5% level

Table 16. Interaction effect of lime and crops (l x v) on nutrient contents of fodder legumes

Treatment	Crude protein %	P %	K %	Ca %	Mg %
l_0v_1	14.51	0.27	1.70	0.97	0.28
l_0v_2	18.71	0.31	1.43	1.01	0.26
l_0v_3	17.07	0.25	1.20	0.95	0.28
l_0v_4	21.47	0.38	1.75	1.16	0.30
l_1v_1	18.98	0.20	2.05	1.12	0.25
l_1v_2	19.13	0.21	1.66	1.04	0.27
l_1v_3	16.96	0.25	1.50	0.97	0.24
l_1v_4	24.38	0.31	1.39	1.45	0.26
l_2v_1	18.28	0.31	1.53	1.22	0.23
l_2v_2	22.05	0.29	1.68	1.05	0.23
l_2v_3	16.49	0.27	1.57	1.04	0.23
l_2v_4	25.67	0.39	2.07	1.24	0.22
$F_{6,54}$	605.19^{**}	6.44^{**}	270.93^{**}	2.63^{*}	3.85^{**}
CD	0.17	0.028	0.045	0.15	0.018
SEd	0.09	0.014	0.023	0.08	0.009

* - Significant at 5 % level

** - Significant at 1 % level

Table 17. Interaction effect of phosphorus and crops (p x v) on nutrient contents of fodder legumes

Treatment	Crude protein %	P %	K %	Ca %	Mg %
p_0v_1	16.06	0.27	1.65	1.04	0.25
p_0v_2	19.21	0.31	1.42	1.01	0.24
p_0v_3	15.17	0.30	1.30	0.96	0.26
p_0v_4	20.88	0.38	1.79	1.34	0.27
p_1v_1	16.68	0.24	1.85	1.07	0.26
p_1v_2	19.37	0.26	1.44	1.04	0.25
p_1v_3	18.47	0.28	1.73	0.97	0.25
p_1v_4	25.71	0.38	1.78	1.22	0.26
p_2v_1	19.02	0.28	1.77	1.20	0.25
p_2v_2	21.31	0.25	1.90	1.04	0.26
p_2v_3	16.88	0.19	1.24	1.03	0.24
p_2v_4	24.93	0.33	1.64	1.29	0.26
$F_{6,54}$	481.00^{**}	9.90^{**}	181.26^{**}	0.97^{ns}	1.04^{ns}
CD	0.17	0.028	0.045	-	-
SEd	0.09	0.014	0.023	0.07	0.009

** - Significant at 1% level   ns - Not significant

Table 18. Interaction effect of lime and phosphorus (l x p) on nutrient contents of fodder legumes

Treatment	Crude protein %	P %	K %	Ca %	Mg %
l_0p_0	15.90	0.33	1.43	1.01	0.28
l_0p_1	19.25	0.32	1.80	1.01	0.28
l_0p_2	18.67	0.26	1.33	1.06	0.29
l_1p_0	16.30	0.26	1.56	1.13	0.27
l_1p_1	21.23	0.24	1.38	1.08	0.25
l_1p_2	22.05	0.23	2.02	1.22	0.25
l_2p_0	21.29	0.35	1.63	1.13	0.23
l_2p_1	19.69	0.31	1.93	1.14	0.24
l_2p_2	20.88	0.30	1.57	1.14	0.22
$F_{4,16}$	737.77^{**}	2.42^{ns}	357.73^{**}	0.76^{ns}	3.14^{*}
CD	0.21	--	0.049	--	0.021
SEd	0.099	0.013	0.023	0.06	0.008

ns - Not significant

* - Significant at 5 % level

** - Significant at 1 % level

Among different legumes, Sesbania rostrata recorded highest crude protein content (23.84 %) followed by cowpea variety C-152 (19.96 %), CO-5 (17.25 %) and Karnataka local (16.84 %).

Table 16 indicates that l x v interaction significantly influenced the crude protein content. In cowpea variety CO-5 crude protein content was significantly increased from 14.51 to 18.98 per cent at 125 kg lime level and at the next higher dose of lime (250 kg) a slight decrease in the crude protein content was noticed. Protein content of cowpea variety C-152 increased with increasing levels of lime. Increase in lime levels decreased the crude protein content of Karnataka local although the difference between two higher levels was marginal. In Sesbania rostrata crude protein content increased with increase in lime levels and was maximum (25.67 %) with the application of highest level of lime.

Table 17 indicates the significant influence of p x v interaction on crude protein content of fodder legumes. Protein content in cowpea variety CO-5 increased with increasing levels of phosphorus at each level and the maximum protein content (19.02) was noticed with the application of 60 kg P_2O_5. In cowpea variety C-152 also the crude protein content was maximum (21.31 %) with the application of highest level of phosphorus. In Karnataka

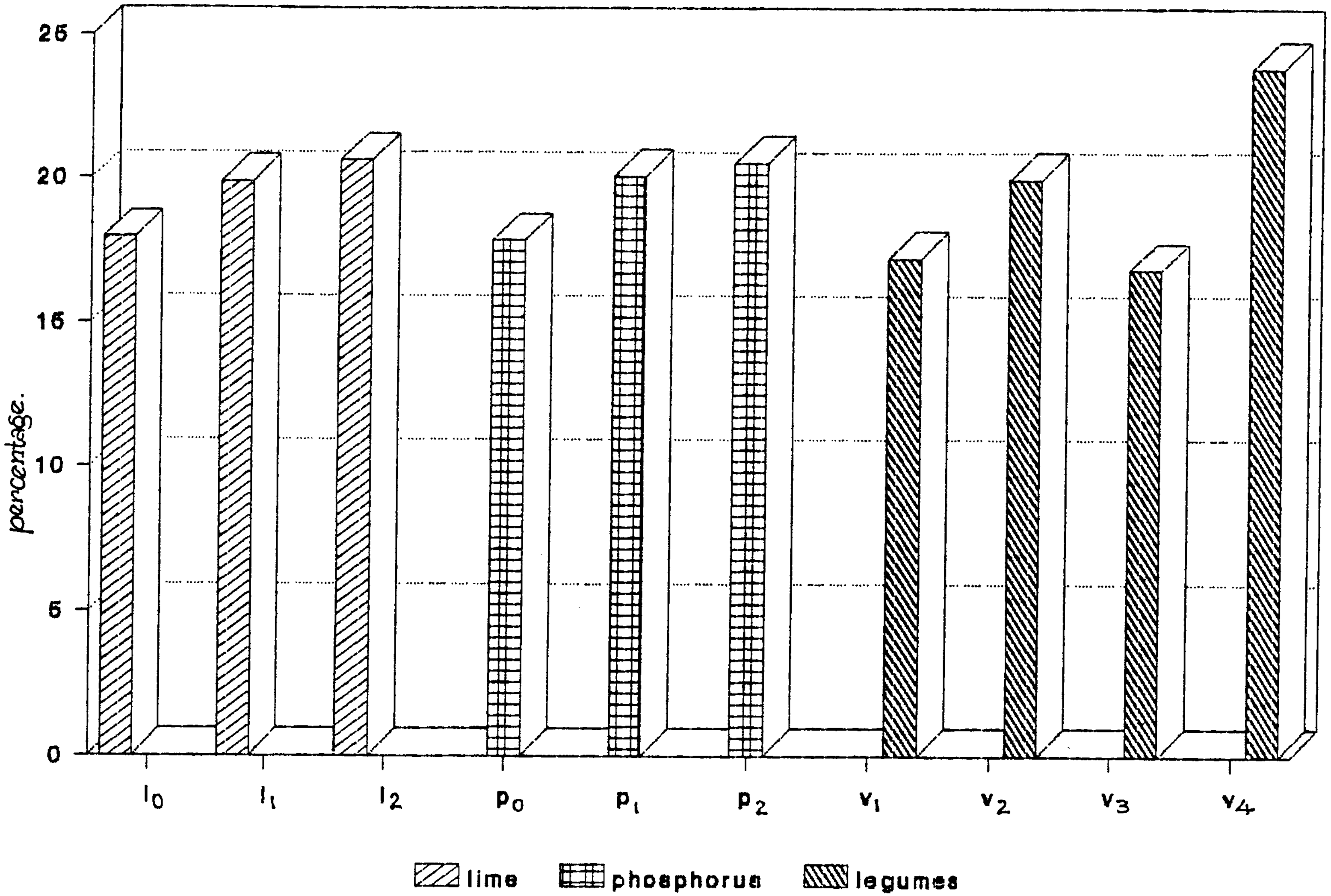


Fig. 8. Crude protein content

local cowpea, protein content increased significantly from 15.17 per cent to 18.47 per cent with the application of 30 kg P_2O_5 and the next higher dose slightly decreased the crude protein content to 16.88 per cent. A similar trend was noticed in Sesbania rostrata too.

l x p interaction significantly influenced the crude protein content as evident from Table 18. Crude protein content was highest (22.05 %) with the application of 125 kg lime + 60 kg P_2O_5 treatment. 250 kg lime when applied alone produced higher crude protein content (21.29 %) compared to 250 kg lime + 60 kg P_2O_5, which recorded a protein content of 20.88 per cent.

4.3.2 Phosphorus content

Plant phosphorus content was influenced by direct effects of lime, phosphorus and legumes, (Table 15).

Highest level of lime recorded maximum phosphorus content (0.32 %) in plants.

Phosphorus content in plant decreased with increasing levels of application of phosphorus and the maximum value was recorded with the control (0.31 %).

There was significant variation in the plant phosphorus contents of different legumes. Sesbania rostrata recorded highest phosphorus content (0.36 %) than all other legumes followed by cowpea variety C-152 (0.27 %) which was on a par with other two varieties.

l x v interaction significantly influenced the plant phosphorus content (Table 16). Maximum phosphorus content of 0.31 % was recorded with the application of highest dose of lime in cowpea variety CO-5 in which the phosphorus content was lower (0.20 %) with the application of 125 kg lime. Cowpea variety C-152 also showed a similar trend though maximum phosphorus content was noticed at the control. In Karnataka local application of 125 kg lime was on a par with the control while the highest level of lime slightly increased the phosphorus content which also was on a par with the control and lower level of lime. In Sesbania rostrata phosphorous content was maximum (0.39 %) with the application of 250 kg lime but the lower level of lime (125 kg) reduced the plant phosphorus content to 0.31 per cent.

Table 17 indicates that the p x v interaction had significant influence on phosphorus content of fodder legumes. In cowpea variety CO-5 application of 30 kg P_2O_5 decreased the phosphorus content from 0.27 to 0.24 per cent while the next higher dose improved the plant phosphorus content. In C-152 application of 30 kg P_2O_5 and 60 kg P_2O_5 which were on a par with each other decreased the plant phosphorus content compared to control. In Karnataka local,

