POTENTIAL AND PROSPECTS OF FODDER LEGUMES IN RICE FALLOWS

By

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THESIS

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the requirement for the degree

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DECLARATION

I hereby declare that this thesis entitled "Potential and Prospects of Fodder Legumes in 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.

Vellanikkara,
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CERTIFICATE

We, the undersigned, members of the Advisory Committee of Smt.Meera V. Menon, a candidate for the degree of Master of Science in Agriculture with major in Agronomy, agree that the thesis entitled "Potential and Prospects of Fodder Legumes in Rice Fallows" may be submitted by Smt.Meera V. Menon, in partial fulfilment of the requirement for the degree.

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Introduction

1. INTRODUCTION

Identification of suitable cropping systems and formulating management practices for different agroclimatic and soil conditions is indeed a challenge for agronomists. To meet this challenge, a thorough knowledge of the basic principles of crop management is essential and techniques should be developed to apply them as crop intensity increases. Fixing fertilizer schedules for intensive cropping needs special mention in this juncture. This is particularly essential under intensive cropping because of complementary effects of component crops and influence of crop residues in soil.

Balanced use of fertilizers is one of the important means to raise the productivity per unit area of land under intensive cropping. In this connection, the wide gap between the demand and production of fertilizers in the country, especially with respect to nitrogen, is worth mentioning. In order to attain the food grain production target of 200 million tonnes stipulated by the National Commission on Agriculture by 2000 A.D., an estimated fertilizer nitrogen consumption of about 15 million tonnes would become necessary as against the present consumption of 7.8 million tonnes (Prasad and Subbiah, 1982). The maximum estimated production of chemical N fertilizers by then would be able to meet two thirds of the demand only.

In addition to the ever widening gap between the indigenous supply and demand, the energy crisis and consequent escalation in the cost of chemical fertilizers, particularly that of N, aggravate the problem. As a result, chemical fertilizers are going beyond the purchasing power of the majority of our rural farming community. The integrated nutrient supply system which contemplates the use of a judicious combination of the locally available organic, inorganic and microbial sources of nutrients, is a very worthy consideration in this juncture.

Under the prevailing conditions of Kerala, availability of farmyard manure and other organic manures is limited and the cost is prohibitive. The State, with a vast stretch of typically sandy and sandy loam soils under rice cultivation, requires an effective alternate source of organic manure which is capable of supplying adequate quantity of N and at the same time, capable of improving the physical and chemical properties of soil.

In Kerala, rice cultivation involves the raising of two rice crops during the virippu season (June-September) and mundakan season (September-December) followed by a fallow period. Due to inadequate moisture availability, cultivation of a third crop is not feasible during the third crop season. Instead of leaving the land fallow during this period, an efficient cropping system which is beneficial in the time and space dimensions and that augments the nutrient status of the soil would be desirable. The cultivation of fodder legumes during this period could be a solution.

Legumes have an inherent capacity to fix atmospheric N and enrich the soil. At the same time, they make less demand on the soil for N. Among them, fodder legumes are worth mentioning. They supply nutritive, succulent, palatable, green fodder. These crops usually maintain their quality better than grasses even at maturity, and being rich in protein, enhance the fodder quality and also add substantially the much needed N to the soil (ICAR, 1980). Quality fodder would also enhance milk yields of cattle substantially.

The performance of legume crops and their beneficial effects on the succeeding crops have been established beyond doubt elsewhere in the State. In sequential cropping, the individual fertilizer rates for each crop included in the system are simply summed up and given. But there are enough indications to show that there could be considerable saving in the total quantity of fertilizers applied earlier, varying mobilising power of the component crops, possible contribution of N from the root nodules by legumes and mineralisation of residues left behind by the previous crop (Singh, 1974 and Iruthayaraj, 1977). Experiments at Chalakudy with a cropping system of rice-rice-cowpea showed that application of recommended dose of nutrients and its 75 per cent produced equal yields (KAU, 1982 a). Increased rice yield due to the effect of a previous crop of cowpea was observed in an experiment at Moncombu (KAU, 1982 b). Yield increase in rice during the kharif and rabi seasons was observed when it was preceded by crops like sesamum and cowpea (KAU, 1983). Legumes have also been reported to favourably influence the physical and chemical characteristics of the soil (Singh and Ashwathi, 1978). This aspect has also not been researched and such information is very essential for giving definite package of practices. For developing the fertilizer schedule for an intensive cropping system, it is important to have an understanding of the nutrient requirements of the component crops, their uptake pattern, how much the soil can contribute and differential response of crops to nutrients (Palaniappan, 1985). However, information on these aspects under intensive cropping of fodder legumes is totally lacking.

The cultivation of fodder legumes in rice fallows is not a common practice in the State. The identification and popularisation of fodder legumes supplying good tonnage of green fodder and also improving soil fertility is warranted for increasing the net income from rice farming.

With these aspects in mind, an investigation was undertaken with the following objectives:

i) To evaluate the relative performances of fodder legumes in rice fallows.

ii) To ascertain the residual effect of fodder legumes in rice fallows and N economy in the succeeding *kharif* rice; and

iii) To investigate the physical and chemical changes in the soil by growing fodder legumes and their subsequent effect on *kharif* rice.

Review of Literature

2.2. REVIEW OF LITERATURE

The performance of certain legume crop varieties in rice fallows, and the beneficial effect exerted by legumes both on associated crops and on the succeeding crops, as well as on soil, are briefly reviewed hereunder. The literature reviewed are classified under the following sections.

2.1. Performance of legumes in rice fallows

2.2. Association of legumes and non-legumes - beneficial effect

2.3. Residual effect of legumes on the succeeding crops

2.4. Nitrogen economy through legumes

2.5. Physico-chemical changes in soil effected by legumes

2.1. PERFORMANCE OF LEGUMES IN RICE FALLOWS

Varkey and Jacob (1978) undertook the screening of cowpea varieties suitable for cultivation in the rice fallows, and the study clearly indicated that C-152, New Era, Ptb-1 and Ptb-118 could be successfully grown in the rice fallows during the third crop season. A range of legumes was evaluated in N.E. Thailand for dry season forage production on stored moisture following harvest of the paddy rice crop, and *Crotalaria juncea* (sannhemp) and *Lablab purpureus* (lablab/

produced the best dry matter yields of 1950 and 2020 kg/ha respectively on a cultivated paddy field without further fertilizer (Shelton, 1980).

Subramanian and Palaniappan (1980) evaluated black gram varieties for growing in rice fallows and found K-3 and Co-3 to be suitable varieties. Studies by Santhakumari et al. (1980) revealed that the cowpea varieties New Era and Kunnamkulam Local were the best suited for cultivation in the summer rice fallows of the Onattukara region as a catch crop during January-May. The same workers in 1980 evaluated the performance of black gram varieties in sandy loam rice fallows and concluded that even in the absence of summer showers, the variety Co-2 thrived better, giving a moderately higher yield.

The effect of graded doses of N, P and K on the yield and quality of black gram variety KM-1 grown in rice fallows was investigated by George et al. (1981) and it was seen that the maximum grain yield of 1757 kg/ha, the maximum grain protein yield of 410.86 kg/ha, and the maximum net profit of Rs.3,696.30 were obtained from the plot which received 30 kg K_2O/ha.

The above reports indicate that certain legume species are well suited for cultivation in rice fallows. However, research on this aspect is limited, and the performance of fodder legumes in rice fallows requires further investigation.

2.2. ASSOCIATION OF LEGUMES AND NON-LEGUMES - BENEFICIAL EFFECT

Mirchandani and Misra (1957) worked on the associated growth of cereal and legumes and found that the association of legumes (peas and lentil) generally increased the yield of cereal (wheat) and improved the protein content in grain.

Agboola and Fayemi (1972) studied the fixation and excretion of N by tropical legumes. The investigations showed that green gram interplanted with corn in the early cropping season increased the yield of the early corn crop but contributed very little to the yield of the late corn crop.

It was also observed by Saraf and De (1975) that legumes grown in association with non-legumes helped in increasing the yield of the non-legume without affecting its yield adversely.

Studies on the intercropping of short duration grain legumes sown in pastures and field crops showed that the yield of forage got enhanced due to the cultivation of three varieties of moong as intercrops, and the increases in the yield of forage grass corresponded to the increased production that could be brought about by an additional application of 15-20 kg N/ha (Singh and Prasad, 1975). According to Morachan et al. (1977), N requirement and fertilizer could be reduced, and at the same time, soil fertility could be improved by intercropping sorghum with pulses like green gram, black gram and cowpea. It was observed by Rao et al. (1982) that there was an increase in total grain yield, land equivalent ratio and monetary return by intercropping legumes in rice and finger millet compared with sole cropping of rice in normal years.

An experiment conducted by Singh et al. (1981) in which pigeonpea was grown pure and mixed with short duration legumes showed that pigeonpea intercropped with groundnut recorded highest pigeonpea equivalent (19.3 q/ha) whereas the pigeonpea intercropped with other intercrops had more or less identical values of pigeonpea equivalent. Fodder sorghum had the lowest pigeonpea equivalent of 4.1 q/ha.

An investigation by Singh and Singh (1984) revealed that intercropping soya bean and black gram under Tarai conditions of U.P. increased grain yield of maize by 17-22 per cent, as compared to monoculture.

The above reports indicate the beneficial effect of growing legumes with non-legumes.

2.3. RESIDUAL EFFECT OF LEGUMES ON THE SUCCEEDING CROPS

Growing legumes had beneficial influence upon the succeeding crops, and the increases in the crop yields after legumes were almost or quite as high when the legumes were harvested as when they were ploughed under as green manures (Lohnis, 1926). Khan and Mathur (1957) reported that the timely burying of sannhemp as green manure could increase the grain and straw yields of the succeeding wheat crop. Similarly green manure crops were found to give significantly higher yield of wheat than no manure treatment (Singh and Sinha, 1961). It was also observed by Singh (1961) that the maximum recovery of N and P per acre was shown in the wheat crop where it followed green manure crops of sannhemp and cowpea.

In an experiment by Jha and Ram (1966) to study the effect of different green manures with phosphate fertilization on some yield components of wheat it was found that legumes increased the number of tillers/plant, the ear length, number of grains/ear and 1000 grain weight over control. It was observed that growing a <u>kharif</u> forage legume before wheat not only gave additional profit from the green fodder, but also increased the yield of the wheat crop (Tiwari and Tiwari, 1967). From rotational studies conducted in fields of normal fertility, Singh (1967) reported that the yield of wheat was highest after sanai (Crotalaria juncea) followed by moong (Phaseolus aureus) and gwar (Cyamopsis psoraliodes). Ballal et al. (1968) made a study on after effects of green manure crops on yield and uptake of nutrients by wheat and found that the uptake of N, P and K by wheat, as well as wheat yields were significantly increased by green manuring. Singh and Verma (1969) found that green manuring proved beneficial to the yield of wheat when practised every year.

A study by Kute and Mann (1969) revealed that green manuring of wheat with sannhemp (Crotalaria juncea) increased the N content of the soil and plant before flowering, after flowering and at harvest. In field trials to study the effect of preceding crops on the growth and yield of wheat, Vasilev (1969) found that the highest yields were obtained when wheat was grown after vetch or pea. Amantaey et al. (1970) recorded the yields of irrigated winter wheat after six different crops and found that the highest yield was harvested after lucerne. A similar result was observed by Borisov and Stamboliev (1970) who observed that the highest wheat yield was obtained after Phaseolus vulgaris, and by Styk and Przybysz (1970) who reported higher yields of winter wheat when preceded by leguminous crops.

Tiwari and Bisen (1971) observed that green manuring of wheat along with fertilizers gave the highest yield of wheat, and showed significant superiority to green manure alone. P application to cowpea, it was found, had a marked effect on increasing wheat crop yields which followed it in the succeeding season (Garg *et al*. 1971).