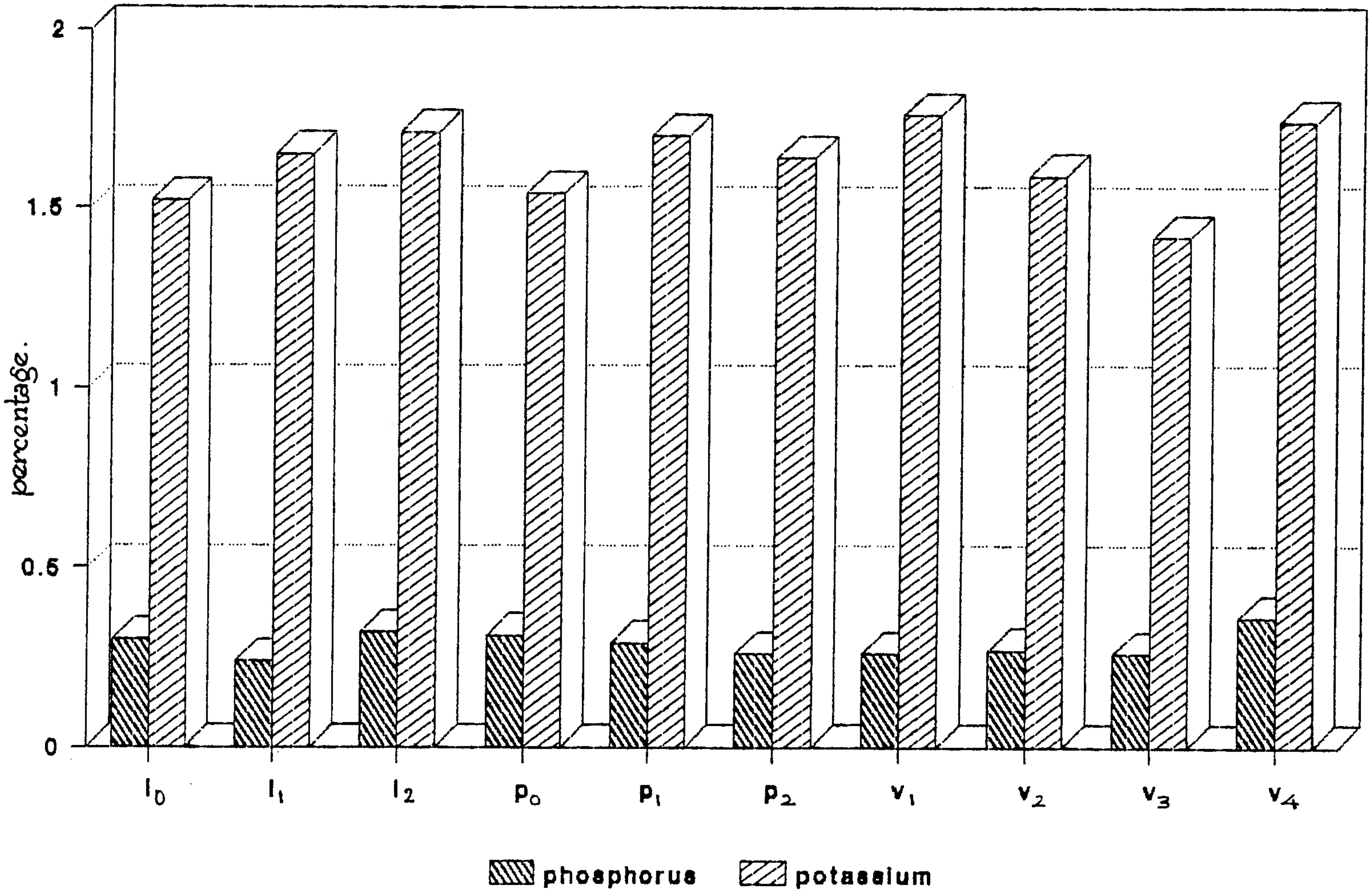


Fig. 9. Phosphorus and potassium contents of legumes

plant phosphorus content was considerably reduced with the application of 60 kg P_2O_5 and 30 kg P_2O_5 treatment produced the same effect of the control. In <u>Sesbania</u> <u>rostrata</u> application of 30 kg P_2O_5 was on a par with the control, and 60 kg P_2O_5 treatment decreased the plant phosphorus content to 0.33 per cent.

l x p interaction had no significant influence on plant phosphorus content, Table 18.

4.3.3 Potassium content

Effects of lime, phosphorus and crops on plant potassium content are shown in Table 15.

Potassium content in plant increased significantly with increasing levels of lime and maximum potassium content (1.71 %) was recorded with the application of 250 kg lime.

Application of 30 kg P_2O_5 produced highest plant potassium content (1.70 %) compared to 60 kg P_2O_5 treatment which in turn was significantly superior to the control.

Maximum potassium content (1.76%) was recorded in cowpea variety CO-5 which was on a par with <u>Sesbania</u> <u>rostrata</u> (1.74 %). C-152 Variety of cowpea ranked second in total potassium content (1.59%) and Karnataka local recorded the lowest potassium content (1.42 %).

It is shown in Table 16 that the l x v interaction significantly influenced the plant potassium content. Cowpea variety CO-5 recorded highest potassium content (2.05 %) with the application of 125 kg lime and the next higher dose of lime significantly reduced the content of potassium to 1.53 per cent. In C-152, application of both the levels of lime significantly increased the potassium content in plant, over the control. Karnataka local variety of cowpea recorded increased potassium content with increasing levels of lime application and highest potassium content of 1.57 per cent was recorded with the application of 250 kg lime. In <u>Sesbania rostrata</u>, highest potassium content (2.07 %) was recorded with the application of 250 kg lime and application of 125 kg lime reduced the plant potassium content compared to the control.

Table 17 indicates the significant influence of p x v interaction on the total potassium content of fodder legumes. In cowpea variety CO-5 application of 30 kg P_2O_5 significantly increased the plant potassium content to 1.85 per cent, but the next higher dose of phosphorus however decreased the potassium content to 1.77 per cent. In C-152 highest potassium content (1.90 %) was recorded with the application 60 kg P_2O_5, but the lower dose produced the same effect of control. In Karnataka local variety of cowpea application of 30 kg P_2O_5 increased the potassium content to

1.73 per cent significantly, but the next higher dose decreased the potassium content to 1.24 per cent. In Sesbania rostrata application of 60 kg P_2O_5 decreased the plant potassium content while the 30 kg P_2O_5 treatment was on a par with the control.

Influence of l x p interaction on the potassium content of fodder legumes is shown in Table 18. Maximum potassium content (2.02 %) was recorded with the application of 125 kg lime + 60 kg P_2O_5 compared to 125 kg lime + 30 kg P_2O_5 to which 125 kg lime + 0 kg P_2O_5 treatment was superior. Plant potassium content was also more with the application of 250 kg lime + 30 kg P_2O_5 treatment compared to 250 kg lime + 0 kg P_2O_5 which in turn was superior to 250 kg lime + 60 kg P_2O_5 treatment. Application of combination of highest levels of lime and phosphorus resulted in more plant potassium content compared to the combination of moderate levels of lime and phosphorus.

4.3.4 Calcium content

Increase in lime levels from 0 to 125 kg increased the calcium content of legumes from 1.02 to 1.14 per cent significantly, although different levels of lime (125 kg and 250 kg) were on a par with each other, (Table 15).

Different levels of phosphorus did not influence the calcium content of fodder legumes.

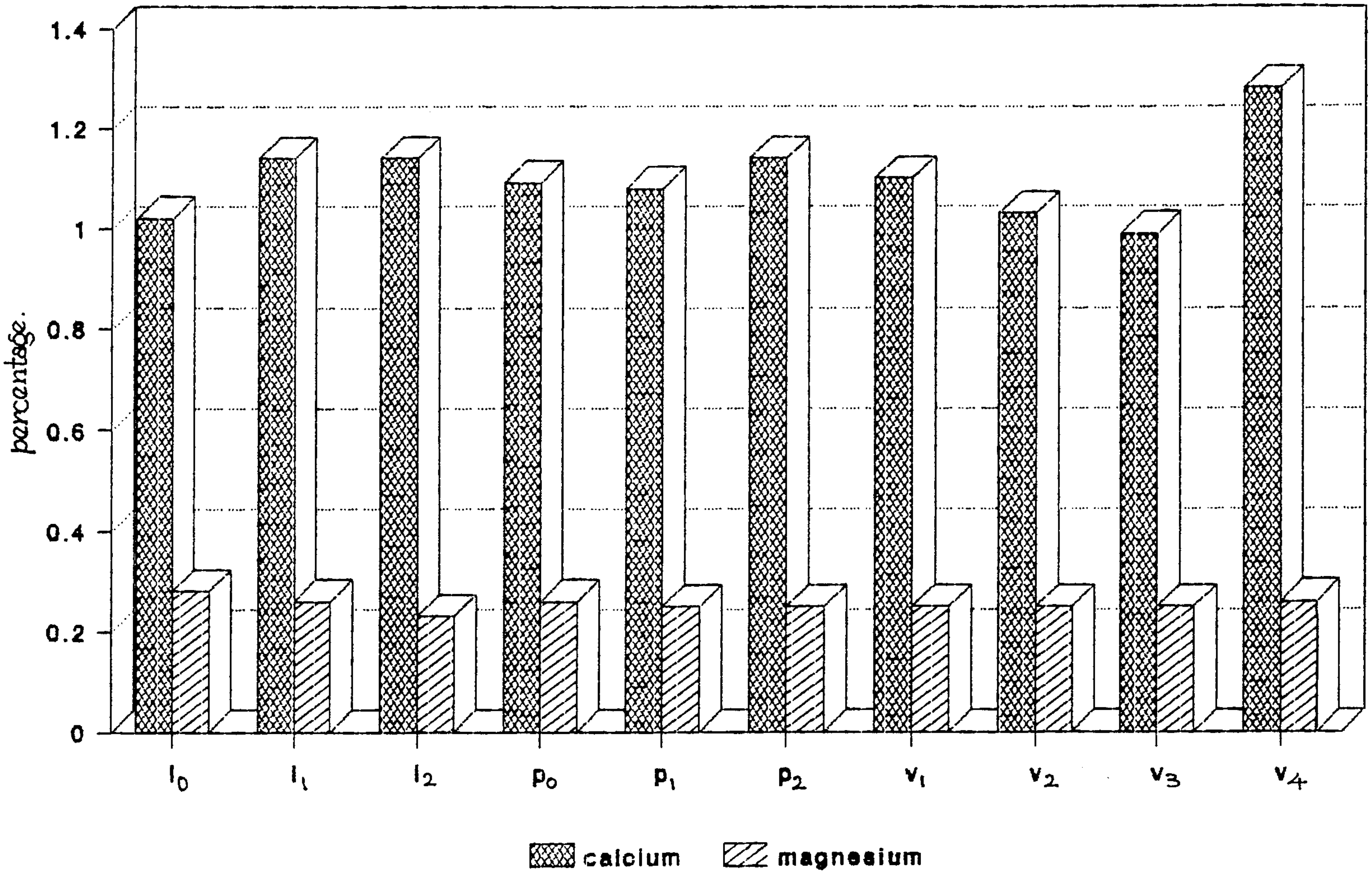


Fig. 10. Calcium and Magnesium contents of legumes

Legumes differed significantly in their calcium content as indicated in Table 15. Highest calcium content (1.28 %) was recorded with Sesbania rostrata followed by cowpea variety CO-5 (1.10 %) which was on a par with the cowpea variety C-152 (1.03%). Lowest calcium content (0.99 %) was recorded with Karnataka local variety of cowpea.

Calcium content in plant was significantly influenced by l x v interaction as shown in Table 16. In cowpea variety CO-5, highest calcium content (1.22 %) was noticed on applying 250 kg lime which was on a par with 125 kg lime treatment. In cowpea variety C-152, application of different levels of lime produced the same effect as that of the control. In cowpea variety Karnataka local, different levels of lime did not produce any significant difference in the calcium content in comparison with the control. Calcium content increased significantly with increasing lime levels upto 125 kg in Sesbania rostrata.

p x v interaction or l x p interaction did not significantly influence the calcium content in legumes, (Tables 17 and 18).

4.3.5 Magnesium content

Influence of lime, phosphorus and crops on magnesium content of legumes are shown in Table 15. Magnesium content decreased with increasing levels of lime.

Different phosphorus treatments however did not significantly influence the total magnesium content of fodder legumes.

<u>Sesbania rostrata</u> recorded the highest magnesium content (0.26 %) while all other legumes were on a par with each other.

l x v interaction had significant impact on the magnesium content of fodder legumes, (Table 16). In CO-5 variety of cowpea increasing levels of lime decreased the magnesium content at each level and lowest value (0.23 %) was recorded with the application of 250 kg lime. In C-152 application of lower dose of lime (125 kg) produced higher magnesium content (0.27 %) compared to higher dose of lime application. In cowpea variety Karnataka local, application of 125 kg lime lowered the magnesium content from 0.28 to 0.24 per cent compared to the control and 250 kg lime was on a par with 125 kg lime treatment. In <u>Sesbania rostrata</u> increasing levels of lime significantly reduced the magnesium content in plant parts.

p x v interaction did not significantly influence the total magnesium content in different legumes, (Table 17).

Table 18 shows the significant influence of l x p interaction on magnesium content of fodder legumes.

Application of highest level of lime and phosphorus combination decreased the magnesium content significantly to 0.22 per cent. Higher magnesium content was recorded with the application of 125 kg lime + 30 kg P_2O_5 combination when compared to 250 kg lime + 60 kg P_2O_5 treatment.

4.4 Nutrient status of soil

4.4.1 Available nitrogen

Available nitrogen status of the soil after the experiment was not significantly different among the plots treated with lime.

Application of 30 kg P_2O_5 and 60 kg P_2O_5 which were on a par with each other increased the available nitrogen status of soil and 60 kg P_2O_5 was on a par with control (Table 19).

Available nitrogen in soil after the experiment was not influenced by different legumes, (Table 19).

l x v interaction and p x v interaction did not significantly influence the available nitrogen in soil (Tables 20 and 21) although l x p interaction influenced the nitrogen status of the soil and is shown in Table 22. Increasing levels of phosphorus without lime increased the available nitrogen status of the soil and was more on

Table 19. Effect of lime, phosphorus and crops on nutrient status of the soil

Factor	Available N kg ha^{-1}	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}	Available Ca kg ha^{-1}	Available Mg kg ha^{-1}
Lime (kg ha^{-1})					
0 (L_0)	318.83	46.42	186.40	255.06	64.87
125 (L_1)	316.21	47.56	193.57	256.22	65.70
250 (L_2)	320.57	42.93	189.28	281.61	62.20
$F_{2,16}$	0.12^{ns}	4.24^{*}	1.19^{ns}	6.48^{**}	4.86^{*}
Phosphorus (P_2O_5 kg ha^{-1})					
0 (P_0)	304.89	43.73	183.49	268.27	64.55
30 (P_1)	329.28	48.52	192.27	265.88	63.88
60 (P_2)	321.44	44.65	193.50	258.75	64.33
$F_{2,16}$	4.08^{*}	4.70^{*}	2.72^{ns}	0.71^{ns}	0.17^{ns}
CD (L/P)	18.48	3.52	-	17.66	2.49
SEd	8.72	1.66	4.67	8.33	1.17
Crops					
Co-5 (V_1)	307.79	45.57	172.73	268.66	64.38
C-152 (V_2)	331.02	48.45	187.31	268.56	63.15
Karnataka local (V_3)	319.41	45.55	198.86	269.53	65.18
<u>Sesbania rostrata</u> (V_4)	315.92	42.96	200.11	250.45	64.30
$F_{3,54}$	1.52^{ns}	4.04^{*}	6.87^{**}	2.43^{ns}	1.46^{ns}
CD	-	3.16	13.77	-	-
SEd	11.08	1.58	6.89	8.41	0.98

* - Significant at 5% level

** - Significant at 1% level

ns - Not significant

Table 20. Interaction effect of lime and crops (l x v) on nutrient status of the soil

Treatment	Available N kg ha^{-1}	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}	Available Ca kg ha^{-1}	Available Mg kg ha^{-1}
l_0v_1	303.15	48.73	216.53	252.93	63.58
l_0v_2	327.54	47.88	142.31	261.33	63.13
l_0v_3	317.08	46.10	192.64	261.46	64.79
l_0v_4	327.54	42.95	194.13	244.54	67.96
l_1v_1	317.08	46.38	143.36	260.99	66.79
l_1v_2	337.99	47.88	226.99	258.51	64.79
l_1v_3	296.18	50.44	206.83	255.73	66.79
l_1v_4	313.60	45.53	197.12	249.66	64.43
l_2v_1	303.15	41.61	158.29	292.05	62.77
l_2v_2	327.54	49.59	192.64	285.84	61.54
l_2v_3	344.96	40.11	197.12	291.39	63.95
l_2v_4	306.63	40.40	209.06	257.16	60.52
$F_{6,54}$	1.45^{ns}	2.17^{ns}	15.89^{**}	0.50^{ns}	2.28^{*}
CD	-	-	23.85	-	3.38
SEd	19.19	2.74	11.93	14.57	1.69

* - Significant at 5% level

** - Significant at 1% level

ns - Not significant

Table 21. Interaction effect of phosphorus and crops (p x v) on nutrient status of the soil

Treatment	Available N kg ha^{-1}	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}	Available Ca kg ha^{-1}	Available Mg kg ha^{-1}
p_0v_1	292.69	47.02	143.36	275.72	64.19
p_0v_2	320.57	42.18	203.09	265.84	62.55
p_0v_3	303.15	47.24	226.24	266.79	66.63
p_0v_4	303.15	38.46	161.28	264.73	64.82
p_1v_1	306.63	43.03	177.71	266.61	63.81
p_1v_2	341.48	50.44	209.07	268.57	64.37
p_1v_3	341.48	49.87	155.31	274.12	63.12
p_1v_4	327.54	50.73	226.99	254.21	64.20
p_2v_1	324.05	46.67	197.12	263.64	65.13
p_2v_2	331.02	52.72	149.78	271.29	62.54
p_2v_3	313.60	39.54	215.04	267.67	65.78
p_2v_4	317.08	39.69	212.05	232.41	63.89
$F_{6,54}$	0.51^{ns}	7.52^{**}	20.40^{**}	0.75^{ns}	1.10^{ns}
CD	-	5.48	23.85	-	-
SEd	19.19	2.74	11.93	14.57	1.69

** - Significant at 1% level

ns - Not significant

Table 22. Interaction effect of lime and phosphorus (l x p) on nutrient status of the soil

Treatment	Available N kg ha^{-1}	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}	Available Ca kg ha^{-1}	Available Mg kg ha^{-1}
l_0p_0	300.53	43.38	164.64	255.58	67.13
l_0p_1	321.44	51.08	181.44	262.39	60.50
l_0p_2	334.51	44.78	213.13	247.22	66.97
l_1p_0	295.31	47.88	193.20	261.57	66.26
l_1p_1	321.44	52.37	213.92	247.38	66.88
l_1p_2	331.89	42.43	173.60	259.73	63.96
l_2p_0	318.83	39.92	192.64	287.66	60.26
l_2p_1	344.96	42.11	181.44	287.86	64.26
l_2p_2	297.92	46.76	193.76	269.32	62.08
$F_{4,16}$	3.24*	4.17*	14.79**	0.75^{ns}	4.92**
CD	32.01	6.09	17.17	-	4.31
SEd	15.10	2.87	8.10	14.43	2.03

* - Significant at 5% level

** - Significant at 1% level

ns - Not significant

applying 0 kg lime + 60 kg P_2O_5 which was on a par with 0 kg lime + 30 kg P_2O_5 treatment. Combined application of 125 kg lime + 60 kg P_2O_5 which was on a par with 125 kg lime + 30 kg P_2O_5 increased the available nitrogen content in soil over 125 kg lime + 0 kg P_2O_5 treatment. Application of 250 kg lime + 30 kg P_2O_5 significantly increased the available nitrogen status of soil from 300.53 kg ha^{-1} to 344.96 kg ha^{-1} compared to the control, where as 250 kg lime + 60 kg P_2O_5 combination was on a par with the control.

4.4.2 Available phosphorus

Increasing levels of lime from 125 to 250 kg considerably reduced the available soil phosphorus status after the experiment, (Table 19) and 125 kg lime was on a par with the control.

Available soil phosphorus was highest (48.52 kg ha^{-1}) with the application of 30 kg P_2O_5 and 60 kg P_2O_5 treatment produced the same effect of the control, (Table 19).

As seen in Table 19, highest available soil phosphorus after the experiment was recorded with cowpea variety C-152 (48.45 kg ha^{-1}) which was on a par with CO-5 and Karnataka local. Available soil phosphours was lower in plots grown with <u>Sesbania rostrata</u> which was on a par with cowpea variety CO-5 and Karnataka local.

l x v interaction did not significantly influence the available soil phosphorus status after the experiment, (Table 20).

p x v interaction significantly influenced the available soil phosphorus status after the experiment, (Table 21). Application of 30 kg P_2O_5 and 60 kg P_2O_5 to the cowpea variety CO-5 did not cause any significant change in the available phosphorus status of soil. In cowpea variety C-152 application of 30 kg P_2O_5 significantly increased the available phosphorus in soil and the next higher dose was on a par with 30 kg P_2O_5. Available phosphorus content of soil was significantly reduced with the application of 60 kg P_2O_5 in Karnataka local. Available soil phosphorus status was maximum with 30 kg P_2O_5 treatment (50.73 kg ha^{-1}) in Sesbania rostrata compared to 60 kg P_2O_5 which in turn was on a par with the control.

l x p interaction significantly influenced the available soil phosphorus status after the experiment (Table 22). Phosphorus content of soil was maximum (52.37 kg ha^{-1}) with the application of 125 kg lime + 30 kg P_2O_5 compared to the control. Application of 0 kg lime + 30 kg P_2O_5 combination increased the available phosphorus in the soil compared to the control. However 250 kg lime + 60 kg P_2O_5 combination was on a par with 250 kg lime + 30 kg P_2O_5 and 125 kg lime + 60 kg P_2O_5 combinations.

4.4.3 Available potassium

Application of different doses of lime or phosphorus did not significantly influence the available soil potassium status after the experiment, (Table 19).

Available potassium content in soil after the cultivation of cowpea variety C-152, Karnataka local variety of cowpea and Sesbania rostrata were on a par with each other. Cowpea variety CO-5 recorded the lowest available soil potassium content of 172.73 kg ha^{-1}, (Table 19).

l x v interaction significantly influenced the available potassium content of soil after the conduct of experiment (Table 20). In cowpea variety CO-5, application of 125 kg lime decreased the available potassium content in soil compared to the control and highest level of lime was (250 kg) on a par with 125 kg lime. Available soil potassium content was highest (226.99 kg ha^{-1}) on applying 125 kg lime in plots grown with cowpea variety C-152 and the next higher dose of lime (250 kg) decreased the soil potassium content to 192.64 kg ha^{-1}. In Karnataka local variety cowpea and <u>Sesbania</u> <u>rostrata</u> plots, available potassium content of soil did not vary significantly with different levels of lime application.

p x v interaction significantly influenced the available potassium content of soil which increased with increasing levels of phosphorus in cowpea variety CO-5 (Table 21). In cowpea variety C-152 plots available soil potassium was on a par with control at 30 kg P_2O_5 level, but the next higher dose reduced the soil potassium status significantly. In Karnataka local cowpea variety, available soil potassium content was significantly lower when applied with 30 kg P_2O_5 compared to the control and 60 kg P_2O_5 treatment. Available soil potassium content was maximum (226.99 kg ha^{-1}) with the application of 30 kg P_2O_5 in <u>Sesbania</u> <u>rostrata</u> compared to the control and the next higher dose of phosphorus did not increase the soil potassium content significantly.

Table 22 indicates that l x p interaction influenced the available potassium content of soil after the experiment. Available soil potassium content was highest (213.92 kg ha^{-1}) when 125 kg lime + 30 kg P_2O_5

combination was applied. Application of 250 kg lime + 60 kg P_2O_5 significantly increased the available potassium content of soil compared to the control and was superior to 125 kg lime + 60 kg P_2O_5 combination.

4.4.4 Available Calcium

Table 19 shows that the available calcium status of soil after the conduct of experiment increased significantly with increasing levels of lime from 125 to 250 kg and highest soil calcium (281.61 kg ha^{-1}) was recorded with the application of 250 kg lime and 125 kg lime was on a par with the control.

Different levels of phosphorus application did not significantly influence the available calcium content of the soil after the experiment. Similarly available soil calcium content was unaffected by varietal differences.

Interaction effects are depicted in Tables 20, 21 and 22.

None of the interactions were significant in influencing the available calcium content in soil after the experiment.

4.4.5 Available magnesium

Available soil magnesium status after the experiment showed a slight non significant increase on applying 125 kg lime and the next higher dose however decreased the soil magnesium status significantly, (Table 19).

Soil magnesium status after the experiment was not significantly influenced by different levels of phosphorus.

Different legumes also did not produce any significant variation in available magnesium content of the soil after the experiment, (Table 19).

l x v interaction did influence the available magnesium content of the soil after the experiment (Table 20). Application of 125 kg lime to cowpea variety CO-5 slightly increased the available magnesium content of soil and was on a par with the control. But there was a reduction in available magnesium content when the lime dose was further increased to 250 kg. In cowpea variety C-152 and Karnataka local, different levels of lime application had the same effect, on available magnesium content of the soil.

Increasing levels of lime decreased the available soil magnesium content after the experiment in Sesbania rostrata.

p x v interaction had no significant influence on available magnesium content of the soil, (Table 21).

l x p interaction significantly influenced (Table 22) the available magnesium in soil after the experiment. Available magnesium decreased with increasing levels of lime and phosphorus compared to control. Available magnesium in soil was significantly higher with the application of 125 kg lime + 30 kg P_2O_5 combination (66.88 kg ha^{-1}) in comparison with 250 kg lime + 60 kg P_2O_5 combination (62.08 kg ha^{-1}).

4.5 Uptake of nutrients

4.5.1 Nitrogen uptake

Different levels of lime or phosphorus application had no significant influence on nitrogen uptake of fodder legumes (Table 23).