Trials by Pahwa *et al*. (1972) to evaluate the effect of crop rotations on the nutritive quality of wheat variety Sonora 64 showed that inclusion of legumes such as cowpea and berseem in the rotations increased the yield as well as protein content of grains of wheat. Sharma and Singh (1972) recorded a significantly higher yield of rice when it was sown after pea and gram than after fallow. Both the legumes were found equally effective. A study by Jones (1974) showed that maize yields were significantly affected by the nature of the previous crop, and was highest in the crop following groundnuts.

Crop rotation and fertilization effects on the yields of some cereals were studied by Roszak (1974) and it was found that yields of wheat and barley tended to be higher following legumes, maize or root crops than following cereals. Singh and Gill (1976) reported that sorghum gave maximum yield when it was preceded by crops like berseem, *senji* (*Melilotus* parviflora) and metha (Trigonella foenum graecum). The yields of corn grown in rotation with alfalfa and oats were compared with continuous corn by Bolton et al. (1976) and it was found that yields of corn varied widely from season to season according to moisture conditions, but always responded to alfalfa in the rotation, particularly where no fertilizer had been applied. Giri and De (1979) observed that yields of pearl millet were significantly increased when grown after legume crops such as groundnut (22.6%), cowpea (24.2%) or pigeonpea (12.1%) instead of after pearl millet. According to Tiwari et al. (1980), grain yield of rice and the accumulation of N, P and K in plants and their availability in soil increased significantly after green manuring.

A leguminous crop in rotation clearly had an added advantage of considerably increasing the yield of the succeeding maize crop, and on an average, the maize yield after green gram was 8.6 q/ha more than after non-leguminous maize fodder, and 4.9 q/ha more that after fallow (Meelu and Rana, 1981). Singh et al. (1982), studying the effect of summer grain and fodder legumes grown pure and mixed with fodder maize on the fertilizer need of rainy season maize, observed that maize following fodder cowpea recorded the highest growth and yield attributes, grain and stover yields and N uptake.

An experiment conducted at R.R.S., Moncombu, revealed that the highest grain yield was observed in the rice crop raised after cowpea (KAU, 1982b), while at the Model Agronomic Research Station, Karamana, increased rice yield was observed when it was preceded by crops like sesamum and cowpea (KAU, 1983).

In an experiment by Mandal and Ghosh (1984) where the residual effect of mulches and preceding crops of groundnut and sesame on the yield of the succeeding rice crop was studied, it was seen that significantly higher grain and straw yields were recorded in plots where rice succeeded groundnut than when sesame was the preceding crop. Singh and Singh (1984) reported that intercropping soya bean and black gram under Tarai conditions of U.P. increased grain yield of maize by 17-22 per cent and left sufficient residual effect to yield 15-20 per cent more wheat as compared to monoculture. In experiments conducted to evaluate the effect of a soya bean green manure intercrop on the grain yield of maize, Pandey and Pendleton (1986) observed that at the zero and lower N rates, the soya bean green manure resulted in significantly larger maize yields than when maize was grown without green manure, providing the equivalent of 28 kg N/ha on the zero nitrogen plots. A study by Morris **et al.** (1986) on rice responses to short duration green manure demonstrated that a fast growing tropical legume would accumulate more than 80 kg N/ha in 45 days and that rice yield responses exceeding 2 t/ha were possible from green manure incorporation. Reddy **et al.** (1986) found that the grass crops, rye, ryegrass, maize and wheat produced significantly higher dry matter (upto 100 %) when planted after green manure summer legumes than when planted after summer fallow.

The above reports indicate that the residual effect of the preceding legume crops very beneficially affects the succeeding non-leguminous crops. However, little is known about the effect of fodder legumes on the succeeding ri e crop.

2.4. NITROGEN ECONOMY THROUGH LEGUMES

Lohnis (1926) reported that in a heavy clay soil poor in humus, considerable losses of soil N occured under 29 crops of non-legumes, whereas conspicuous gains in N, equivalent to one third of the total N originally present in this soil, were secured when legumes were grown a few times between the non-legumes. Studies on the building up of soil fertility by the phosphatic fertilization of legumes, conducted by Acharya *et al.* (1953) showed that the plots where berseem had been grown in the rotation with phosphatic manuring, possessed at the end of a 10 year period, about 40 per cent higher N content than the plots where berseem had not been grown and about 17 per cent higher N content than the plots where berseem had been grown in the rotation without phosphatic manuring. The N increase in the soil amounted to 88 kg/ha/berseem crop. Experiments at Chalakudy with a cropping system of rice-rice-cowpea showed that application of the recommended dose of nutrients and its 75 per cent produced similar yields (KAU, 1982 a).

Estimates of the amount of N supplied by legumes in a corn-oats-meadow rotation on Edina silt loam ranged from 139 to 226 kg/ha in 1957 and from 61 to 94 kg in 1958 (Sutherland *et al.*, 1961). Das and Chatterjee (1977) in their study on N economy in forage production through grass and legume mixed cropping observed that, mixed cropping with cowpea gave as much dry matter yields as could be obtained from pure grass swards with 75-100 kg N/ha in dry (March-June) and 25-35 kg N/ha in wet (June-September) seasons. Rao and Sharma (1978) investigated the balance of soil N and P as influenced by cropping sequences and fertilizer constraints and found that the highest average gain in soil N was of the order of 81 kg N/ha recorded under maize-potato-gram sequence.

Pal et al. (1978) conducted field experiments to assess quantitatively the contribution of preceding crops, including legumes, on the fertilizer N economy of the following wheat and maize crops. They found that fodder legume cowpea grown in the monsoon benefitted the wheat crop to the equivalent of about 40 kg of fertilizer N/ha, whereas winter fodder crop of berseem benefitted maize to the extent of 75 kg N/ha. Nair et al. (1979) evaluated legume intercropping in conservation of fertilizer N in maize culture and found that at 40 kg N/ha intercropping maize with soya bean gave 19.5 % more yield than taking it as a pure crop. When the option to use adequate fertilizer N did not exist, as was invariably the case with the average Indian farmer, intercropping maize with legumes such as soya bean, was the logical way out. All the intercropping treatments left sufficient residual fertility to significantly increase yield of a wheat crop given no fertilizer which followed maize crop.

A study on the fertilizer use in groundnut based cropping system under different agroclimatic conditions by Dwivedi (1981) revealed that groundnut economised N requirement of succeeding crops because it fixed 40-60 kg N/ha. According to Bhardwaj et al. (1981), who worked on economizing N by green manures in rice - wheat rotation, 74.5, 49.9 and 25.3 kg/ha N could be saved by green manuring with sannhemp, dhaincha and *Ipomoea* respectively. Ahlawat *et al.* (1981) observed that various winter grain legumes, such as chickpea, lentil, pea and *Lathyrus sativus* reduced the need for fertilizer N in succeeding maize to the extent of 18-68 kg/ha compared with cereal (wheat) or fallow.

Faroda and Singh (1983) studied that effect of preceding crops on the N need of succeeding wheat crop and showed that the grain yield of wheat was maximum when the crop was grown after black gram closely followed by green gram and cowpea, and that there was a significant increase in wheat yield with N application upto 80 kg N/ha. The optimum dose of N to wheat grown after black gram was 63.28 kg N/ha followed by green gram (71.12 kg N/ha), cowpea (77.44 kg N/ha), pigeonpea (81.12 kg N/ha), pearl millet fertilized with 60 kg N/ha (90.60 kg N/ha) and pearl millet fertilized with 90 kg N/ha (103.36 kg N/ha). Yadav and Singh (1985) observed that the yield of wheat crop was higher after *mung* bean and *urd* bean as compared to fallow. The yield obtained at 120 kg N after fallow could be obtained with the application of 90 kg N/ha when a preceding crop of *urd* bean was taken. It was reported by Nagre and Chandrasekhar (1985) that the effects of groundnut, black gram and green gram were equivalent to 40 kg N/ha and the effect of cowpea was equivalent to 80 kg N/ha, when the crops were grown as summer legumes followed by *kharif* sorghum.

Hargrove (1986) evaluated winter legumes as a N source for no-till grain sorghum and found that grain sorghum did not respond to fertilizer N when following a legume cover crop but responded to as much as 99 kg N/ha when following a non-legume cover crop or no cover crop. A mean estimate of 72 kg N/ha was obtained for the fertilizer N replaced by the legume. A trial to study the input requirements for rice based cropping patterns revealed that rice-rice-daincha recorded the maximum grain yield during the first crop season followed by rice-rice-cowpea and they were significantly superior to the other treatments. With regard to the fertilizer levels, even though the highest yield in rice was recorded when the recommended dose of fertilizers was applied, it was on par with the yield obtained by the application of 75 per cent of the recommended dose of fertilizer. (KAU, 1986 b) A study by Morris *et al.* (1986) demonstrated that a fast growing tropical legume could accumalate more than 80 kg N/ha in 45 days and that rice yield responses exceeding 2 t/ha were possible from green manure incorporation.

Thus a considerable saving of fertilizer N can be obtained by cultivating legumes prior to non-legumes. However, the amount saved varies with the type of legume cultivated.

2.5. PHYSICO-CHEMICAL CHANGES IN SOIL AFFECTED BY LEGUMES

The growing of berseem (*Trifolium alexandrinum*) in a rotation consisting of cycles of three *rabi* crops of berseem followed by three *rabi* crops of wheat, with cowpea being grown during the *kharif* (summer) season led to the building up of soil fertility, as shown by the increase of soil organic matter from 0.696 to 0.989 per cent over a 10 year experimental period (Acharya *et al*. 1953). Moore (1962) studied the influence of a legume on soil fertility under a grazed tropical pasture and reported that the inclusion of centro (*Centrosema pubescens*) in a giant stargrass (*Cynodon plectostachyus*) pasture resulted in significantly higher levels of organic matter, total N and nitrifiable N in the underlying soil.

A study by Kute and Mann (1968) to study the nature of the beneficial effects of green manuring with and without P on wheat revealed that the percentage of water stable aggregates in the soil was higher under green manure treatments. The influence of different green manure crops on soil structure and wheat yield was studied by Darra *et al*. (1968) and they observed that green manuring significantly increased water stable aggregates bigger than 0.25 mm diameter, decreased bulk density, and increased water holding capacity, total porosity and permeability. Sharma and Singh (1970) investigated the effect of growing winter legumes on certain properties of an alluvial soil of Northern India and found that legumes in general decreased the bulk density of the soil and increased the total water stable aggregates. They also left the soil high in organic C, total N and available P, and among the legumes, bersaem was most effective.

A long term experiment to study the effect of four rotations and application of farmyard manure and fertilizers on chemical and physical properties of soil showed that application of farmyard manure and use of green manure decreased the bulk density of the soil and increased the water stable aggregates (Havanagi and Mann, 1970). A study by Maurya and Ghosh (1972) revealed that farmyard manure and green manuring with phosphate resulted in the highest contents of organic matter and nitrogen in the soil, and green manuring increased the cation exchange capacity of the soil. The maintenance of soil fertility under intensive multiple cropping in northern India was studied by Nair et al. (1973) and they reported that the available N, P, K and organic matter content of the soil slightly improved after leguminous crops were grown. However, the changes in the parameters of soil fertility were temporary, and the soil reverted back to near initial position after the subsequent crops. Bairathi et al. (1974) observed that bulk density of the soil decreased while total porosity and water holding capacity of soil increased due to incorporation of legume residues.

A two year study conducted by Singh and Ashwathi (1978) on the maintenance of soil fertility in the hills with incorporation of legumes in cropping sequences showed that at the end of the period, the available N and K increased in tomato-green gram-wheat and green manure - wheat sequences respectively, and the available P decreased in the fallow - wheat rotation. The physico-chemical properties of the surface soil (0-15 cm) were, in general, favourably influenced in rotations involving legumes and were adversely affected in sequences including maize. Thind et al. (1979), studying the effect of crop rotations on soil fertility, observed that leguminous crops beneficially affected the water stable aggregates in the soil. Meelu and Rana (1981) reported that leguminous crops in rotation beneficially affected the aggregation and improved the physical condition of the soil.

Bin (1983), working on the utilization of green manure for raising soil fertility in China, reported that green manuring was effective in renewing humus and promoting microbial activity, and that it could increase the proportion of water stable aggregates larger than 0.25 mm, lower the bulk density and increase soil porosity and water retaining capacity. Studies on rice based multiple crop sequences by Deka and Singh (1984) revealed that organic C and total N content of the soil increased in all the rotations except in pure cereal (rice - wheat), maximum being in rice-berseem. There was continuous build up of P status of soil in all the rotations, maximum being in rice-berseem. After a 16 year study, Singh **et al.** (1985) found that the yield of pearl millet was 11% higher when the crop was grown in rotation with cluster bean than with pearl millet alone, and that the schedule improved the soil organic C by 12% and soil available P by 25%.

The above reports indicate that legumes significantly affect the physico-chemical properties of the soil. However, the changes in soil properties vary from location to location.

Materials & Methods

3. MATERIALS AND METHODS

The details of the materials used and the techniques adopted during the course of this investigation are presented in this chapter.

3.1. Experimental site

The experiment was conducted in the rice fields of the Agricultural Research Station, Mannuthy, Trichur district. The station is situated at 12° 32' N latitude and 74° 20' E longitude at an altitude of 22.25 m above MSL. This area enjoys a typical humid tropical climate.

3.2. Season and weather conditions

The experiment was conducted during the third crop season (January-April) of 1985-'86 and first crop season (June-September) of 1986-'87. The details of the meteorological data recorded at the District Agricultural Farm, Mannuthy during the crop periods are presented in Table 1 and Fig.1.

3.3. Soil characteristics

Composite soil samples from 0-15 cm depth were drawn before the commencement of the experiment, and were used for

Table-1. Meteorological data for the experimental period (third crop season of 1985-'86 and first crop season of 1986-'87)

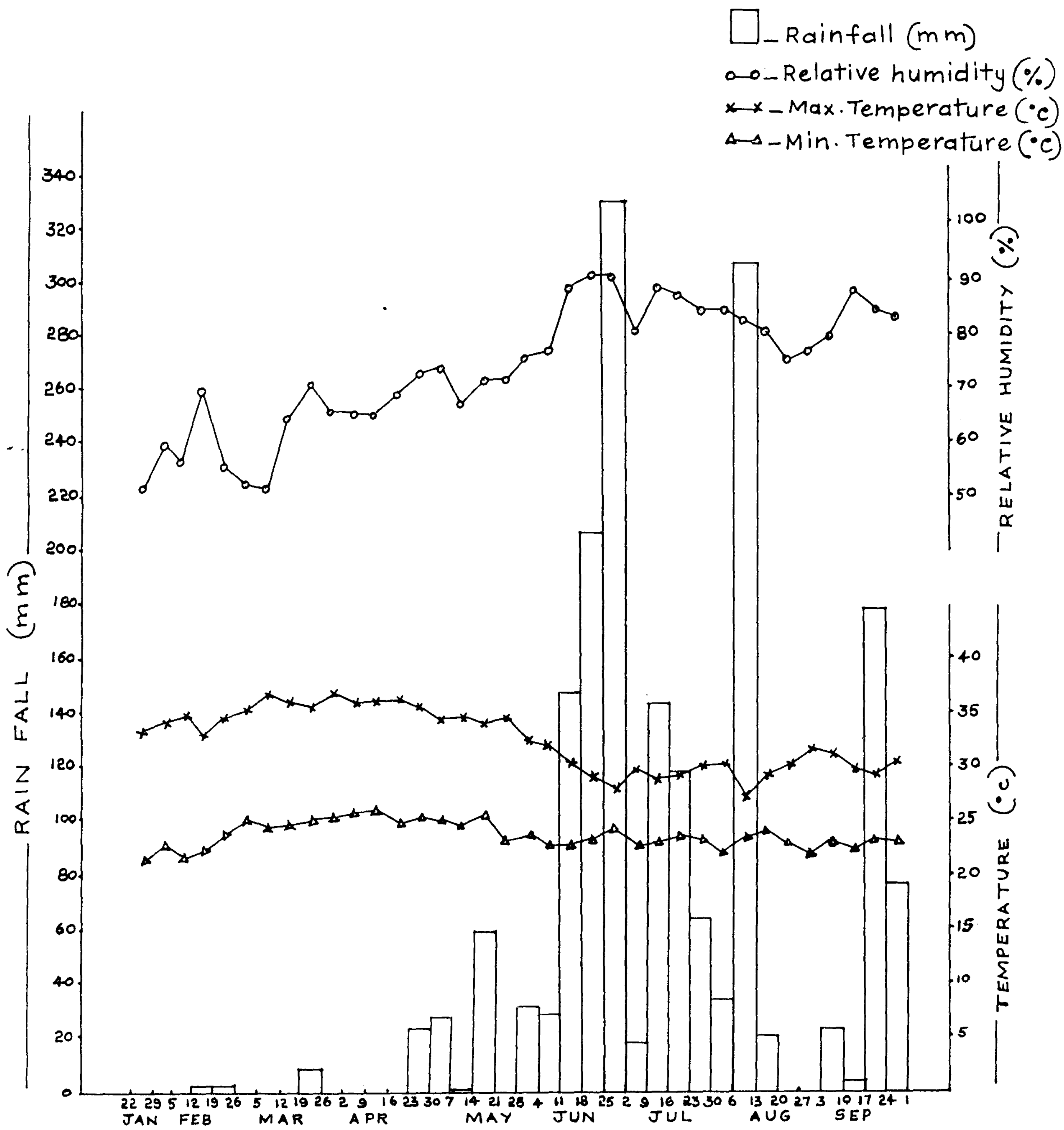
Standard week	Period	Total rainfall (mm)	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Relative humidity (%)
1	2	3	4	5	6
	January				
4	22-23	0	33.2	21.5	51
5	29-4th	0	33.9	22.8	59
	February				
6	5-11	0	34.6	21.8	56
7	12-18	1	32.9	22.3	69
8	19-25	1	34.7	23.4	55
9	26-4th	0	35.4	24.6	52
	March				
10	5-11	0	36.6	24.3	51
11	12-18	0	36.1	24.6	64
12	19-25	8	35.7	24.9	70
13	26-1st	0	36.5	25.4	65
	April				
14	2-8	0	35.8	25.6	65
15	9-15	0	36.1	25.7	65
16	16-22	0	36.1	24.6	68
17	23-29	23	35.4	25.0	72
18	30-6th	27	34.5	25.0	73
	May				
19	7-13	1	34.5	24.6	67
20	14-20	59	33.9	25.3	71

Contd.

Table-1. Continued

1	2	3	4	5	6
21	21-27	0	34.5	23.3	71
22	28-3rd	31	32.4	23.4	75
	June				
23	4-10	28	31.9	22.8	76
24	11-17	147	30.2	22.8	88
25	18-24	206	28.9	22.9	90
26	25-1st	328	27.6	24.0	90
	July				
27	2-8	18	29.7	22.7	80
28	9-15	143	28.8	22.8	88
29	16-22	118	29.2	23.3	87
30	23-29	64	30.0	23.0	84
31	30-5th	34	30.0	21.9	92
	August				
32	6-12	305	27.2	23.3	82
33	13-19	20	29.3	23.6	80
34	20-26	0	30.0	23.0	75
35	27-2nd	0	31.5	22.0	76
	September				
36	3-9	23	30.9	23.0	79
37	10-16	3	29.6	22.5	87
38	17-23	179	29.3	23.2	84
39	24-30	77	30.3	23.1	83

FIG. 1 METEOROLOGICAL OBSERVATIONS DURING EXPERIMENTAL PERIOD



the determination of physico-chemical properties. The data are given in Tables 2.1., 2.2. and 2.3.

Table-2. Physical and chemical properties of the soil

2.1. Mechanical composition of the soil

Fraction	Per cent composition	Procedure adopted
Coarse sand	26.3	Robinson's international Pipette method (Piper, 1942)
Fine sand	23.9	
Silt	22.6	
Clay	27.0	
Textural class	Sandy clay loam	I.S.S.S.System

2.2. Physical constants of the soil

Constant	Value	Procedure adopted
Bulk density, g/cm^3	1.53	Core method (Piper, 1942)
Particle density, g/cm^3	2.22	

2.3. Chemical composition of the soil

Description of property	Value
Organic carbon (%)	0.663
Total N (%)	0.135
Total P (%)	0.077
Total K (%)	0.255
Available N (kg/ha)	1881.6
Available P (kg/ha)	31.17
Available K (kg/ha)	170.67
pH	5.48

3.4. Cropping history

The experimental site was a double cropped wetland. The land was usually left fallow during the third crop season.

3.5. Experimental technique

3.5.1. Treatments

There were seven main plot treatments during the summer rice fallow season. These treatments were further divided into two sub-plots each during the first crop season (Fig.2). The main plot treatments included six fodder legumes, namely, sannhemp, soya bean, rice bean, velvet bean,

FIG. 2 PLAN OF LAYOUT

N ↑

Replication I		Replication II		Replication III	
$L_1 N_1$	$L_1 N_2$	$L_4 N_1$	$L_4 N_2$	$L_6 N_1$	$L_6 N_2$
$L_3 N_1$	$L_3 N_2$	$L_6 N_1$	$L_6 N_2$	$L_2 N_1$	$L_2 N_2$
$L_4 N_1$	$L_4 N_2$	$L_5 N_1$	$L_5 N_2$	$F N_1$	$F N_2$
$L_2 N_1$	$L_2 N_2$	$F N_1$	$F N_2$	$L_5 N_1$	$L_5 N_2$
$L_5 N_1$	$L_5 N_2$	$L_3 N_1$	$L_3 N_2$	$L_1 N_1$	$L_1 N_2$
$F N_1$	$F N_2$	$L_1 N_1$	$L_1 N_2$	$L_3 N_1$	$L_3 N_2$
$L_6 N_1$	$L_6 N_2$	$L_2 N_1$	$L_2 N_2$	$L_4 N_1$	$L_4 N_2$

MAIN PLOT TREATMENTS

L_1 – Sannhemp
L_2 – Soya bean
L_3 – Rice bean
L_4 – Velvet bean
L_5 – Cowpea
L_6 – Black gram
F – Fallow

SUB PLOT TREATMENTS

N_1 – 75 % N (52.5 Kg/ha)
N_2 – 100% N (70 Kg/ha)

TREATMENTS	14
REPLICATIONS	3
DESIGN	SPLIT PLOT IN RBD
NET PLOT SIZE	7.5 X 4 SQ.M

cowpea, black gram, (Refer Plates 1 to 6) and fallow, in three replications. The details of the treatments are given below.

<u>Main plot treatments</u> (Third crop season) | <u>Notation</u>

a. Sannhemp	L_1
b. Soya bean	L_2
c. Rice bean	L_3
d. Velvet bean	L_4
e. Cowpea	L_5
f. Black gram	L_6
g. Fallow	F

Fertilizers were placed to the leguminous crops @ 25 kg N + 60 kg P_2O_5 per hectare one month after sowing as per the package of practices recommendations of the Kerala Agricultural University (KAU, 1986 a). N and P were applied in the form of urea and mussorie phos respectively.