Significant difference in nitrogen uptake was noticed among crops (Table 23). Uptake of nitrogen was

Table 23. Effect of lime, phosphorus and crops on nutrient uptake of legumes

Factor	N uptake kg ha^{-1}	P uptake kg ha^{-1}	K uptake kg ha^{-1}	Ca uptake kg ha^{-1}	Mg uptake kg ha^{-1}
Lime (kg ha^{-1})					
0 (L_0)	115.71	12.09	60.79	41.08	10.99
125 (L_1)	118.10	9.27	60.62	41.49	9.49
250 (L_2)	136.09	12.00	68.44	47.75	9.42
$F_{2,16}$	0.53^{ns}	1.26^{ns}	0.31^{ns}	0.95^{ns}	0.94^{ns}
Phosphorus (P_2O_5 kg ha^{-1})					
0 (P_0)	114.74	11.93	60.88	41.99	9.67
30 (P_1)	117.89	10.57	62.68	39.14	9.46
60 (P_2)	137.28	10.86	66.29	49.20	10.77
$F_{2,16}$	0.63^{ns}	0.25^{ns}	0.12^{ns}	1.82^{ns}	0.59^{ns}
SEd	21.67	2.02	11.36	5.43	1.30
Crops					
Co-5 (V_1)	110.93	11.29	71.33	47.58	11.12
C-152 (V_2)	124.60	10.56	61.89	39.66	9.65
Karnataka local (V_3)	62.03	5.32	31.64	22.60	5.63
Sesbania rostrata (V_4)	195.66	17.32	88.27	63.92	13.46
$F_{3,54}$	18.98^{**}	18.10^{**}	17.76^{**}	14.89^{**}	10.46^{**}
CD	35.93	3.28	15.98	12.62	2.88
SEd	17.97	1.64	7.99	6.31	1.44

** - Significant at 1% level ns - Not significant

Table 24. Interaction effect of lime and crops (l x v) on uptake of nutrients

Treatments	N uptake kg ha^{-1}	P uptake kg ha^{-1}	K uptake kg ha^{-1}	Ca uptake kg ha^{-1}	Mg uptake kg ha^{-1}
l_0v_1	96.36	11.21	69.90	40.24	11.81
l_0v_2	105.97	11.13	50.44	35.88	9.28
l_0v_3	65.44	5.51	27.94	24.04	6.35
l_0v_4	195.10	20.50	94.88	64.16	16.54
l_1v_1	124.99	10.43	85.80	45.72	10.84
l_1v_2	118.54	8.16	64.91	39.80	10.34
l_1v_3	49.73	4.66	28.21	17.09	4.69
l_1v_4	179.15	13.84	65.55	63.36	12.09
l_2v_1	111.44	12.22	58.29	56.77	10.72
l_2v_2	149.30	12.38	70.32	43.31	9.34
l_2v_3	70.92	5.77	38.76	26.68	5.86
l_2v_4	212.73	17.62	106.39	64.24	11.75
$F_{6,54}$	0.42^{ns}	0.56^{ns}	2.61^{*}	0.30^{ns}	0.58^{ns}
CD	—	—	27.68	—	—
SEd	31.12	2.84	13.84	10.93	2.50

* - Significant at 5% level

** - Significant at 1% level

ns - Not significant

Table 25. Interaction effect of phosphorus and crops (p x v) on uptake of nutrients

Treatments	N uptake kg ha^{-1}	P uptake kg ha^{-1}	K uptake kg ha^{-1}	Ca uptake kg ha^{-1}	Mg uptake kg ha^{-1}
p_0v_1	111.32	12.07	70.52	45.98	10.92
p_0v_2	135.65	13.50	62.61	44.52	10.63
p_0v_3	50.85	4.92	27.79	19.75	5.13
p_0v_4	161.13	17.25	82.61	57.70	12.01
p_1v_1	103.08	4.03	74.29	41.20	10.62
p_1v_2	110.11	8.99	51.20	36.59	9.19
p_1v_3	52.43	5.20	30.39	16.28	4.47
p_1v_4	205.95	17.05	94.86	62.49	13.55
p_2v_1	118.39	10.76	69.19	55.55	11.81
p_2v_2	128.04	9.18	71.86	37.88	9.13
p_2v_3	82.80	5.83	36.74	31.78	7.31
p_2v_4	219.90	17.65	87.35	71.58	14.82
$F_{6,54}$	0.62^{ns}	0.43^{ns}	0.50^{ns}	0.45^{ns}	0.36^{ns}
SEd	31.12	2.84	13.84	10.93	2.50

ns - Not significant

Table 26. Interaction effect of lime and phosphorus (l x p) on uptake of nutrients

Treatment	N uptake kg ha^{-1}	P uptake kg ha^{-1}	K uptake kg ha^{-1}	Ca uptake kg ha^{-1}	Mg uptake kg ha^{-1}
l_0p_0	84.78	11.32	49.98	33.95	9.20
l_0p_1	127.72	13.36	74.90	41.47	11.05
l_0p_2	134.64	11.58	57.49	47.83	12.73
l_1p_0	86.40	8.55	51.50	36.08	8.69
l_1p_1	116.60	9.36	48.68	37.06	9.53
l_1p_2	151.31	9.90	81.67	51.34	10.24
l_2p_0	173.04	15.93	81.16	55.93	11.12
l_2p_1	109.36	8.97	64.47	38.90	7.79
l_2p_2	125.89	11.09	59.70	48.43	9.34
$F_{4,16}$	1.73^{ns}	1.05^{ns}	1.55^{ns}	1.28^{ns}	0.994^{ns}
SEd	37.52	3.50	19.68	9.40	2.25

ns - Not significant

maximum in <u>Sesbania rostrata</u> (195.66 kg ha^{-1}) followed by cowpea variety C-152 (124.60 kg ha^{-1}) and CO-5 (110.93 kg ha^{-1}) which were on a par and was lowest in Karnataka local variety (62.03 kg ha^{-1}).

None of the treatment combinations significantly influenced the nitrogen uptake by legumes as evident from Tables, 24, 25 and 26.

4.5.2 <u>Phosphorus uptake</u>

Phosphorus uptake was not significantly influenced by different levels of lime or phosphorus, (Table 23).

Legumes differed significantly with regard to phosphorus uptake as shown in Table 23. <u>Sesbania rostrata</u> recorded the highest phosphorus uptake (17.32 kg ha^{-1}) followed by cowpea variety CO-5 (11.29 kg ha^{-1}) and cowpea variety C-152 (10.56 kg ha^{-1}) which were on a par with each other. Uptake was minimum (5.32 kg ha^{-1}) in Karnataka local variety. Phosphorus uptake was unaffected by l x v interaction, p x v interaction and l x p interaction, as indicated in Tables 24, 25 and 26 respectively.

4.5.3 Potassium uptake

Different doses of lime or phosphorus did not significantly influence the potassium uptake by legumes.

However the potassium uptake varied significantly in different legumes, (Table 23). Highest potassium uptake (88.27 kg ha^{-1}) was noticed in *Sesbania rostrata* followed by the cowpea variety CO-5 (71.33 kg ha^{-1}) which was on a par with C-152. Potassium uptake in cowpea variety Karnataka local was only half as that of other legumes (31.64 kg ha^{-1}).

l x v interaction significantly influenced the potassium uptake by legumes. Cowpea varieties CO-5, C-152 and Karnataka local did not produce any significant difference in potassium uptake at various levels of lime application while *Sesbania rostrata* recorded significantly higher values of uptake at 0 kg and 250 kg lime levels (Table 24).

p x v interaction or l x p interaction did not produce any significant influence on potassium uptake, (Tables 25 and 26).

4.5.4 Calcium uptake

Calcium uptake was unaffected by different levels of lime or phosphorus, however calcium uptake significantly differed in different legumes (Table 23). Highest calcium uptake was recorded with Sesbania rostrata (63.92 kg ha^{-1}) followed by cowpea variety CO-5 (47.58 kg ha^{-1}) and C-152 (39.66 kg ha^{-1}) which were on a par. Calcium uptake by Karnataka local variety of cowpea was only half of that by other legumes (22.60kg ha^{-1}).

None of the interactions were significant in influencing the calcium uptake by legumes (Tables 24, 25 and 26).

4.5.5 Magnesium uptake

Different levels of lime did not significantly influence the magnesium uptake of fodder legumes. Similarly uptake of magnesium was unaffected by different levels of applied phosphorus.

Varietal difference significantly influenced (Table 23) the magnesium uptake by legumes where Sesbania rostrata recorded maximum uptake (13.46 kg ha^{-1}) which was on a par with the cowpea variety CO-5 (11.12 kg ha^{-1}). Magnesium uptake in cowpea variety C-152 was more than the uptake in Karnataka local.

None of the interactions significantly influenced the magnesium uptake by fodder legumes (Tables 24, 25 and 26).

Table 27. Effect of lime, phosphorus and crops on the yield of succeeding rice crop

Factor	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Lime (kg ha^{-1})		
0 (L_0)	1.03	2.91
125 (L_1)	1.11	3.24
250 (L_2)	1.03	3.15
$F_{2,16}$	0.58^{ns}	0.48^{ns}
Phosphorus (P_2O_5 kg ha^{-1})		
0 (P_0)	1.13	2.79
30 (P_1)	0.99	2.94
60 (P_2)	1.05	3.56
$F_{2,16}$	1.24^{ns}	2.68^{ns}
CD (L/P)	--	--
SEd	0.09	0.35
Crops		
Co-5 (V_1)	1.08	3.07
C-152 (V_2)	0.99	3.05
Karnataka local (V_3)	1.06	3.06
Sesbania rostrata (V_4)	1.10	3.22
$F_{3,54}$	0.50^{ns}	0.46^{ns}
CD	--	--
SEd	0.10	0.17

ns - Not significant

Table 28. Interaction effect of lime and crops (l x v) on the yield of succeeding rice crop

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
l_0v_1	1.01	2.65
l_0v_2	0.99	3.06
l_0v_3	0.99	2.95
l_0v_4	1.11	2.97
l_1v_1	1.17	3.27
l_1v_2	0.99	3.19
l_1v_3	1.24	3.25
l_1v_4	1.03	3.25
l_2v_1	1.07	3.30
l_2v_2	0.97	2.90
l_2v_3	0.94	2.96
l_2v_4	1.14	3.43
F 6,54	0.62^{ns}	0.96^{ns}
CD	--	--
SEd	0.17	0.29

ns - Not significant

Table 29. Interaction effect of phosphorus and crops (p x v) on the yield of succeeding rice crop

Factor	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
p_0v_1	1.17	2.73
p_0v_2	1.06	2.63
p_0v_3	1.09	2.72
p_0v_4	1.18	3.08
p_1v_1	1.03	2.88
p_1v_2	0.96	2.95
p_1v_3	0.91	3.28
p_1v_4	1.08	2.67
p_2v_1	1.04	3.61
p_2v_2	0.94	3.57
p_2v_3	1.17	3.17
p_2v_4	1.03	3.90
$F_{6,54}$	0.39^{ns}	2.11^{ns}
CD	--	--
SEd	0.17	0.29

ns - Not significant

Table 30. Interaction effect of lime and phosphorus (l x p) on the yield of succeeding rice crop

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
l_0p_0	1.01	2.26
l_0p_1	1.01	3.00
l_0p_2	1.06	3.45
l_1p_0	1.71	3.05
l_1p_1	1.00	3.16
l_1p_2	1.16	3.52
l_2p_0	1.20	3.06
l_2p_1	0.97	2.67
l_2p_2	0.92	3.71
$F_{4,16}$	0.81^{ns}	0.54^{ns}
SEd	0.15	0.61

ns - Not significant

4.6 Yield of succeeding rice crop

4.6.1 Grain yield

Table 27 shows that grain yield of succeeding rice crop was not influenced by the application of different levels of lime or phosphorus to the preceding legume crops. Growing of different legumes in rice fallow also did not produce any significant effect on the grain yield of succeeding rice crop. However an increasing trend in grain yield was noticed in plots where Sesbania rostrata was grown previously compared to the other legumes.

The interaction effects were also not significant, (Tables 28, 29 and 30).

4.6.2 Straw yield

Straw yield of succeeding rice crop was not significantly influenced by different levels of lime or phosphorus application to the various legumes. As in case of grain yield, an increasing trend in the straw yield was observed in plots where Sesbania rostrata was grown as a previous crop, compared to cowpea varieties (Table 27).

l x v interaction or p x v interaction or l x p interaction did not significantly influence the straw yield of succeeding paddy crop, (Tables 28, 29 and 30).

Table 31. Economics of cultivation of leguminous crops

Treatment	Cost of cultivation excluding the treatment		Additional cost for the treatment		Total cost of cultivation (a)		Green matter yield (t ha^{-1})	Gross return (b)		Net return (b - a)		Benefit/ cost ratio
	Rs.	Ps.	Rs.	Ps.	Rs.	Ps.		Rs.	Ps.	Rs.	Ps.	
Lime (kg ha^{-1})												
0	16200	00	---	00	16200	00	25.86	19395	00	3195	00	1.19
125	16200	00	250	00	16450	00	25.52	19140	00	2690	00	1.16
250	16200	00	500	00	16700	00	26.54	19905	00	3205	00	1.19
Phosphorus (P_2O_5 kg ha^{-1})												
0	16200	00	---	00	16200	00	24.38	18285	00	2085	00	1.13
30	16200	00	255	00	16455	00	25.71	19282	00	2827	00	1.17
60	16200	00	510	00	16710	00	27.84	20880	00	4170	00	1.25
Legumes												
CO-5	16200	00	---	--	16200	00	30.66	22995	00	6795	00	1.42
C-152	16200	00	---	--	16200	00	31.19	23392	50	7192	00	1.44
Karnataka local	16200	00	---	--	16200	00	15.39	11542	50	-4657	50	0.71*
Sesbania _rostrata_	16200	00	---	--	16200	00	26.67	20002	50	3802	50	1.23

* indicates the loss

Price of 1 kg lime = Rs. 2

Price of 1 kg P_2O_5 = Rs. 8.50

Price of 1 tonne green fodder = Rs. 750

4.7 Economics of cultivation of leguminous crops

Analysis of the economics of cultivation of leguminous crops indicated that the application of 250 kg lime and 60 kg P_2O_5 produced higher net return and were more economic compared to the lower doses. Respective Benefit-Cost ratio also support this result, (Table 31).