<u>Sub-plot treatments</u>

<u>N level</u> (kg/ha)	<u>Notation</u>
52.5	N_1
70	N_2

3.5.2. <u>Details of the experiment</u>

a) Third crop season, 1985-86 : Fodder legumes (January-April)

Design	:	Randomized block
No. of treatments	:	Seven
No. of replications	:	Three
No. of plots	:	21

b) First crop season, 1986-87 : Rice
(June-September)

Design	:	Split plot
No. of main plot treatments	:	Six
No. of sub-plot treatments	:	Two
No. of replications	:	Three
Total No. of plots	:	42

3.5.3. <u>Size of the plots</u>

Season	Row spacing (cm)	Gross area (Sq.m)	Net area (Sq.m)
Third crop - Fodder legumes	Broadcast	16.2 x 4.6	15 x 4
First crop - rice	15 x 10	8.1 x 4.6	7.5 x 4

3.5.4. <u>Crops and seed rate</u>

<u>Crops</u>	<u>Seed rate</u> (kg/ha)
I. Fodder legumes	
Sannhemp	100
Soya bean	100
Rice bean	30
Velvet bean	40

Cowpea	40
Black gram	40
II. Rice, variety Jyothi	85

3.6. Details of the cultural operations

3.6.1. For fodder legumes

The land was ploughed twice, first by tractor and then by power tiller, and levelled. Seeds were dibbled 2-4 cm deep in random rows, on 23rd January, 1986. A week after sowing, gap filling was done wherever necessary to maintain uniform plant population.

A uniform dose of 25 kg N and 60 kg P_2O_5 per hectare was applied in all the plots one month after sowing. The fertilizers were placed in between the rows. Hand weeding of all the plots was done prior to fertilizer application. A prophylactic spraying with 2% Ekalux was given 35 days after sowing. The plots were irrigated copiously immediately after sowing, and later, life saving irrigations were given when essential.

All the fodder legumes were harvested thrice, on 4-3-1986, 26-3-1986 and 25-4-1986. The yields were recorded in terms of fresh weight (kg/ha).

Plate 1. Sannhemp

Plate 2. Soya bean

Plate 3. Rice bean

Plate 4. Velvet bean

Plate 5. Cowpea

Plate 6. Black gram

3.6.2. For transplanted rice

The cultivation practices recommended for short duration transplanted rice were followed (KAU, 1986 a).

With the onset of the south west monsoon, individual plots were separately ploughed using a power tiller. Nitrogen doses were given as per the treatments, and P_2O_5 and K_2O were given at 35 kg/ha each. Application of fertilizers was done as per the package of practices recommendations.

Paddy seeds were sown in the nursery at a seed rate of 85 kg/ha on 30th May, 1986. One month old seedlings were transplanted with two or three seedlings per hill at a spacing of 15 x 10 cm.

Controlled irrigation was done when necessary. The plots were hand weeded 25 days after transplanting. Prophylactic sprays with 0.05% Dimecron, 0.2% Hinosan and 0.1% Metacid were given 30, 60 and 70 days after transplanting respectively.

The crop was harvested on 26th September, 1986.

3.7. Observations recorded

3.7.1. Crop growth characters and yield components

3.7.1.1. <u>Fodder legumes</u>

a) <u>Height of plants</u>

From each plot, 10 plants were selected randomly and the height was measured in cm from ground level to the tip of the shoot just before each cut, ie., at 40, 62 and 92 days after sowing. The average height per plant was worked out.

b) <u>No. of leaves</u>

Ten plants were selected at random from each plot just before each cut, and the number of leaves were counted. The average number of leaves per plant was worked out.

c) <u>Nodule count</u>

Just before each cut, 10 plants were selected randomly from each plot, pulled out carefully and the total number of nodules was counted and their average worked out.

d) <u>Leaf - stem ratio</u>

Leaf-stem ratio was determined for 10 plants per plot selected randomly prior to each cut. The plants were cut at the base, their leaves and stems carefully separated and weighed, and the leaf-stem ratio calculated. The ratio was calculated both for the fresh weight of samples and for their oven - dry weights.

e) Yield

At each harvest, the fresh weight of the fodder legumes was recorded in kg/plot and expressed as t/ha.

3.7.1.2. Transplanted rice

a) Height of plants

The plant height in cm was recorded at the 30th and 60th days after transplanting and at harvest. Heights of plants were measured from the bottom of the culm to the tip of the longest leaf or tip of the earhead whichever was tallest. The average height per plant was worked out.

b) Number of tillers

The number of tillers per sq.m was counted on the above dates and the value per plant was computed.

c) Number of productive tillers

The number of productive tillers from each sampling unit was counted and the value per plant was calculated.

d) Length of panicle

The length in cm from the neck to the tip of the panicles of 10 panicles selected randomly from each plot was measured, and the average length per panicle was worked out.

e) <u>No. of grains per panicle</u>

Grains from 10 randomly selected panicles from each plot were used for counting and the average number of grains per panicle was calculated.

f) <u>Percentage of filled grain</u>

From the above grains, the number of filled grains was counted and the percentage of filled grain was calculated. The average value per panicle was also computed.

g) <u>Thousand grain weight</u>

One thousand grains were counted from the cleaned produce from each plot, weighed and recorded.

h) <u>Grain yield</u>

The total produce of grain from each net plot was cleaned, dried, winnowed, weighed and expressed as kg/ha.

i) <u>Straw yield</u>

The weight of sun dried straw was recorded plot-wise and the yield of straw in kg per ha was computed.

j) Grain-straw ratio

From the grain and straw yields of each plot, the grain-straw ratio was calculated.

k) Dry matter production

Plants from five hills selected at random from each plot were cut at the base and removed at three stages, viz., at panicle initiation, at 50% flowering and at harvest. The leaf blades, stems and panicles of the plants were separated and dried in the oven. From the oven-dry weights of these samples, the total dry matter production in kg/ha at the above three stages was worked out.

3.8. Physical constants of soil

a) Bulk density

The conventional core method (Piper, 1942) was used for determining the bulk density of the soil of each plot both prior to as well as after the fodder legume crops.

b) Percentage aggregate stability

The unsieved composite soil samples were used for the determination of the percentage of water stable aggregates prior to the sowing of fodder legumes as well as after their harvest. The Yoder's sieving apparatus was utilised for this (Yoder, 1937).

3.9. Chemical analysis

3.9.1. Chemical analysis of soil

Composite soil samples were taken from each plot prior to the sowing of fodder legumes as well as after the harvest of the crops. Samples were taken at two depths, viz., 0-15 cm and 15-30 cm. The soil samples were then air dried, powdered and passed through a 2 mm sieve.

a) Organic carbon

Walkley and Black method (Jackson, 1958) was used for the determination of total organic carbon content of soil.

b) Total nitrogen

The semi micro-Kjeldahl method (Jackson, 1958) was adopted for the determination of total N content of soil.

c) Total phosphorus

The total phosphorus content of soil was determined by the vanadophosphoric yellow colour method using the perchloric-nitric acid (1:2) extracts (Hesse, 1971 and Jackson, 1958).

d) Total potassium

The total potassium content of the soil was determined in the flame photometer using the perchloric-nitric acid (1:2) extracts (Hesse, 1971 and Jackson, 1958).

e) Available nitrogen

The alkaline permanganate method was used for determining the available nitrogen content of soil (Subbiah and Asija, 1956).

f) Available phosphorus

Available phosphorus content of the soil was determined using Bray I extractant and molybdophosphoric acid method in hydrochloric acid system (Jackson, 1958).

g) Available potassium

The available potassium content of soil was determined flame photometrically, using the neutral normal ammonium acetate extract (Jackson, 1958).

h) pH

The pH of the soil was determined in a 1:2.5 soil - water suspension using a pH meter.

i) Cation exchange capacity of soil

It was determined using 1 N neutral ammonium acetate to displace the cations. The ammonium ions were then displaced by I N KCl. The ammonium in the leachate was then distilled using a micro Kjeldahl apparatus (Jackson, 1958).

3.9.2. Plant analysis

The plant samples dried in an oven at 70°C were ground into fine powder and the diacid extracts were used for the chemical analyses.

3.9.2.1. Fodder legumes

Composite samples of fodder legumes taken just before each cut were analysed.

a) Nitrogen

Total N content was estimated by the micro Kjeldahl method (Jackson, 1958) and expressed as percentage.

b) Phosphorus

The P content was estimated colorimetrically by the vanadomolybdate method (Jackson, 1958) and expressed as percentage.

c) Potassium

The K content was determined in a flame photometer (Jackson, 1958) and expressed as percentage.

3.9.2.2. Rice

Analyses of plant samples of rice were carried out separately for leaf, stem and panicle. The determination of N, P and K contents of rice was carried out as mentioned earlier under section 3.9.2.1.

3.10. Uptake of nutrients

The total uptake of N, P and K was worked out from the nutrient content and dry matter production and expressed as kg/ha for leaf blades, stems and panicles.

3.11. Statistical analysis

Data relating to each character were analysed statistically on an electronic computer. The 'F' test was carried out by analysis of variance technique (Panse and Sukhatme, 1978). Significant results were compared after finding out the critical differences.

3.12. Economics

Costs of production of fodder legumes and that of *kharif* rice were calculated on the basis of rates obtained from the store of the Agricultural Research Station, Mannuthy. The net return per hectare and the net return per rupee invested (Johl and Kapur, 1981) were also calculated.

Results and Discussion

4. RESULTS AND DISCUSSION

The results of the experiment conducted to study the potential of fodder legumes in rice fallows are presented and discussed in this chapter under the following heads.

4.1. Performance of fodder legumes

4.1.1. Growth characters of fodder legumes

4.1.2. Number of nodules

4.1.3. Leaf-stem ratio

4.1.4. Nutrient content

4.1.5. Fodder yield (fresh weight)

4.2. Soil physical properties

4.3. Soil chemical properties

4.4. Performance of rice succeeding legumes - Growth characters of rice.

4.5. Nutrient content and uptake

4.6. Yield and yield attributes

4.7. Economics of different cropping systems

4.1. Performance of fodder legumes

4.1.1. Growth characters of fodder legumes

The data on the mean height of plants of the legume crops just before each harvest (at 40, 62 and 92 days after sowing) are presented in Table 3. Significant variation was noticed among the different legume crops with respect to the height at all the three stages. Sannhemp recorded the maximum height during the different stages (81.33, 84.37 and 77.53 cm, respectively) followed by velvet bean (34.67, 44.8 and 53.4 cm, respectively). Comparing between the different stages, all the legume crops were tallest at the time of the second harvest (ie., 62 days after sowing), except soya bean, which showed a decrease in height. Velvet bean was tallest just before the final harvest (ie., 92 days after sowing). At the time of the third harvest, all the legume crops (except velvet bean) recorded the minimum height, the rate of increase in height not being as proportionally high as expected.

The mean number of leaves per plant also showed significant variation, (Table 3). Sannhemp and velvet bean had more number of leaves than the other four legume crops which were on par. At all the three stages, sannhemp recorded the highest mean number of leaves per plant (24, 30.97 and 57.9), followed by velvet bean (22.33, 29.33 and 46.17). The mean number of leaves per plant increased with age, maximum number being recorded at the time of the third harvest. It can be attributed to the increased number of secondary branches which emerged during the first two cuts.

Table 3. Mean height, number of leaves and number of nodules of fodder legumes in rice fallows

Treatment	Mean height/plant (cm)			No. of leaves/plant			No. of nodules/plant		
	I harvest	II harvest	III harvest	I harvest	II harvest	III harvest	I harvest	II harvest	III harvest
Sunnhemp (L_1)	81.33	84.37	77.53	24.00	30.97	57.90	4.73	2.80	1.90
Soya bean (L_2)	30.67	28.77	22.87	8.67	13.57	13.67	2.33	3.07	1.80
Rice bean (L_3)	24.67	33.63	30.53	9.00	16.13	19.27	4.07	3.23	3.37
Velvet bean (L_4)	34.67	44.80	53.40	22.33	29.33	46.17	30.00	21.33	12.33
Cowpea (L_5)	30.67	33.33	29.07	11.00	11.83	15.87	9.67	4.80	7.70
Black gram (L_6)	27.00	30.50	19.70	9.67	10.77	13.77	5.40	4.70	1.73
C.D. at 5% level	7.85	7.07	9.18	3.41	9.93	25.19	9.49	2.75	9.22
S.Em $\pm$	2.49	2.24	2.91	1.08	3.15	7.99	3.01	0.87	2.93

4.1.2. Number of nodules

The data on the mean number of nodules on the legume crops at three harvests are presented in Table 3. It is seen from the table that significant variation occurred between velvet bean and other legumes during the first two harvests, with velvet bean recording the highest number of nodules per plant compared to the other legumes. At all the three stages, velvet bean recorded the highest number of nodules per plant.

Comparing between the different stages, sannhemp had maximum number of nodules just before the final harvest (92 days after sowing), while all the other crops recorded the highest number of nodules at the first harvest (40 days after sowing). This may be because legume crops had not been grown previously in the plots, and the soil lacked a natural build up of Rhizobium. However, velvet bean had a fairly high number of nodules. It is presumed that the root exudates of velvet bean might have favoured the microbial build up in the rhizosphere.

4.1.3. Leaf-stem ratio

The legume crops differed significantly in their leaf-stem ratio (dry weight). However, there was no general trend (Table 4). The lowest leaf-stem ratio was observed just before the third harvest. This was noticed in spite of the

Table 4. Leaf-stem ratio (dry wt.) of fodder legumes in rice fallows

Treatment		At first harvest	At second harvest	At third harvest
Sannhemp	(L_1)	1.03	0.62	0.18
Soya bean	(L_2)	2.94	2.88	0.81
Rice bean	(L_3)	4.52	3.65	0.60
Velvet bean	(L_4)	2.98	2.68	2.29
Cowpea	(L_5)	3.47	2.23	0.38
Black gram	(L_6)	4.08	2.77	0.64
C.D. at 5% level		0.585	0.871	1.049
S.Em ±		0.19	0.28	0.33

observation that most of the legume crops recorded lowest height before the third harvest, and all of them produced the highest number of leaves at the third harvest. The probable reason attributed for the low leaf-stem ratio just before the third harvest may be the higher number of secondary branches produced and the smaller sized leaves.

4.1.4. Nutrient content

There was no significant variation in the N content of the different legume crops. The highest N content was noted at the first harvest, and the lowest at the third harvest (Table 5). This may be explained by the mean number of nodules per plant, which was highest just before the first harvest. Though the N content did not vary significantly between the different legumes, the highest content was seen in velvet bean (3.56%). This can be attributed to the higher number of nodules produced in velvet bean as was seen from Table 3.

The P content of the different legumes also did not vary significantly (Table 5). The highest P content was seen at the time of the first harvest in all the legumesexcept black gram. The probable reason may be due to the decreased growth and nutrient uptake from the soil after the first harvest. In black gram, the content was highest at the second

Table 5. Nutrient content of fodder legumes in rice fallows

Treatment	Nitrogen content (%)			Phosphorus content (%)			Potassium content (%)		
	At first harvest	At second harvest	At third harvest	At first harvest	At second harvest	At third harvest	At first harvest	At second harvest	At third harvest
Sannhemp (L_1)	3.22	2.42	1.23	0.81	0.28	0.10	2.20	2.40	1.90
Soya bean (L_2)	2.89	2.66	1.00	0.73	0.57	0.17	1.89	1.97	0.90
Rice bean (L_3)	3.28	2.66	1.20	0.82	0.60	0.24	2.92	2.75	1.48
Velvet bean (L_4)	3.56	3.21	1.32	0.79	0.58	0.15	1.63	1.89	1.60
Cowpea (L_5)	3.30	2.69	1.23	1.02	0.76	0.39	2.04	3.40	1.58
Black gram (L_6)	3.36	2.75	1.29	0.74	0.81	0.25	2.45	2.93	1.35
C.D. at 5% level	NS	NS	NS	NS	NS	NS	NS	0.51	NS
S.Em ±	0.16	0.16	0.07	0.07	0.15	0.08	0.38	0.16	0.38

harvest.

At the second harvest, the K content of the different legumes was found to vary significantly with cowpea having the highest content (3.4%) and velvet bean the lowest (1.89%) (Table 5). At the other two stages there was no significant difference in the K content. In all the legume crops except rice bean, the highest K content was observed at the second harvest. Rice bean had the highest K content at the first harvest. During the final harvest, the K content of all the legumes was minimum, probably due to the reduced growth and nutrient uptake.

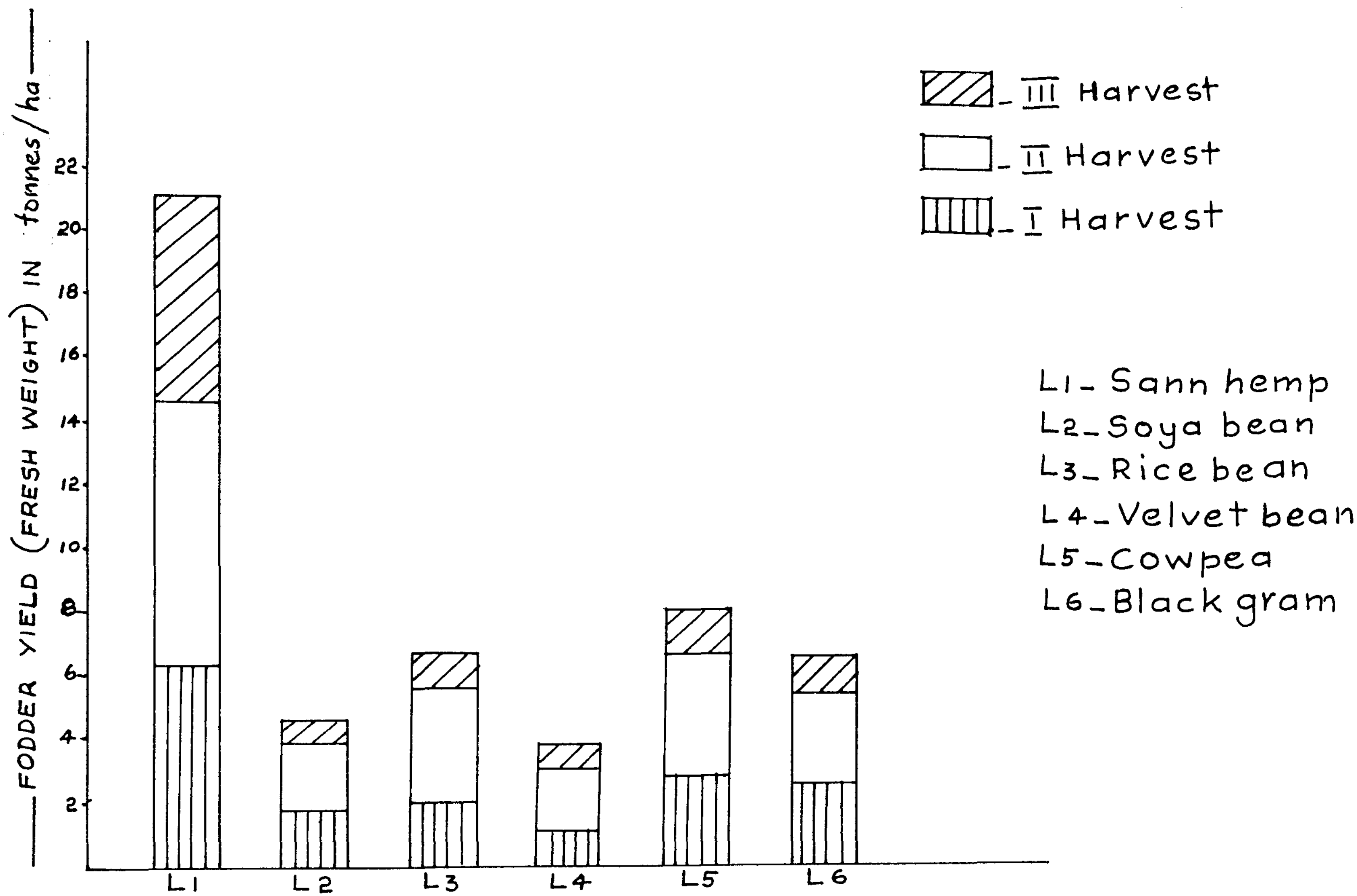
4.1.5. Fresh weight of fodder

The fresh weight of fodder at all three harvests was found to vary significantly. The data are presented in Table 6 and Fig. 3. It can be seen from the figure that the highest yield was recorded by sannhemp (6.35, 8.35 and 6.3 t/ha respectively) followed by cowpea (2.76, 3.86 and 1.35 t/ha respectively). Sannhemp was found to be significantly superior to all other legume crops. The superlative performance of sannhemp is in accordance with the findings of Shelton (1980) who reported that sannhemp produced the best fodder yield of 1950 kg/ha compared to other dry season forage legumes when grown on stored moisture following harvest of paddy rice crop.

Table 6. Fodder yield of legumes in rice fallows

Treatment		Average fodder yield (fresh wt., t/ha)			
		I harvest	II harvest	III harvest	Total
Sannhemp	(L_1)	6.35	8.35	6.30	21.00
Soya bean	(L_2)	1.79	2.06	0.72	4.57
Rice bean	(L_3)	1.85	3.61	1.10	6.56
Velvet bean	(L_4)	1.09	1.82	0.87	3.78
Cowpea	(L_5)	2.76	3.86	1.35	7.96
Black gram	(L_6)	2.57	2.82	0.85	6.24
C.D. at 5%		1.27	1.60	1.44	3.07
S.Em ±		0.40	0.51	0.46	0.98

FIG. 3 FODDER YIELD (FRESH WEIGHT IN tonnes / ha OF LEGUMES



The highest yields of all legume crops were obtained during the second harvest in the order: sannhemp (8.35 t/ha), cowpea (3.86 t/ha), rice bean (3.61 t/ha), black gram (2.82t/ha), soya bean (2.06 t/ha) and velvet bean (1.82 t/ha). All the legume crops recorded the lowest yield during the third harvest (ie. 3 months after sowing).

Except for sannhemp, all the legume crops produced a uniformly poor yield at the third harvest. The extremely dry conditions experienced by the crops after the second harvest, during the crop period and may be the main reason for this. Under these conditions, sannhemp performed relatively better (6.3 t/ha) at the final harvest as compared to the other legumes, proving its suitability to withstand moisture stress conditions.

4.2. Soil physical properties

4.2.1. Bulk density of soil

There was no significant change in the bulk density of the soil after the legumes (Table 7). However, it can be seen that the bulk density appears to have decreased in the legume cropped plots while the fallow plots recorded a slight increase in the bulk density. The lowest bulk density was seen in plots with rice bean (1.35 g/cm^3), followed by cowpea (1.36 g/cm^3), sannhemp (1.37 g/cm^3), black gram (1.38 g/cm^3),

Table 7. Bulk density and aggregate stability of soil as influenced by the preceding legume crops and fallows

Treatment		Bulk density of soil (g/cm^3)		Water stable aggregates (%)	
		Before legumes	After legumes	Before legumes	After legumes
Sannhemp	(L_1)	1.49	1.37	56.41	62.44
Soya bean	(L_2)		1.41	58.30	61.61
Rice bean	(L_3)		1.35	60.04	62.51
Velvet bean	(L_4)		1.40	57.72	63.77
Cowpea	(L_5)		1.36	56.74	63.85
Black gram	(L_6)		1.38	56.61	64.03
F			1.54	57.56	56.99
C.D. at 5%			0.18	NS	NS
S.Em ±			0.06	2.28	1.95

velvet bean (1.4 g/cm^3) and soya been (1.41 g/cm^3). The fallow plots recorded the highest mean bulk density of 1.54 g/cm^3.