In this study, cowpea variety C-152 was found to be more economic under summer rice fallow conditions.

DISCUSSION

DISCUSSION

5.1 Growth attributes

5.1.1 Plant height

Increasing levels of lime significantly increased the plant height only during final stage of observation and maximum plant height was recorded with the application of highest dose of lime (Table 2).

Nitrification, nitrogen mineralization and symbiotic nitrogen fixation are enhanced by liming which increases, the availability of nitrogen to the plants which might have been utilised for the growth of legumes. Nybong and Hoyt (1978) reported the beneficial influence of liming on nitrogen mineralization and nitrification. This explains the increased plant height due to liming. Similar results were obtained by Ramanagowda (1981), Adhikari et al. (1989) and Murali (1989). Variation in plant height under the influence of liming is clearly shown in Figure 3.

Taller plants were produced with the application of 60 kg P_2O_5 during the final stage of observation (Figure 3), whereas phosphorus application did not influence the plant height at 15 DAS and 30 DAS. Phosphorus is known to influence the growth and development of roots positively. Phosphorus application might have resulted in better root formation which helped in fixing higher amount of atmospheric nitrogen, thus increasing the plant available nitrogen. This increased amount of nitrogen might have been utilised for the vegetative growth which ultimately resulted in increased plant height. Similar observations were made by Singh and Singh (1991). Beneficial effect of phosphorus application in increasing plant height has been previously reported by Panda (1972) in greengram, Murali (1989) in *Sesbania rostrata* and Thakuria and Luikham (1991 a) in fodder cowpea.

Table 2 shows that maximum plant height was recorded in cowpea variety C-152 and minimum in *Sesbania rostrata* during 15 DAS. But *Sesbania rostrata* produced taller plants than all other legumes at 30 DAS and at the final stage of observation. Presence of more number of leaves is another reason for increased plant height. According to Jacob (1960), leaves also influence elongation of adjacent nodes, through modulation of the rate and amount of transport of growth substances like sucrose. Increased plant height noticed in this study may be due to the presence of more number of leaves (Table 2). Variation in the plant height of different legumes has been depicted in Figure 3.

Maximum plant height was recorded with the application of 250 kg lime in cowpea variety CO-5, cowpea variety C-152 and Sesbania rostrata, while in Karnataka local highest dose of lime recorded lowest plant height at final stage (Table 3). This reduction in the plant height is probably due to the utilization of absorbed nutrients, through the action of lime for the production of more branches observed in this crop (Table 3).

p x v interaction (Table 4) significantly influenced the plant height at the third stage of observation only and maximum plant height was recorded with the application of 60 kg P_2O_5 in C-152 and Sesbania rostrata whereas Karnataka local and CO-5 responded only upto 30 kg P_2O_5 per hectare. Thus no definite trend was recorded in different legumes on liming which is probably due to variation in genetic make up.

Combination of highest level of lime and phosphorus produced taller plants than all other combinations which is a manifestation of main effects (Table 5).

5.1.2 Number of leaves per plant

Although lime application did not influence the number of leaves per plant at 15 DAS and 30 DAS, application of 250 kg lime produced more number of leaves (Table 2) during the final stage of observation. The process of symbiotic nitrogen fixation is favoured by liming which consequently increases the growth of legumes (Tisdale _et al._, 1990). This increased amount of nitrogen fixed might have been utilized for the production of more number of leaves. Beneficial effect of liming in the production of more number of leaves have been reported early by Mariyappan (1978) in _Stylosanthes gracilis_, Viswanathan _et al_. (1980) and Ramanagowda (1981) in cowpea. Leaf production pattern under the influence of lime application is shown in Figure 4.

Increasing levels of phosphorus significantly increased the number of leaves per plant just before harvest (Figure 4) though it had no influence during the early stages of observation. Phosphorus application increases the root proliferation and development and also favours the extensive exploitation of treated soil areas for nutrients and moisture which eventually reflects in better vegetative growth. The increased leaf production in legumes is mainly due to the better utilization of nutrients. Similar results were previously reported by Garg _et al_. (1970), Tarila and Ormrod (1977), Geethakumari (1981), Jain _et al_. (1986) and Murali (1989).

Number of leaves produced by different legumes differed significantly at all the stages of observation (Table 2). _Sesbania rostrata_ produced more number of leaves at all the three stages of observation. This difference is mainly due to the variation in genotypical character. Varietal variation in leaf production was previously reported by Bhat (1979) and Subramanian et al. (1987) in fodder cowpea.

l x v interaction influenced the number of leaves per plant only at the final stage of observation, where application of highest level of lime produced significantly more number of leaves (Table 3) in all fodder legumes. This can be explained as a manifestation of main effects discussed earlier.

Table 4 shows that under p x v interaction all the legumes except cowpea variety Karnataka local produced more number of leaves at the final stage of observation with the application of highest level of P_2O_5 while the later responded only upto 30 Kg P_2O_5. From the observations made earlier, Karnataka local is found to behave differently in the pattern of vegetative growth and response to applied fertilizers which can be attributed to the genotypical variation of this cultivar.

l x p interaction (Table 5) significantly influenced the number of leaves per plant at the last stage of observation and combination of highest levels of lime and phosphorus produced more number of leaves, which is a manifestation of main effects of lime and phosphorus explained earlier.

5.1.3 Leaf area index

LAI of four legumes under the influence of three levels of lime and phosphorus is depicted in Figure 5.

Leaf area index increased significantly with increasing levels of lime and the maximum value was obtained with the highest level of application (Table 2). This favourable influence of lime on LAI is mainly due to the indirect effect of increasing the nitrogen availability to the plants through increased nitrification. A similar result was reported previously by Ramanagowda (1981) in fodder cowpea.

Increasing levels of phosphorus increased the leaf area index of legumes (Table 2). Phosphorus application increases the supply of nitrogen for leaf expansion thereby resulting in higher leaf area. Similar observations were made by Tarila and Ormrod (1977) in cowpea, Rollin Bhaskar (1979) in greengram, Geethakumari (1981) in fodder cowpea and Murali (1989) in *Sesbania rostrata*.

Maximum LAI was recorded in *Sesbania rostrata*. Table 2 indicates that *Sesbania rostrata* produced higher number of leaves during the final stage of observation. The higher LAI recorded by Sesbania rostrata may be attributed to the higher number of leaves produced by this crop.

l x v interaction significantly influenced the LAI of legumes (Table 3). In cowpea variety CO-5, cowpea variety Karnataka local, and Sesbania rostrata, maximum LAI was recorded at the highest level of lime application which might be due to the varietal affinity to higher levels of calcium.

LAI was influenced by p x v interaction (Table 4). In all legumes except Karnataka local cowpea maximum leaf area index was produced with the application of highest level of phosphorus. Increase in phosphorus levels increased the number of leaves per plant in all other legumes (Table 4) which might have resulted in more LAI.

Table 5 shows that more LAI was produced with the combination of highest dose of lime (250 kg) and phosphorus (60 kg) which is a true manifestation of single effects of lime and phosphorus.

5.1.4 Leaf : stem ratio

Lime and phosphorus application had no significant influence on leaf : stem ratio of fodder legumes (Tables 2, 3, 4 and 5).

There was no significant difference among the leaf : stem ratio of different legumes. This agrees with the result obtained by Mariyappan (1978) who reported that lime application and different levels of phosphorus did not significantly influence the leaf : stem ratio of Stylosanthes gracilis.

5.1.5 Number of branches

Different levels of lime did not influence the number of branches per plant at 30 DAS but branching was more when 250 kg lime was applied just before harvest (Table 2). Similar results were obtained by Elkins et al. (1976) in soybean and Ramanagowda (1981) in fodder cowpea. Increase in the number of branches due to lime application is probably through the indirect effect of increasing the availability of nitrogen to the plants as reported by Bhattacharaya (1971) and Sheelavantar (1980).

Maximum number of branches were obtained with the application of 60 Kg P_2O_5 (Table 2) which is in agreement with the result obtained by Jain et al. (1986) and Singh and Singh (1991) in cowpea. Phosphorus is known to increase the development of roots and rootlets thereby favouring the nitrogen fixation in legumes. This increased amount of nitrogen fixed is utilized by the host plant for its own growth as reported by Singh and Trivedi (1981).

There was significant difference in the number of branches produced by different fodder legumes at both 30 DAS and before harvest. Cowpea varieties CO-5, C-152 and Karnataka local which did not differ each other in branching had more branches (Table 2) than Sesbania rostrata at 30 DAS. However, branching was more in Sesbania rostrata at the final stage of observation as indicated in the Table 2. Cowpea variety C-152 produced more number of branches than other two cowpea varieties at the last stage of observation. This difference in number of branches in mainly due to the difference in the genetic make up of each cultivar. Such variation in number of branches have been reported by previous workers like Bhat (1979) in cowpea, Sheelavantar (1980) in soybean and Subramanian et al. (1987) in fodder cowpea.

l x v interaction (Table 3) significantly influenced the branching at the final stage of observation. Branching was maximum on applying 250 kg lime in cowpea variety CO-5, Karnataka local cowpea and Sesbania rostrata but in C-152 variety of cowpea application of moderate doses of lime decreased the number of branches compared to the control. This variation in branching under the influence of liming may be due to varietal difference.

Table 4 shows that prior to harvest, number of branches increased with increasing levels of P_2O_5 in all legumes except in Karnataka local cowpea where the highest level of application decreased the branching compared to control treatment. This is may be due to the varietal character of the particular cultivar.

Main effects of lime and phosphorus were manifested in the l x p interaction where branching was favourably influenced by the combination of highest levels of lime and phosphorus (Table 5).

5.1.6 Days to flower

Days taken for flowering increased significantly when the lime level was increased to 125 kg, but further enhancement in lime level did not produce by significant effect (Table 2). Lime improves the nitrification by supplying adequate amount of calcium to the nitrifying bacteria (Tisdale et al., 1990). This increased availability of nitrogen may have prolonged the vegetative period, thereby extending the days to flower.

Application of highest dose of phosphorus (60 kg P_2O_5) resulted in more days for flowering (Table 2). Supply of phosphorus would have resulted in better utilization of nitrogen through increased root proliferation, subtending more area for nitrogen fixation. Utilization of biologically fixed nitrogen would have prolonged the vegetative growth period thereby increasing the days to flower.

Table 2 shows that cowpea variety CO-5 took more days to flower than all other legumes. This difference is truly a genotypical variation.

Only l x v interaction influenced the number of days taken for flowering (Table 3). Cowpea varieties CO-5 and Karnataka local took equal days for flowering under 125 kg lime and 250 kg lime treatments. Cowpea variety C-152 required more days to flower when lime level was increased. The variation in flowering may possibly be due to the variation in length of vegetative period under the influence of lime application.

5.1.7 Nodulation

Straight effect of lime, phosphorus, legumes and their interaction effect on both root nodulation of legumes and stem nodulation of *Sesbania rostrata* are discussed hereunder.

5.1.7a Root nodulation

Different levels of lime did not influence the number of root nodules at all the three stages of observation.

Phosphorus application influenced the number of nodules per plant at the last stage of observation (Table 6). Increasing the levels of phosphorus from 0 to 30 kg decreased the number of root nodules, but nodulation was improved at the higher level of phosphorus application. Favourable influence of phosphatic fertilization on nodulation was previously reported by Pandey (1969) in gram and Thakuria and Luikham (1991 b) in cowpea. The increased nodulation at higher levels of phosphorus is due to the favourable influence of phosphorus on the development of roots and rootlets availing more area for nodulation as reported by Singh and Trivedi (1981). Increased nitrogen availability in soil (Table 19) consequent to the phosphorus application might have depressed the root nodulation at 30 kg P_2O_5 level. Authors like Mishra and Singh (1968) have reported the reduced nitrogen fixation at higher levels of nitrogen.

There was significant difference in the nodulation of different legumes during all the three stages of observation (Table 6). Cowpea variety C-152 produced highest number of nodules at all the three stages of observation and Sesbania rostrata was inferior to all other crops in root nodule production. Varietal difference in nodulation has been previously reported in leguminous crops by Nair (1966) and Bhat (1979). Variation in root nodulation can be related to the difference in dry matter production. The cowpea variety C-152 which produced maximum number of root nodules ranked only third in the dry matter production while Sesbania rostrata out yielded all other legumes (Table 11). This is probably due to the diversion of energy towards nitrogen fixation which otherwise would have been utilized for dry matter production in case of former variety. Mahon (1977) suggested that 17 g of carbohydrate is consumed for every gram of nitrogen fixed. Hence more the nitrogen fixed in nodules, the more will be the carbohydrate consumed. This might be the probable reason for recording lesser dry matter in cowpea variety C-152 inspite of its higher nitrogen fixing activity and lesser nodulation along with higher dry matter production in Sesbania rostrata.

l x v interaction significantly influenced the root nodulation just before harvest as indicated in Table 7. In CO-5, application of 125 kg lime increased the root nodulation while 250 kg lime depressed the nodulation which is possibly a varietal response to applied lime. In cowpea variety C-152 and cowpea variety Karnataka local root nodulation increased linearly with increase in lime levels which is probably due to the varietal affinity to applied lime for improving the nodulation. In Sesbania rostrata increasing leaves of lime significantly reduced the root nodulation. This is probably due to the higher dry matter production under higher levels of lime (Table 12) for which more energy was utilized which otherwise would have been used for nodulation.

p x v interaction influenced the root nodulation only during the third stage of observation (Table 8). In cowpea variety CO-5, cowpea variety Karnataka local and Sesbania rostrata root nodulation decreased with the application of 30 kg P_2O_5, but improved with the application of 60 kg $P_2 O_5$. This is probably due to the increasing trend in drymatter production as shown in Table 13. In cowpea variety C-152 root nodulation increased with the application of 30 kg $P_2 O_5$ but decreased when phosphorus level was further raised to 60 kg $P_2 O_5$. This variation in nodulation corresponds with the variation in dry matter production (Table 13) of this legume which has been explained earlier in case of main effects.

l x p interaction significantly influenced the root nodulation during the last stage of observation (Table 9). Maximum nodulation was observed when 250 kg lime + o kg P_2O_5 was applied and nodulation was lower than the control with the combined application of 125 kg lime + 30 kg P_2O_5. Higher available N content in the soil at the treatment (Table 22) might have suppressed the nodulation as explained by Mishra and Singh (1968).

5.1.7 b Stem nodulation of Sesbania rostrata

Increase in levels of lime and phosphorus application decreased the number of stem nodules in Sesbania rostrata though the highest dose of phosphorus (60 kg P_2O_5) improved the nodulation (Table 10). Decreased stem nodulation with the application of fertilizers is probably due to the higher dry matter production in Sesbania rostrata. Minchin and Pate (1973) suggested that about 1/5 of carbon assimilated photosynthetically is spent for the nodule activity and another part is utilized for dry matter production. Hence more the dry matter production, lesser will be the energy diverted for nodulation and lower will be the nodule activity. The slight improvement in nodulation at highest level of phosphorus application is probably due to the fact that the excess energy would have been diverted for the nodulation after being utilized for the dry matter production.

5.2 Yield

5.2.1 Green fodder yield

Different levels of lime did not influence the green fodder yield of legumes.

Similarly, green fodder yield was not significantly influenced by different levels of phosphorus. Similar results have been reported by Sundaram et al. (1974) in cowpea.

Table 11 shows that varietal difference significantly influenced the green fodder production. cowpea variety C-152 recorded the highest green fodder yield (Figure 6) followed by cowpea variety CO-5 and Sesbania rostrata, while Karnataka local variety recorded the lowest. Highest green matter production potential of cowpea variety C-152 was previously reported by AICRP (1984). The green fodder yield is invariably associated with the production of branches. Jindal et al. (1982) reported that the number of primary branches per plant is an important parameter determining the fodder yield. From Table 2 it is clear that the variety C-152 which recorded the highest green fodder yield also produced more number of branches just before harvest. This observation agrees with the results obtained by Jindal (1989) who opined that the number of branches per plant appear to be a major component for leafiness and green fodder yield in cowpea grown under rainfed conditions. Cowpea variety Karnataka local was inferior to other legumes in branching and plant height (Table 2) which are important parameters deciding fodder yield as reported by Jindal (1989). Thus the lesser number of branches produced and lesser plant height may be the reason for recording a low green matter yield in Karnataka local variety of fodder cowpea.

5.2.2 Dry fodder yield

Various levels of lime had no significant influence on the dry fodder yield.

Similarly, different levels of phosphorus did not significantly influence the dry fodder yield of legumes. This agrees with the results obtained by Kruger *et al*. (1990) in sub-tropical pasture legumes.

Influence of varietal difference on dry fodder yield of legume is shown in Table 11. *Sesbania rostrata* recorded maximum dry fodder yield followed by cowpea variety CO-5 which was on a par with variety C-152 (Figure 7). Karnata local variety recorded the lowest dry matter yield. Table 2 indicates that *Sesbania rostrata* produced almost two times taller plants than other legumes. Number of branches per plant was also maximum in *Sesbania rostrata* at the final stage of observation. Therefore the higher dry fodder yield in *Sesbania rostrata* can be attributed to the higher branching and plant height. This is in agreement with the result obtained by Paroda (1975) who reported that plant height and branching are the important components of dry matter yield. Therefore the low dry fodder yield recorded with Karnataka local is probably due to lesser branching and plant height.

5.2.3 Crude protein yield

Crude protein yield was not significantly influenced by different levels of lime or phosphorus.

But, Table 11 indicates that fodder legumes showed significant difference in crude protein yield. *Sesbania rostrata* out yielded all other legumes in crude protein yield followed by cowpea variety C-152 and CO-5, while the lowest crude protein yield was recorded with cowpea variety Karnataka local. Higher crude protein yield in *Sesbania rostrata* is mainly due to the high crude protein content and dry matter production as evident from Table 15 and Table 11 respectively. Highest crude protein content in *Sesbania rostrata* was previously reported by AICRP (1991). The low crude protein yield in Karnataka local is due to the low dry matter yield (Table 11) recorded by the variety.

5.3 Fodder quality

5.3.1 Crude protein content

Influence of liming on crude protein content of legumes is given in Table 15. Lime application increased the crude protein content significantly with the maximum crude protein content being obtained by the application of highest level of lime (Table 15). Higher requirement of calcium for the nitrogen fixation by Rhizobia in legume was previously reported by Wild (1988). The increased supply of calcium due to liming might have favoured the biological nitrogen fixation which in turn increased the crude protein content. Sarkar and Debnath (1990) also obtained similar increase in crude protein content due to liming in greengram. Influence of lime on crude protein content of legumes is depicted in Figure 8.

Increase in phosphorus levels enhanced the crude protein content of legumes although the higher dose of phosphorus resulted only in a slight improvement in the crude protein content (Table 15). This agrees with the results obtained by Sen and Bains (1956) in cowpea, Sahu (1973) in blackgram and horsegram, Murali (1989) in Sesbania rostrata and Thakuria and Luikham (1991 a) in fodder cowpea. Phosphorus application would have resulted in better root formation which might have helped in fixing higher quantity of atmospheric nitrogen which in turn improved the nitrogen content and crude protein content of plant parts. Authors like Whyte et al. (1953) and Singh and Singh (1991) have previously pointed out the beneficial effect of phosphorus application in similar manner. Improvement in crude protein content under the influence of phosphorus application is shown in Figure 8.

Crude protein content of legumes differed significantly (Table 15). Maximum crude protein per cent was recorded in Sesbania rostrata (Figure 8), while cowpea variety Karnataka local recorded the minimum. The higher crude protein content of Sesbania rostrata was previously reported in trials at Rajendranagar under AICRP (1991). The increased nitrogen content of plant parts is mainly responsible for the higher crude protein content in Sesbania rostrata. Halepyati and Sheelavantar (1991) reported a nitrogen content as high as 5.69 per cent under low density planting in Sesbania rostrata.

Under l x v interaction, crude protein content of CO-5 increased when lime level was increased from 0 to 125 kg, but the next higher dose slightly reduced the crude protein content (Table 16). In C-152 there is a linear increase in crude protein content with increasing levels of lime due to varietal response to the lime application (Table 16). In Karnataka local, crude protein content decreased with increase in lime levels which is probably due to the low response of this particular cultivar to applied lime as explained earlier.

Table 17 shows the p x v interaction effect which significantly influenced the crude protein content of legumes. In CO-5 cowpea, a linear increase in crude protein content was noticed with the application of 60 kg phosphorus. In C-152 maximum crude protein content was obtained with the application of 60 kg P_2O_5 which is a general response of legumes to phosphorus application. In Karnataka local cowpea variety and Sesbania rostrata though the application of 30 kg P_2O_5 increased the crude protein content, a lower value was recorded at the highest level of application of P_2O_5. This is probably due to the dilution effect resulted from the higher dry matter production (Table 13) as explained by Jarrel and Beverly (1981).

With the application of moderate level of lime + moderate to higher levels of P_2O_5, crude protein content was favourably influenced (Table 18) which may be an indirect effect of better root formation and increased microbial activity resulted from the treatment.

5.3.2 Phosphorus content

Influence of lime on plant phosphorus content of legumes is depicted in Table 15. Phosphorus content in legumes increased significantly at the highest level of lime application. Addition of a liming agent to the acidic soils will inactivate the iron and aluminium increasing the level of plant available phosphorus (Tisdale et al., 1990). Therefore in acid soils liming decreases the phosphorus fixation and hence more phosphorus should have been available in the soil. But as the plant has already taken up this phosphorus and accumulated it during its growth period, available phosphorus content in the soil after the experiment decreased (Table 19). This explains the increased plant phosphorus content due to liming, which is clearly evident from Figure 9.

It is shown in Table 15 and Figure 9 that the increase in phosphorus levels decreased the plant phosphorus content significantly at each level. Phosphorus uptake (Table 23) showed a decreasing trend compared to control although the general effect was not significant. This might have resulted in low plant phosphorus content. Besides Table 11 indicated an increasing trend in green and drymatter yield with increasing levels of phosphorus. With reduced uptake, increased biomass production might have resulted in the dilution of plant phosphorus which may be the probable reason for low plant phosphorus content. Dilution effect of plant nutrients was previously reported by Jarrel and Beverly (1981).

Varietal difference significantly influenced the plant phosphorus content and is shown in (Table 15). Maximum phosphorus content was recorded with Sesbania rostrata. This is in agreement with the results reported by Murali (1989) who obtained a plant phosphorus content of 0.57 percent in Sesbania rostrata under no phosphorus application. This legume also recorded maximum uptake compared to other crops (Table 23). This increased uptake in combination with higher nitrogen fixation might have resulted in highest total phosphorus content in vegetative parts. Phosphorus content of different legumes is depicted in Figure 9.

Table 16 indicates the significant influence of l x v interaction on plant phosphorus content. In cowpea varieties CO-5 and C-152, more phosphorus content was recorded with the application of highest dose of lime (250 kg) while phosphorus content was decreased with the application of 125 kg lime. Increased phosphorus uptake due to reduced phosphorus fixation on liming is the probable reason for this increase in plant phosphorus content and the lesser uptake with the application of lower dose of lime may be the possible reason for the decreased plant phosphorus content, (Table 24).

p x v interaction had significant influence on the phosphorus content of fodder legumes (Table 17). In cowpea vareity Karnataka local, Sesbania rostrata and cowpea variety C-152 phosphorus content decreased with the highest level of phosphorus. The dry matter production showed an increasing trend at the highest dose of phosphorus application in all these legumes (Table 13) which might have reduced the plant phosphorus content due to the dilution effect. In CO-5 although application of lower dose of phosphorus decreased the plant phosphorus content, it was improved with the further increase in phosphorus level. Improvement in the plant phosphorus content on applying higher dose of P_2O_5 was previously reported by Thakuria and Luikham (1991 a) in fodder cowpea.

5.3.3 Potassium content

It is clear from Table 15 that the potassium content increased significantly with increasing levels of lime and a maximum content was recorded with the application of highest level of lime. Figure 9 also supports this result. Liming acid soils improves the potassium availability by increasing the ability of soils to retain exchangeable potassium and competitive effect of aluminium on potassium is reduced when insoluble aluminium hydroxide is formed following the additions of lime (Tisdale et al., 1990). Increased potassium concentration in legume due to liming was previously reported by Cheng (1976) and Sarkar and Debnath (1990).

Table 15 indicated the improvement in plant potassium content due to phosphorus application, where maximum potassium content was recorded with the application of 30 kg P_2O_5. Supply of phosphorus encourages the root development and promotes the root proliferation which in turn might have helped the plants in accumulating more amount of potassium; the root type and density being important characters affecting potassium availability to crops (Tisdale *et al*., 1990). Similar results were reported by Faroda and Tomer (1975) in fodder cowpea, Mariyappan (1978) in *Stylosanthes gracilis* and Murali (1989) in *Sesbania rostrata*.