Legumes in general were found to decrease the bulk density of the soil, and this is in conformity with the findings of Darra __et al__. (1968), Sharma and Singh (1970), and Havanagi and Mann (1970), who observed a reduction in bulk density following legumes. It was also reported by Bairathi __et al__. (1974) that different legume crop residues decreased the bulk density of the soil.

4.2.2. Aggregate stability

Data on the percentage aggregate stability of the soil are presented in Table 7. The data revealed that though there was no significant change in the proportion of water stable aggregates in the soil, it exhibited an increase in the legume cropped plots whereas a slight decrease was noticed in the fallow plots. The highest percentage of water stable aggregates was observed in the treatment with black gram (64.03), followed by cowpea (63.85), velvet bean (63.77), rice bean (62.51), sannhemp (62.44), soya bean (61.61) and fallow (56.99).

In general, in the present study, legume crops were found to increase the proportion of water stable aggregates in the soil. The beneficial effect of legumes on the aggregate stability of the soil has been reported by Sharma and Singh (1970).

A similar effect by green manuring has also been observed by Kute and Mann (1968), Darra <u>et al</u>. (1968), Havanagi and Mann (1970) and Bin (1983). However, the increase in the proporation of water stable aggregates in the soil after the legume crops is relatively small and this can be explained by the short term nature of the experiment. A more significant increase in the aggregate stability could be achieved by a longer period of legume cropping and a greater incorporation of legume residues into the soil.

4.3. Soil chemical properties

4.3.1. Organic Carbon

After the legume crops, there was an increase in the organic carbon content of the soil, and the increase was higher in the top 0-15 cm layer than in the lower 15-30 cm layer in all cases (Table 8). From Fig. 4, it can be seen that in the top 0-15 cm layer, the highest content of organic carbon was recorded with cowpea (1.38%), followed by black gram (1.37%), rice bean (1.29%), velvet bean (1.14%) and sannhemp (1.05%). The fallow plots had the minimum organic carbon content (0.48%). The organic carbon content in the lower 15 cm of soil also increased after the legumes, with the highest content seen after cowpea (0.88%) and the least in sannhemp (0.69%).

Table 8. Organic carbon and available N in the top 0-15 and 15-30 cm of soil as influenced by the preceding legume crops and fallows

Treatments		Organic carbon (%)				Available N (kg/ha)			
		0-15 cm		15-30 cm		0-15 cm		15-30 cm	
		Before legume	After legume	Before legume	After legume	Before legume	After legume	Before legume	After legume
Sannhemp	(L_1)	0.52	1.05	0.66	0.69	2016	3136	2016	2912
Soya bean	(L_2)	0.72	0.89	0.83	0.72	2016	3136	1792	2464
Rice bean	(L_3)	0.44	1.29	0.81	0.88	2240	2912	1792	2464
Velvet bean	(L_4)	0.51	1.14	0.84	0.78	2240	3808	2016	3584
Cowpea	(L_5)	0.61	1.38	0.88	0.80	1568	2912	1568	2688
Black gram	(L_6)	0.60	1.37	0.66	0.77	2016	2912	1792	2240
Fallow	(F)	0.55	0.48	0.66	0.42	2016	2240	1568	2016
C.D. at 5% level		0.19	0.34	0.19	0.34	403.20	NS	403.20	NS
S.Em ±		0.06	0.12	0.06	0.12	0.01	0.02	0.01	0.02

FIG. 4 ORGANIC CARBON CONTENT (%) IN TWO DEPTHS OF SOIL (0-15 cms and 15-30 cms) BEFORE AND AFTER FODDER LEGUMES AND FALLOW

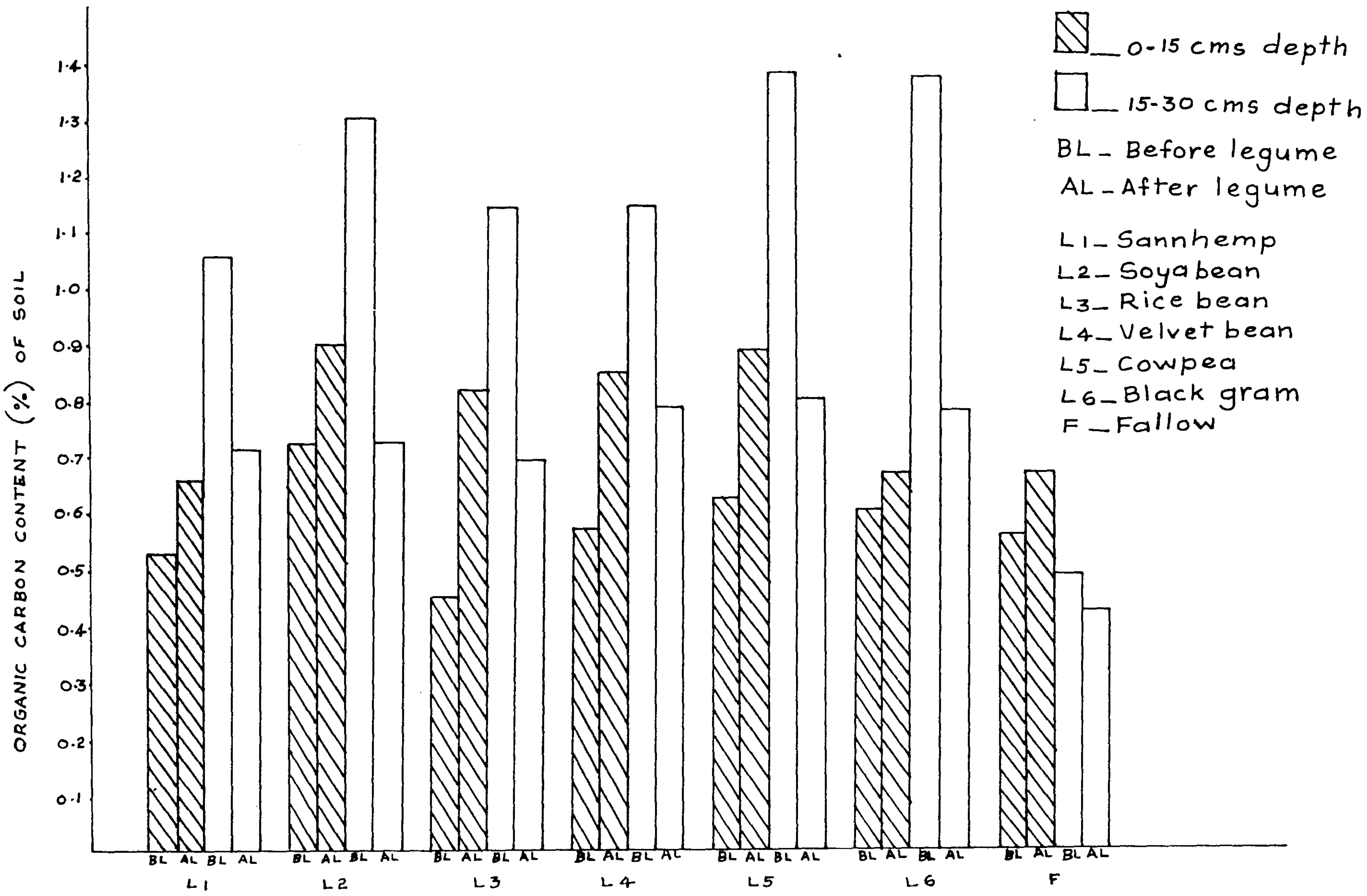


Table 9. Available P and available K in the top 0-15 and 15-30 cm of soil as influenced by the preceding legume crops and fallows

Treatment		Available P (kg/ha)				Available K (kg/ha)			
		0-15 cm		15-30 cm		0-15 cm		15-30 cm	
		Before legume	After legume	Before legume	After legume	Before legume	After legume	Before legume	After legume
Sannhemp	(L_1)	25.38	54.50	39.94	46.66	168.00	177.34	186.66	149.34
Soya bean	(L_2)	40.70	42.18	47.04	37.34	177.34	177.34	158.66	186.66
Rice bean	(L_3)	30.24	47.04	18.66	36.58	196.66	149.34	186.66	168.00
Velvet bean	(L_4)	32.48	50.78	31.74	36.96	186.66	177.34	158.66	196.00
Cowpea	(L_5)	32.46	54.14	30.24	46.30	224.00	121.34	196.00	158.66
Black gram	(L_6)	30.98	56.38	19.04	48.54	121.34	205.34	121.34	196.00
Fallow	(F)	24.64	25.02	32.86	25.02	168.00	186.66	149.34	168.00
C.D. at 5% level		NS	14.65	NS	14.65	NS	NS	NS	NS
S.Em ±		6.34	5.04	6.34	5.04	25.92	25.69	25.92	25.69

All the legume cropped plots have registered a higher soil organic carbon content in the top 15 cm layer of soil. This is in conformity with the findings of Sharma and Singh (1970), Bairathi et al. (1974), Balachandran (1982), Deka and Singh (1984) and Singh et al. (1985), who observed increased organic carbon content of the soil subsequent to growing legumes.

4.3.2. Total nitrogen

Data on total nitrogen content of the soil (Table 10) before and after the legume crops indicated that among the legume cropped plots, the highest content of total nitrogen was after cowpea (0.16%), followed by velvet bean (0.14%), rice bean and black gram (0.13%), soya bean (0.12%) and sannhemp (0.10%). The fallow plots registered no change in total nitrogen content.

The higher total nitrogen content in cowpea and velvet bean cropped plots indicate the ability of these crops for better nitrogen fixation. Though velvet been produced the highest number of nodules (Table 3), the increase in total nitrogen content of the soil was highest after cowpea, which may be explained by the greater plant population in the case of the latter. In general, the total nitrogen content of the soil was found to increase after legume cropping and this

Table 10. Total N, total P and total K in the top 0-15 cm soil layer as influenced by the preceding legume crops and fallows

		Total N (%)		Total P (%)		Total K (%)	
		Before legume	After legume	Before legume	After legume	Before legume	After legume
Sannhemp	(L_1)	0.14	0.24	0.08	0.09	0.26	0.26
Soya bean	(L_2)	0.15	0.27	0.08	0.09	0.26	0.26
Rice bean	(L_3)	0.13	0.26	0.08	0.09	0.25	0.25
Velvet bean	(L_4)	0.14	0.28	0.07	0.08	0.25	0.25
Cowpea	(L_5)	0.12	0.28	0.07	0.08	0.25	0.26
Black gram	(L_6)	0.13	0.26	0.07	0.08	0.26	0.26
Fallow	(F)	0.12	0.13	0.08	0.08	0.25	0.25
C.D. at 5% level		NS	0.057	NS	NS	NS	NS
S.Em ±		0.01	0.02	0.01	0.01	0.01	0.01

observation is supported by the findings of Moore (1962), Kute and Mann (1968), Sharma and Singh (1970), Bairathi *et al.* (1974) and Singh and Sandhu (1980) who reported that legumes left the soil richer in total nitrogen.

4.3.3. Total phosphorus

Analysis of the soil for total phosphorus before and after the legume crops indicated that there was no significant change due to legume cropping, and that there was no significant difference between treatments (Table 10). This observation that legumes do not bring about any major difference in the total phosphorus content of the soil is supported by Maurya and Ghosh (1972) and Sadanandan and Mahapatra (1973).

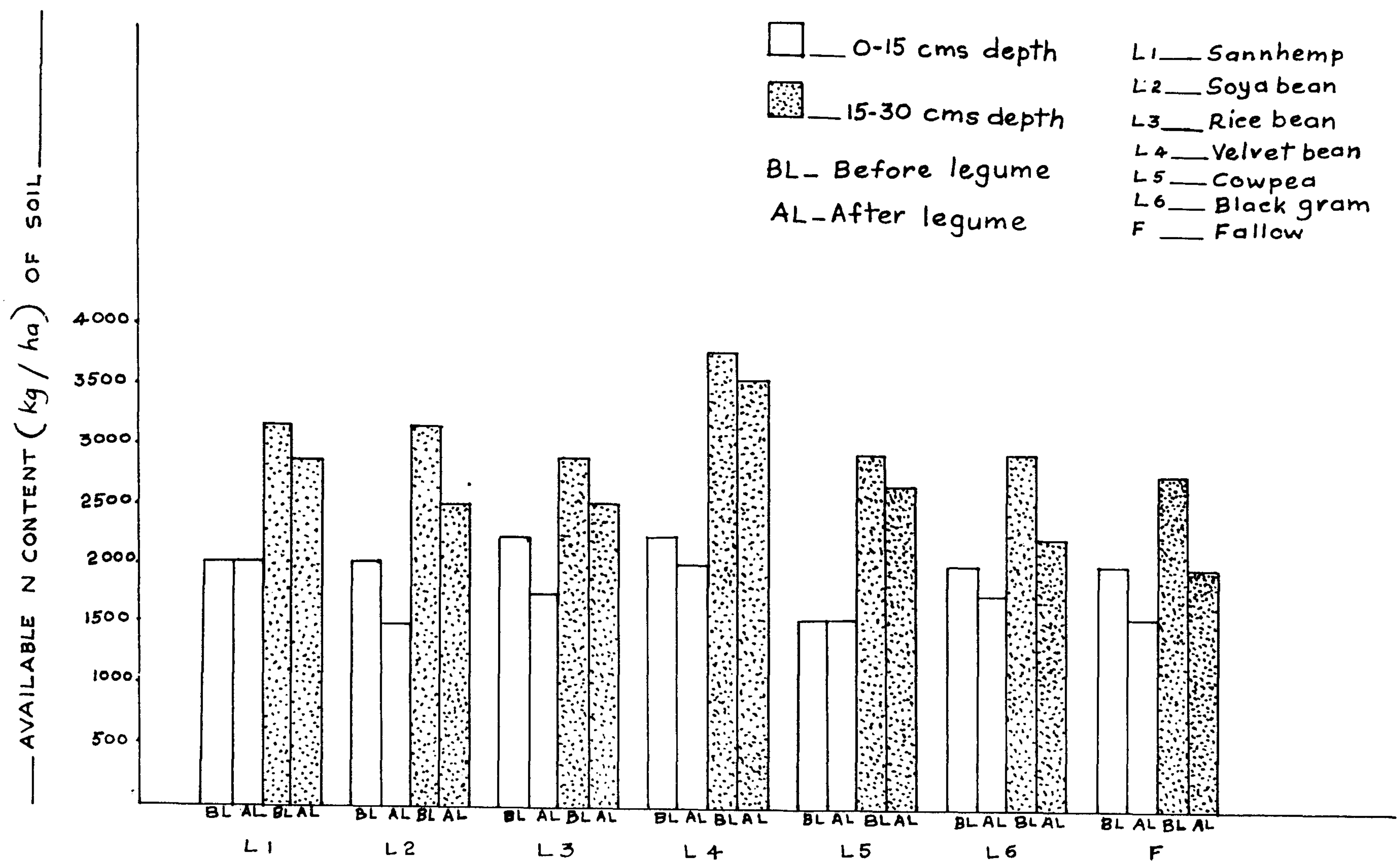
4.3.4. Total potassium

As in the case of total phosphorus, the total potassium content of the soil was not subjected to any major change by the cultivation of legumes (Table 10), and this observation is in conformity with the findings of Maurya and Ghosh (1972).

4.3.5. Available nitrogen

Data on the available nitrogen content of the soil (Table 8 and Fig.5) in two depths of soil (0-15 cm and 15-30 cm) determined before and after the legumes, and also between

FIG. 5 AVAILABLE NITROGEN CONTENT (kg/ha) IN TWO DEPTHS OF SOIL (0-15 cm and 15-30 cm) BEFORE AND AFTER LEGUMES AND FALLOW



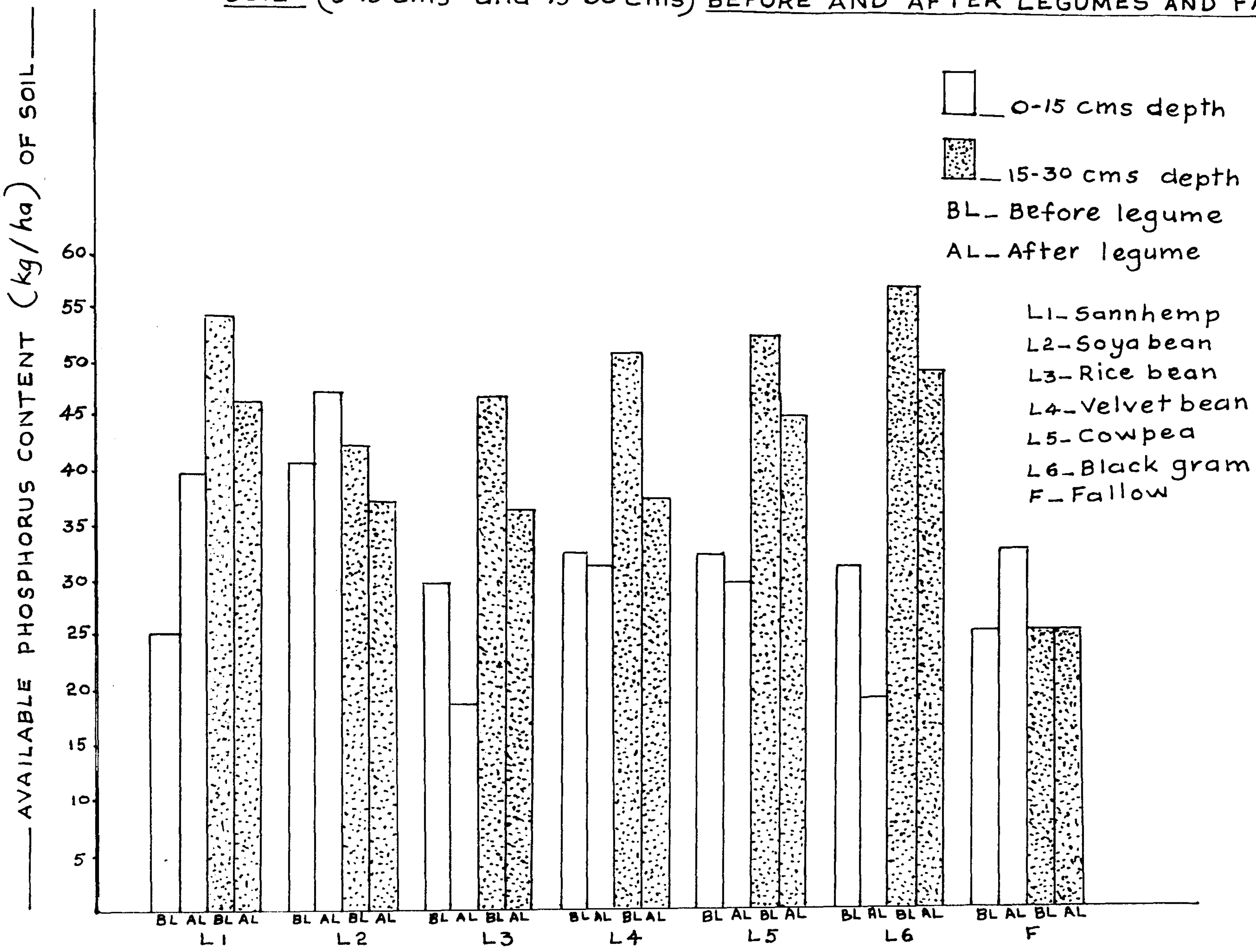
treatments did not differ significantly. However, a slight increase in the available nitrogen content of the soil is noted in all the treatments, the highest being in velvet bean plots (3808 and 3584 kg/ha), followed by cowpea plots (2912 and 2688 kg/ha). The lowest value was seen in the fallow plots (2240 and 2016 kg/ha).

The velvet bean cropped plots recorded the highest available nitrogen content and this can be explained by the higher number of root nodules (Table 3) and the fixation of a larger amount of nitrogen in the available form. The higher available nitrogen content after cowpea in also to be expected as the total nitrogen content was highest after cowpea. In general, in all the legume cropped plots, an increase in the available nitrogen content was noticed. A similar finding was reported by Nair et al. (1973), Singh and Ashwathi (1978) and Dhillon and Dev (1979).

4.3.6. Available phosphorus

A significant difference in the available phosphorus content of the soil was noticed after the legume crops, but a specific trend could not be seen. In the top 15 cm layer of soil, the greatest increase in available phosphorus content was noticed after sannhemp followed by black gram (Table 9 and Fig. 6), while in the 15-30 cm layer of soil, the greatest

FIG. 6 AVAILABLE PHOSPHORUS CONTENT (kg/ha) IN TWO DEPTHS OF SOIL (0-15 cms and 15-30 cms) BEFORE AND AFTER LEGUMES AND FALLOW



increase in available P content was seen after black gram followed by rice bean. In the fallow plots, the top layer of soil recorded a very slight increase in the available P content while the lower layer recorded a decrease.

Except for the lower soil layer (15-30 cm) in the soya bean cropped plot, all other legume cropped plots recorded an increase in the available P content of soil. The increased available P content in the soil of the black gram cropped plots may be due to its deeper root system, which enabled the plants to extract more P from deeper layers. An improvement in the available P status of the soil following legumes was reported by Kute and Mann (1968), Sharma and Singh (1970), Nair *et al.*(1973), Bairathi *et al.* (1974) and Deka and Singh (1984).

4.3.7. Available potassium

As in the case of available P, the available K content of the soil changed significantly after the legume crops, but no general trend of variation could be noticed (Table 9). In most cases, there was a reduction in the available K status of the soil, with the greatest reduction being after cowpea (102.66 and 37.34 kg/ha). An increase in the available K content was noticed after black gram (84.00 and 74.66 kg/ha), and in the fallow plots (18.66 and 18.66 kg/ha).

From the present study, no conclusive result coult be drawn on the available K status of the soil after the legume crops. Varying trends in the available K status of soil after legume cropsare seen reported. Nair *et al*. (1973), Singh and Ashwathi (1978) and Baldock *et al*. (1980) reported an increase in the available K content of the soil after legumes, while Singh *et al*. (1977) and Deka and Singh (1984) observed a decrease in the available K content of the soil after legumes.

4.3.8. Cation exchange capacity (C.E.C.)

There was no significant change in the C.E.C. of the soil after the legume crops (Table 11). However, the black gram cropped plot recorded the maximum increase in C.E.C. (0.22 me/100 g) followed by sannhemp, velvet bean and fallow plots. The soya bean and rice bean cropped plots recorded a decrease in C.E.C. (0.04 and 0.03 me/100 g respectively) as compared to the C.E.C. before the legume crops.

The effect of legume crops on the C.E.C. of soil was thus found to give a varying trend. The absence of significant trend of variation in C.E.C. in the present study may be due to the relative short-term nature of the experiment.

Table 11. Cation exchange capacity in the top 0-15 cm soil layer as influenced by the preceding legume crops and fallows

Treatment		Cation exchange capacity (me/100 g soil)	
		Before legume	After legume
Sannhemp	(L_1)	8.65	8.84
Soya bean	(L_2)	8.29	8.25
Rice bean	(L_3)	8.21	8.18
Velvet bean	(L_4)	7.99	8.18
Cowpea	(L_5)	7.88	7.99
Black gram	(L_6)	8.21	8.43
Fallow	(F)	8.32	8.51
C.D. at 5% level		NS	NS
S.Em ±		0.27	0.27

4.3.9. Soil pH

Soil pH was not significantly influenced by the legume crops. However, a decrease in pH following legume cropping was noticed (Table 12).