Plant potassium content was maximum in cowpea variety CO-5 which was on a par with *Sesbania rostrata* (Figure 9 and Table 15). The lowest potassium content was recorded with cowpea variety Karnataka local. It is evident from Table 19 that the available potassium in the soil after the experiment was lowest under cowpea variety CO-5. This explains the highest potassium content recorded in this variety as the plant would have accumulated more amount of potassium during the early growth stage leaving lesser amount of potassium in soil. Subramanian *et al*. (1987) reported a higher ash content of 16 per cent in cowpea variety CO-5 compared to CO-1.

l x v interaction significantly influenced the plant potassium content (Table 16). In variety CO-5 application of highest dose of lime reduced the plant potassium content. In C-152 and Karnataka local higher levels of lime application increased the potassium content. In Sesbania rostrata application of 125 kg lime, recorded low potassium content in plant, which significantly improved with the application of 250 kg lime. The varied plant potassium content recorded in different legumes can be attributed to the variation in potassium uptake pattern of these crops under liming (Table 24).

p x v interaction also significantly influenced the plant potassium content in fodder legumes (Table 17). In cowpea variety CO-5 and Sesbania rostrata application of higher dose of phosphorus reduced the plant potassium content which may be probably due to the reduced potassium uptake in these legumes (Table 25). In C-152 application of 60 kg P_2O_5 increased the plant potassium content coupled with the increased uptake. Karnataka local variety responded only upto 30 kg P_2O_5.

Application of 250 kg lime + 60 kg P_2O_5 resulted in more potassium content (Table 18) than 125 kg lime + 30 kg P_2O_5 treatment. Similarly maximum plant potassium content was recorded with the application of 125 kg lime + 60 kg

P_2O_5. Uptake pattern depicted in Table 26 supports this trend.

5.3.4 Calcium content

Liming increased the calcium content of fodder legumes significantly although two higher levels of lime did not differ from each other (Table 15). Increased plant calcium content due to liming can be explained on the basis of increased availability of phosphorus on account of reduced phosphorus fixation consequent to liming. A good supply of phosphorus has been historically associated with increased root growth and extensive root proliferation as suggested by Tisdale *et al*. (1990). The same author also reported the increased uptake and accumulation of calcium in those plants possessing highly developed root system.

Different levels of phosphorus did not significantly influence the calcium content of fodder legumes. This is in agreement with the result obtained by Faroda and Tomer (1975) who reported that different levels of phosphorus had no effect on plant calcium content in fodder cowpea.

Highest calcium content was noticed in *Sesbania rostrata* while cowpea variety Karnataka local recorded the lowest (Table 15 and Figure 10). This could be explained on the basis of difference in genetic potentials in accumulating nutrient elements. In Sesbania rostrata, calcium content as high as 1.2 per cent was reported previously by Murali (1989). Result of the calcium uptake studies (Table 23) also indicated the superiority of Sesbania rostrata in accumulating higher amount of calcium.

Calcium content in fodder legumes were significantly influenced by l x v interaction (Table 16). In cowpea varieties C-152 and Karnataka local different levels of lime did not produce much variation in plant calcium content. In CO-5 variety, increased calcium content was observed with the application of 250 kg lime which can be explained on the basis of increasing trend in the calcium uptake of this cowpea variety at the highest level of lime application (Table 24). Sesbania rostrata responded upto 125 kg lime only.

5.3.5 Magnesium content

Increasing levels of lime significantly decreased (Table 15) the plant magnesium content. Similar results were reported previously by Andrew and Johnson (1976) who suggested the changes in magnesium concentration in plant tops on account of liming may be due to the capacity of the plants to preserve cation balance. Murali (1989) also made similar observations. Tisdale et al. (1990) reported that the continued use of high calcic liming materials may result in an unfavourable calcium: magnesium balance and the consequent development of magnesium deficiency symptoms on certain crops. Therefore reduced mangnesium content in plant parts on account of liming is most probably due to the adjustment mechanism of plants to preserve cation balance.

Magnesium content in fodder legumes was not significantly influenced by different levels of application of phosphorus. This is in agreement with the results obtained by Murali (1989).

Sesbania rostrata recorded the highest magnesium content (Table 15) while the cowpea varieties recorded same magnesium contents. Figure 10 clearly explains this trend exhibited by fodder legumes. Difference in the magnesium contents in crops is mainly due to the variation in genetic potential of plants. There are important genetic differences in the magnesium requirement and efficiency of plants (Tisdale et al., 1990). This genetic difference might be responsible for the increased uptake of magnesium in Sesbania rostrata (Table 23).

Table 16 indicates that in all fodder legumes, plant magnesium contents decreased at the highest level of lime application and in Sesbania rostrata and CO-5 a linear decrease in plant potassium content with increasing levels of lime was noticed. Table 24 indicates the increased calcium uptake in all the fodder legumes at the highest levels of lime application. This increased calcium uptake might have resulted in reduced magnesium accumulation in plants as reported by Tisdale _et al_. (1990).

Application of moderate levels of lime and phosphorus (125 kg lime +30 kg P_2O_5) recorded more magnesium content compared to the combination of higher levels of lime and phosphorus which is possibly due to the adjustment mechanism of plants to conserve cations as suggested by Andrew and Johnson (1976) as exlained earlier.

5.4 Nutrient status of soil

5.4.1 Available nitrogen

Available nitrogen in soil after the conduct of experiment was not significantly influenced by the application of different levels of lime.

Phosphorus application significantly increased the available nitrogen content of soil although different levels of phosphorus did produce same effect (Table 19). Specific effect of phosphorus on nodule function and nitrogen fixation has been reported by Mclaughlin _et al_. (1990). Phosphorus application therefore might have resulted in increased nitrogen fixation and available nitrogen in the soil.

Similar observations have been made by Sing and Khatri (1972) and Raut and Kohire (1991).

Different legumes had no significant influence on the available nitrogen in the soil after the experiment.

l x p interaction influenced the available nitrogen status of soil after the conduct of experiment as shown in Table 22. Application of 250 kg lime + 30 kg P_2O_5 increased the available nitrogen content of soil compared to the control whereas 250 kg lime + 60 kg P_2O_5 was on a par with the control. As discussed earlier, application of lime and phosphorus is found to influence the nitrifying organisms favourably and hence application of 250 kg lime + 60 kg P_2O_5 would actually have accelerated the nitrogen mineralisation making more nitrogen available to the plant. As the plant would have already utilized this additional amount of nitrogen during its growth period, the residual available nitrogen in soil turned out to be lesser in quantity. This explanation is supported by nitrogen uptake pattern shown in Table 26, where nitrogen uptake was more with the application of 250 kg lime + 60 kg P_2O_5 compared to the control.

5.4.2 Available phosphorus

Increasing the levels of lime to highest dose decreased the available phosphorus in soil after the conduct of experiment (Table 19). Application of lime generally decreases the toxicity of iron and aluminium thereby increasing the level of plant available phosphorus as suggested by Tisdale et al. (1990). However, the reduced phosphorus fixation as a result of liming tended to increase the phosphorus uptake and accumulation, resulting in low available phosphorus in the soil after the experiment. Table 15 clearly shows higher plant phosphorus content under highest level of lime. Increased phosphorus uptake due to lime application was reported previously by authors like Robson et al. (1970), Bansaridas et al. (1990) and Sarkar and Debnath (1990).

Available phosphorus content of soil after the experiment was highest with the application of 30 kg P_2O_5 ha^{-1} and the highest dose of phosphorus produced the same effect of the control (Table 19). Phosphorus uptake showed a decreasing trend (Table 23) with increase in the phosphorus levels, compared to the control. This decreased uptake might have resulted in increased available soil phosphorus content at 30 kg P_2O_5 level and the further improvement in the phosphorus uptake at 60 kg P_2O_5 might have decreased the available phosphorus in soil at that level, after the conduct of experiment as explained earlier.

Available phosphorus in soil was maximum under cowpea variety C-152 whereas the other legumes were on a par with each other (Table 19). High available soil phosphorus content under cowpea variety C-152 can be related with the phosphorus uptake pattern of this variety where the uptake was poor compared to all other varieties except Karnataka local (Table 23). This low uptake would have resulted in high available phosphorus in soil after the conduct of experiment. The difference in the uptake pattern is decided by the genetic nature of the variety.

l x v interaction did not significantly influence the available phosphorus content of soil, (Table 20).

p x v interaction however significantly influenced the available soil phosphorus status (Table 21) after the conduct of experiment. Cowpea variety CO-5 did not produce any significant change in available phosphorus content in soil due to phosphorus application when compared to control. In C-152, available phosphorus in soil increased with the application of 30 kg P_2O_5 and the next higher dose was on a par with 30 kg P_2O_5. This is probably due to the reduced uptake of phosphorus by this crop at 30 kg P_2O_5 (Table 25) which left more amount of available phosphorus in soil. Similarly in Karnataka local variety of cowpea, application of 30 kg P_2O_5 increased the available phosphorus in soil. Sesbania rostrata recorded the maximum available soil phosphorus content with the application of 30 kg P_2O_5 which can be explained by the increasing trend in phosphorus uptake of this variety at higher levels of phoshorus application (Table 25) as explained previously.

l x p interaction significantly influenced the available phosphorus content in the soil. Application of moderate levels of lime and phosphorus (Table 22) combination increased the available soil phosphorus content. This can be attributed to the lesser uptake of phosphorus (Table 26) with the combined application of moderate levels of lime and phosphorus compared to the control which would have left more amount of available phosphorus in soil after the conduct of experiment.

5.4.3 Available potassium

Different levels of lime or phosphorus did not influence the available potassium content of soil after the conduct of experiment.

Varietal effect however significantly influenced the available soil potassium status (Table 19). Available soil potassium content was lowest under cowpea variety CO-5 while all other legumes recorded similar effects. Table 15 indicated the higher potassium content in cowpea variety CO-5 which can be attributed to the low available soil potassium content as the plant would have accumulated major part of the soil potassium during its growth period leaving lesser amount in the soil after the experiment. The higher nutrient accumulation capacity may be genetical. Such varietal difference in nutrient accumulation has been reported early by Faroda and Tomer (1975) and Subramanian et al. (1987) in fodder cowpea. Moderate potassium uptake in CO-5 cowpea variety (Table 23) further reinforces this explanation.

l x v interaction significantly affected the available potassium content in soil after the experiment (Table 20). Karnataka local **cowpea** and Sesbania rostrata produced no significant variation in the available soil potassium status, while in CO-5 and C-152 available potassium content in soil was lower at the highest level of lime application. Thus a diverse varietal response was obtained with the application of lime.

p x v interaction significantly influenced the available soil potassium content after the experiment (Table 21). In all legumes except Sesbania rostrata and cowpea variety C-152 higher levels of phosphorus application increased the available soil potassium content.

l x p interaction (Table 22) also influenced the available potassium content of soil where application of 125 kg lime along with 30 kg P_2O_5 increased the available soil potassium content. Reduced potassium uptake (Table 26) might have resulted in more available potassium content in soil after the experiment.

5.4.4 Available calcium

Available calcium in soil increased with increasing levels of lime application after the conduct of experiment (Table 19). Improved availability of calcium due to liming was reported previously by Tripathi et al. (1984). This increased availability of calcium along with reduced leaching losses in summer rice fallow conditions might have resulted in more available calcium content of soil after the conduct of experiment. The suggestion made by Tisdale et al. (1990) that the quantity of calcium lost through leaching is much greater than other cations, strengthens this view.

Different levels of phosphorus had no influence on the available calcium content of soil, after the conduct of experiment.

Similarly varietal difference could not influence the available calcium content of soil after the experiment. None of the interactions significantly influenced the available calcium in soil, (Tables 20, 21 and 22).

5.4.5 Available magnesium

Application of 125 kg lime slightly increased the available magnesium content of soil after the experiment (Table 19). However, the next higher dose of lime decreased the magnesium content in soil. Similar results have been reported by Sumner et al. (1978) who observed that liming increased the magnesium level initially, but as the pH approached neutrality, it got decreased. This reduction can be due to magnesium fixation through reactions with soluble silica or aluminium chlorate and due to the co-precipitation with $Al(OH)_3$. Authors like Tisdale et al. (1990) also reported the fixation of mangnesium under certain soil conditions.

Neither phosphorus application nor varietal difference produced any significant variation in available magnesium status of soil, (Table 19).

Table 20 shows that l x v interaction was significant in influencing the available soil magnesium status after the experiment where a varied varietal response was noticed. p x v interaction (Table 21) however did not significantly influence the available soil magnesium status after experiment. l x p interaction (Table 22) significantly influenced the available magnesium content in soil, after the conduct of experiment, where higher available soil magnesium content was noticed with the combined application of moderate levels of lime and phosphorus compared to the combined application of higher levels of lime and phosphorus. This can also be due to the fixation reaction of magnesium as explained earlier.

5.5 Uptake of nutrients

5.5.1 Nitrogen uptake

Different levels of lime or phosphorus did not significantly influence the nitrogen uptake of fodder legumes, (Table 23).

However, nitrogen uptake was maximum in Sesbania rostrata and minimum in Karnataka local variety of cowpea. Higher nitrogen uptake in Sesbania rostrata is mainly due to the higher dry matter production (Table 11) and nitrogen content (Table 15). Haleapyati and Sheelavantar (1991) reported a nitrogen content as high as 5.69 per cent in Sesbania rostrata. The low nitrogen uptake in cowpea variety Karnataka local is probably due to the low nitrogen content (Table 15) and low dry matter production (Table 11).

5.5.2 Phosphorus uptake

Phosphorus uptake was not significantly influenced by lime or phosphorus treatments, (Table 23).

Sesbania rostrata recorded highest phosphorus uptake while cowpea variety Karnataka local recorded the lowest (Table 23). This increased phosphorus uptake was favoured mainly by higher dry matter production (Table 11) and nitrogen content. Murali (1989) reported a dry matter production as higher as 6.05 tonnes ha^{-1} in Sesbania rostrata under limed condition. The low uptake in Karnataka local due to low dry matter production as evident from Table 23.

5.5.3 Potassium uptake

Potassium uptake by fodder legumes were not influenced by different lime or phosphorus treatments.

Varietal difference significantly influenced the potassium uptake (Table 23) and Sesbania rostrata recorded the highest potassium uptake and Karnataka local recorded the lowest. Here also the higher dry matter production as evident from Table 11 in combination with high plant potassium content (Table 15) may be responsible for higher uptake in Sesbania rostrata.

Only l x v interaction significantly influenced the potassium uptake by legumes (Table 24). There was no difference in the potassium uptakes of CO-5, C-152 and Karnataka local due to the application of different levels of lime in each variety. In Sesbania rostrata potassium uptake was reduced with application of 125 kg lime, but improved by the application of 250 kg lime. This variation is probably due to the variation in dry matter production of this crop as indicated in Table 12.

5.5.4 Calcium and magnesium uptakes

Both calcium and mangnesium uptakes were not influenced by lime or phosphorus application. Varietal difference significantly influenced the calcium and magnesium uptake by fodder legumes (Table 23). Uptake of calcium and magnesium were maximum in Sesbania rostrata compared to all other cowpea varieties which is mainly due to higher dry matter production (Table 11) and highest calcium and magnesium contents (Table 15).

5.6 Yield of succeeding rice crop

5.6.1 Grain yield

Grain yield of succeeding rice crop was not influenced by different levels of lime or phosphorus treatments (Table 27).

Varietal difference of previous legumes did not significantly influence the grain yield of succeeding rice crop. However, grain yield was slightly higher in plots where Sesbania rostrata was grown previously. This agrees with the results obtained by Takahashi et al. (1986) who reported that rice yield was higher when Sesbania sp. was grown as a preceding crop.

l x v interaction or p x v interaction or l x p interaction did not significantly influence the grain yield of succeeding rice crop (Table 28, 29 and 30).

5.6.2 Straw yield

Straw yield of succeeding paddy crop was not influenced by different lime or phosphorus treatments to the preceding legumes, (Table 27).

Similarly different legumes grown previously did not significantly influence the straw yield of succeeding rice crop. However, straw was higher in plots where Sesbania rostrata was grown previously which agrees with the results obtained by Takahashi et al. (1986).

None of the interactions significantly influenced the straw yield of succeeding rice crop (Tables 28, 29 and 30).

SUMMARY

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An experiment was conducted at Cropping Systems Research Centre, Karamana, Thiruvananthapuram during February-August, to compare the fodder production potential of four legumes under lime and phosphorus nutrition in summer rice fallows and also to find out the residual effect of the treatments on the succeeding crop of paddy. The treatment consists of three levels of lime viz. 0, 125, 250 kg and 3 levels of phosphorus viz. 0, 30 and 60 kg P_2O_5 as main treatments and four fodder legumes viz. cowpea variety CO-5, cowpea variety C-152, cowpea variety Karnataka local and Sesbania rostrata as sub-treatments. The trial was laid out as a spit plot experiment in RBD. A bulk crop of paddy variety Hriswa (Culture 24-20) was grown retaining the same layout, in the first crop season, after the harvest of leguminous fodder crops. The data generated were statistically analysed, presented and discussed in the foregoing chapters. The findings of this study are summarised below.

1. Application of 250 kg lime in combination with 60 kg P_2O_5 produced highest plant height (97.78 cm). Cowpea variety CO-5 produced taller plants (84.48 cm) than other cowpea varieties and Sesbania rostrata produced the maximum plant height (122.47 cm).

2. Application of 250 kg lime in combination with 60 kg P_2O_5 produced more number of leaves (54.38). Cowpea variety C-152 produced more number of leaves (24.19) than all other cowpea varieties, while sesbania rostrata produced highest number of leaves (53.87).

3. Maximum LAI (15.80) was produced with the combined application of 250 kg lime + 60 kg P_2O_5. Sesbania rostrata and cowpea variety C-152 recorded more LAI than other legumes, which were 10.44 and 9.93 respectively.

4. Maximum number of branches (6.22) was produced under the combined application of 250 kg lime + 60 kg P_2O_5. Sesbania rostrata recorded maximum number of branches (4.33) among different legumes while cowpea variety C-152 produced more number of branches (3.70) than other cowpea varieties.

5. Vegetative growth period was enhanced from 32 to 34 days in Sesbania rostrata when 125 kg lime was applied. Cowpea variety CO-5 took more days to flower (51 days) than all other varieties while early flowering was noticed in Sesbania rostrata and Karnataka local.

6. Combined application of 125 kg lime and 30 kg P_2O_5 reduced the root nodulation from 11.12 to 8.89. Cowpea variety C-152 produced maximum number of root nodules (18.58) just before harvest, while Sesbania

rostrata was poor in root nodulation (3.88). Stem nodulation of *Sesbania rostrata* was declined to 0.06 nodules per plant with the combined application of 250 kg lime and 60 kg P_2O_5.

7. Highest green fodder yield of 31.19 t ha^{-1} was recorded in cowpea variety C-152 while Karnataka local variety of cowpea recorded the lowest green fodder yield (15.39 t ha^{-1}).

8. *Sesbania rostrata* recorded the highest dry fodder yield of 4.99 t ha^{-1} where as cowpea variety Karnataka local recorded the lowest dry fodder yield (2.31 t ha^{-1}).

9. Crude protein yield was highest in *Sesbania rostrata* (1222.88 kg ha^{-1}) and lowest in cowpea variety Karnataka local (386.18 kg ha^{-1}).

10. Application of moderate levels of lime (125 kg) in combination with 60 kg P_2O_5 increased the crude protein content of legumes. *Sesbania rostrata* recorded the highest crude protein content (23.84 %) while Karnataka local recorded the lowest (16.84 %).

11. *Sesbania rostrata* recorded the highest plant phosphorus content (0.36 %).

12. Combined application of 125 kg lime + 60 kg P_2O_5 resulted in more plant potassium content (2.02%). Cowpea variety CO-5 recorded the highest plant potassium content (1.76 %).

13. A highest calcium content of 1.28 % was recorded in Sesbania rostrata.

14. Available nitrogen content in soil was increased from 300.53 kg ha^{-1} to 344.96 kg ha^{-1} due to the combined application of 250 kg lime + 30 kg P_2O_5. Single application of phosphorus was also found to improve the available nitrogen status of soil.

15. Combined application of 125 kg lime and 30 kg phosphorus increased the available soil phosphorus status.

16. Available soil potassium status was increased due to the combined application of 125 kg lime and 30 kg P_2O_5. Available soil potassium content was lowest in plots where cowpea variety CO-5 was grown.

17. Available calcium content of soil increased with increasing levels of lime but available magnesium content was decreased with the application of 250 kg lime treatment.

18. The uptake of N, P, K, Ca and Mg were maximum in Sesbania rostrata. Uptake of nutrients were lower in cowpea variety Karnataka local where the calcium uptake was only half as that of other legumes.

19. Grain yield and straw yields of succeeding crop of paddy were unaffected by the preceding legumes. However both grain and straw yields of rice were found to be higher in plots where Sesbania rostrata was grown previously.

20. Sesbania rostrata is a promising fodder crop on account of its higher dry matter production and crude protein content.

21. Cowpea variety C-152 followed by CO-5 is suited for rice fallow conditions for cultivation as a fodder crop.

22. Cowpea variety C-152 was found to be more economic as a fodder crop than other legumes.

23. Finally it is concluded that leguminous fodder crops can be best grown utilizing the residual moisture in summer rice fallows under adequate lime and phosphorus nutrition.

Future line of work

In Kerala, the rice fallow conditions offer a good opportunity for fodder cultivation where short duration fodder legumes can be grown on residual moisture. New varieties and types of good quality leguminous crops which remain fodder productive after one or more cuts may be tried in future to ascertain their suitability in rice fallows.

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APPENDICES

APPENDIX I

Weather data during the cropping period

Standard week	Period			Rainfall (mm)	Average maximum temperature (^{o}C)	Average minimum temperature (^{o}C)	Average Relative humidity (%)
	From		to				
10	March 5	–	March 11	4.2	31.89	21.20	73.21
11	March 12	–	March 18	0	31.77	21.21	67.86
12	March 19	–	March 25	0	32.21	22.78	72.71
13	March 26	–	April 1	0	32.30	24.10	73.62
14	April 2	–	April 8	0	32.71	23.89	70.42
15	April 9	–	April 15	5.4	32.31	23.20	72.50
16	April 16	–	April 22	0	32.42	24.50	73.40
17	April 23	–	April 29	7.2	32.12	22.32	74.40
18	April 30	–	May 6	0	33.40	23.00	71.20
19	May 7	–	May 13	21.6	32.37	25.00	76.14
20	May 14	–	May 20	43.0	29.19	23.92	89.71
21	May 21	–	May 27	0	31.85	24.45	80.35
22	May 28	–	June 3	64.0	32.02	24.77	75.14
23	June 4	–	June 10	43.4	29.15	22.96	87.33
24	June 11	–	June 17	67.8	29.56	23.98	85.85
25	June 18	–	June 24	43.9	29.98	25.25	82.28
26	June 25	–	July 1	14.0	29.92	24.53	81.78
27	July 2	–	July 8	113.7	29.18	23.74	84.92
28	July 9	–	July 15	22.0	28.93	22.92	80.64
29	July 16	–	July 22	68.8	29.02	22.74	83.28
30	July 23	–	July 29	48.2	28.60	22.84	86.64
31	July 30	–	August 5	5.8	28.22	22.45	87.50
32	August 6	–	August 12	19.4	28.70	24.50	85.40

HERBAGE PRODUCTION OF LEGUMINOUS CROPS IN SUMMER RICE FALLOWS

BY

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ABSTRACT OF A THESIS
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ABSTRACT

An investigation was carried out at Cropping Systems Research Centre, Karamana, Thiruvananthapuram to study the fodder production potential of four legumes (cowpea variety CO-5, cowpea variety C-152, cowpea variety Karnataka local and *Sesbania rostrata*) under three levels of lime (0, 125 and 250 kg per hectare) and three levels of phosphorus (0,30 and 60 kg P_2O_5 per hectare) in summer rice fallow. To study the residual effect, a bulk crop of paddy was raised in the first crop season retaining the same layout. The trial was laid out as a split-plot experiment in RBD with three replications.

Application of lime increased the growth attributes like plant height, number of leaves, LAI and number of branches in all fodder legumes. Various growth parameters were increased due to the application of phosphorus. Combined application of lime and phosphorus improved the growth parameters through the indirect effect of increased availability of nutrients. Combined application of higher levels of lime and phosphorus decreased the nodulation in *Sesbania rostrata*.

Combined application of 125 kg lime and 60 kg P_2O_5 improved the crude protein content. Application of 250 kg lime increased the plant phosphorus content which however decreased with increasing levels of application of phosphorus. Combined application of 125 kg lime and 60 kg P_2O_5 resulted in more plant potassium content. Increase in lime levels from 0 to 125 kg increased calcium content of legumes. Combined application of 125 kg lime and 30 kg P_2O_5 produced more magnesium content in plant than 250 kg lime and 60 kg P_2O_5 treatment combination.

Available nitrogen content in soil after the experiment increased with the combined application of 250 kg lime and 30 kg P_2O_5 . Combined application of moderate levels of lime and phosphorus resulted in more available phosphorus and potassium contents. Available calcium content of soil increased with increasing levels of lime, but magnesium content of soil was found to decrease with the application of 250 kg lime.

Sesbania rostrata and cowpea variety CO-5 produced taller plants, while Sesbania rostrata followed by cowpea variety C-152 recorded more number of leaves and LAI. Sesbania rostrata also recorded maximum number of branches, but was poor in nodulation where the combined application of 250 kg lime and 60 kg P_2O_5 declined the stem nodulation.

Green fodder yield was maximum in cowpea variety C-152, while dry fodder production was maximum in Sesbania rostrata.

Sesbania rostrata recorded highest crude protein, phosphorus, calcium and magnesium contents where as CO-5 had maximum plant potassium content.

Available soil potassium content was lowest under cowpea variety CO-5.

Uptake of nutrients were maximum in Sesbania rostrata and minimum in Karnataka local.

The trial also indicated the suitability of Sesbania rostrata as a fodder crop on account of its higher dry matter production and nutrient content.

Cowpea variety C-152 was found to be more economic as a fodder crop under summer rice fallow conditions.