4.4. Performance of rice succeeding fodder legumes - Growth characters of rice.

4.4.1. Plant height

In the first and second months after transplanting, there was no significant difference between treatments (Table 13 and Fig. 7). However, just before harvest, there was an increase in the height of plants due to application of N. A significant increase in height of plants was recorded in rice grown after black gram, receiving 100% of the recommended N dose.

It is also to be noted that at all stages of the growth of rice, the preceding legumes (except in the late stages of rice following black gram) exerted a significant influence on plant height. This may be due to the higher soil organic carbon content and increased available nitrogen content (Table 8) subsequent to the growth of the legumes. Rice after fallow with 75% N recorded a lesser height than the other treatments in the first two months after transplanting.

Table 12. pH of soil as influenced by the preceding legume crops and fallows

Treatment		pH of soil	
		Before legume	After legume
Sannhemp	(L_1)	5.63	4.32
Soya bean	(L_2)	5.33	4.78
Rice bean	(L_3)	5.68	4.72
Velvet bean	(L_4)	5.23	4.38
Cowpea	(L_5)	5.42	4.65
Black gram	(L_6)	5.48	4.67
Fallow	(F)	5.55	5.37
C.D. at 5% level		NS	NS
S.Em ±		0.18	0.23

Table 13. Plant height as influenced by the preceding legume crops and fallows under two levels of N

Treatment		Plant height (cm)								
		One month after transplanting			Two months after transplanting			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	45.67	46.33	46.00	61.33	61.0	61.17	65.67	66.67	66.17
Soya bean	(L_2)	45.0	48.0	46.50	60.67	64.33	62.50	63.33	66.67	65.00
Rice bean	(L_3)	45.33	51.0	48.17	57.67	63.0	60.33	65.0	64.0	64.50
Velvet bean	(L_4)	46.0	50.0	48.00	62.33	62.33	62.33	63.0	67.0	65.00
Cowpea	(L_5)	46.0	45.67	45.83	61.0	61.33	61.17	64.67	65.67	65.17
Black gram	(L_6)	48.67	49.33	49.00	60.0	64.0	62.00	61.67	67.0	64.33
Fallow	(F)	45.67	48.33	47.00	60.33	60.67	60.50	62.33	64.67	63.50
Mean		46.05	48.38		60.48	62.38		63.67	65.95	
C.D. at 5% level and S.Em ±										
Main plot means			NS (1.40)			NS (1.68)			NS (1.40)	
Sub plot means			NS (0.83)			NS (0.66)			1.93 (0.64)	
Sub plot means within same main plot			NS (3.11)			NS (2.48)			NS (2.38)	
Main plot means at same or different sub plot levels			NS (3.06)			NS (2.63)			NS (2.45)	

Figures in parenthesis are S.Em.

FIG. 7 PLANT HEIGHT (cm) AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS UNDER TWO LEVELS OF NITROGEN

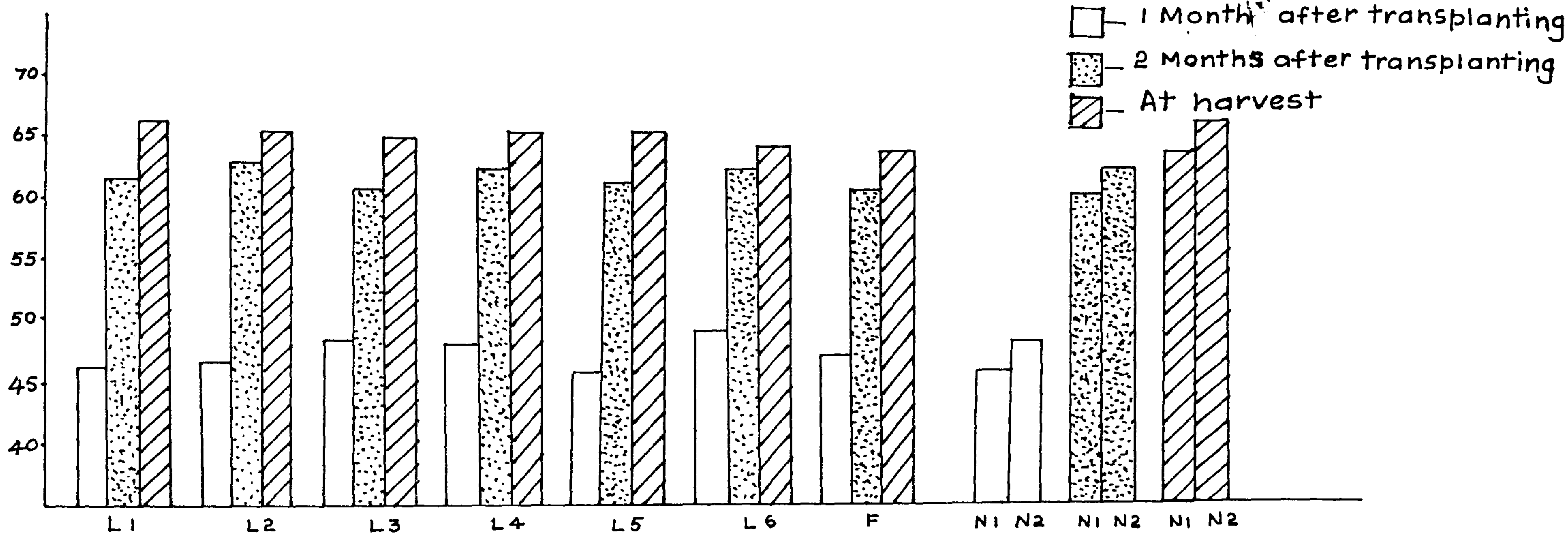
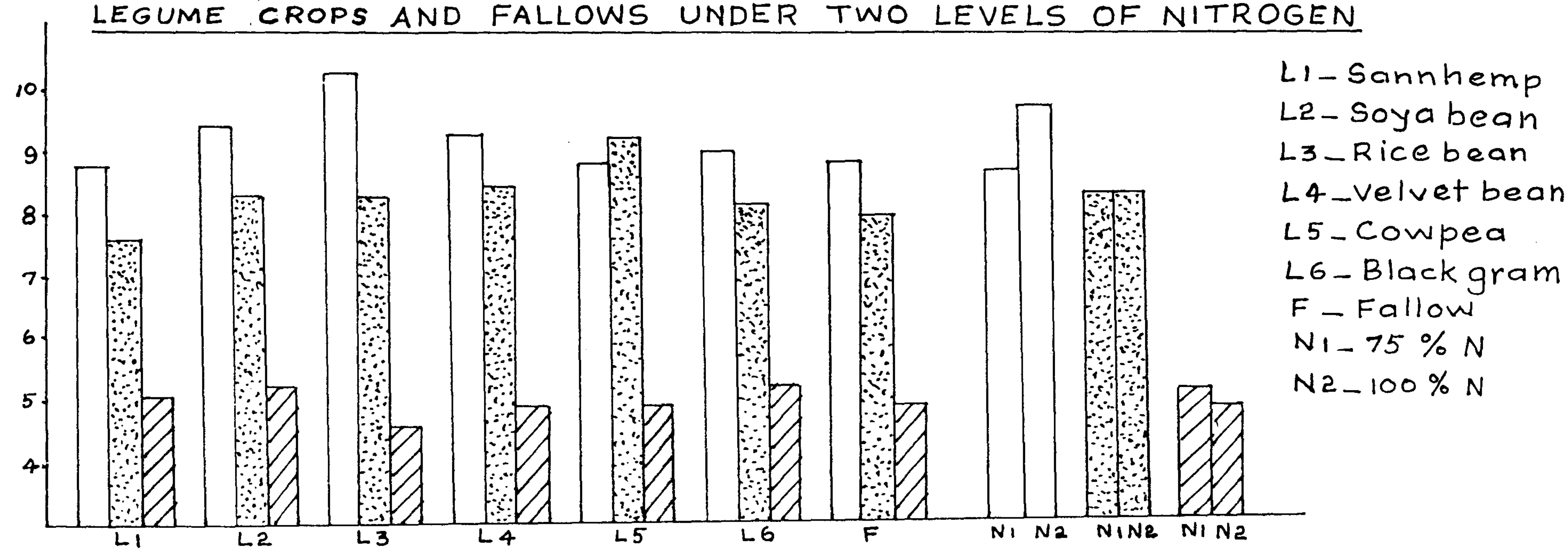


FIG. 8 NUMBER OF TILLERS PER HILL AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS UNDER TWO LEVELS OF NITROGEN



4.4.2. Number of tillers per hill

The data on the number of tillers per hill are presented in Fig. 8 and Table 14. Except in the first month after transplanting, all the main plot and sub-plot treatments produced similar number of tillers. After the first month, with increased N application, sub-plot treatments were found to differ significantly in tiller number. Rice crop following rice bean with 100% N recorded the highest number of tillers.

Application of 100% of the recommended dose of N influenced the tillering only at the initial stages. This may be probably due to the fact that in the initial stages, the plant roots were not in a position to absorb large quantities of nutrients from the soil. Subsequent to this the beneficial effect of the preceding legume crops was expressed through addition of organic carbon and increase in total and available N (Table 8). This is in conformity with the results of experiments conducted in wheat by Jha and Ram (1966) who observed that preceding legume crops increased the number of tillers per plant of wheat over control.

4.4.3. Dry matter accumulation

The dry matter accumulation of rice was found to be significantly affected by the N level only at 50% flowering (Table 15). From the table, it can be seen that at this stage,

Table 14. Number of tillers per hill as influenced by the preceding legume crops and fallows under two levels of N

Treatment		Number of tillers per hill								
		One month after transplanting			Two months after transplanting			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	8.0	9.33	8.67	7.67	7.33	7.50	5.0	5.0	5.00
Soya bean	(L_2)	8.67	10.0	9.33	8.0	8.33	8.17	5.0	5.33	5.17
Rice bean	(L_3)	9.33	11.0	10.17	7.67	8.67	8.17	4.67	4.33	4.50
Velvet bean	(L_4)	8.33	10.0	9.17	8.0	8.67	8.33	5.0	4.67	4.83
Cowpea	(L_5)	8.67	8.67	8.67	9.0	9.00	9.00	5.0	4.67	4.83
Black gram	(L_6)	8.67	9.0	8.83	8.67	7.33	8.00	5.67	4.67	5.17
Fallow	(F)	8.33	9.0	8.67	8.0	7.67	7.83	5.0	4.67	4.83
Mean		8.57	9.57		8.14	8.14		5.05	4.76	
C.D. at 5% level and S.Em ±										
Main plot means		NS (0.50)			NS (0.39)			NS (0.31)		
Sub plot means		0.708 (0.23)			NS (0.25)			NS (0.15)		
Sub plot means within same main plot		NS (0.87)			NS (0.92)			NS (0.56)		
Main plot means at same or different sub plot levels		NS (0.89)			NS (0.90)			NS (0.57)		

Figures in parenthesis are S.Em.

Table 15. Dry matter accumulation of rice as influenced by the preceding legume crops and fallows under two levels of N

Treatment		Dry matter accumulation (kg/ha)								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	999	1013	1006	6353	7109	6732	6971	7527	7249
Soya bean	(L_2)	942	1124	1033	6109	6269	6190	8322	8060	8191
Rice bean	(L_3)	835	1315	1075	5576	7193	6385	6585	7438	7012
Velvet bean	(L_4)	1022	986	1004	5478	6131	5805	8184	7975	8080
Cowpea	(L_5)	1004	990	998	5958	6896	6427	6580	9077	7829
Black gram	(L_6)	866	866	866	5136	6074	5605	6478	7398	6938
Fallow	(F)	1030	1035	1033	6531	6767	6649	8517	8051	8285
Mean		957	1047		5878	6635		7377	7933	
C.D. at 5% level and S.Em ±										
Main plot means			NS (92)			NS (344)			NS (601)	
Sub plot means			NS (39)			701 (231)			NS (244)	
Sub plot means within same main plot			NS (146)			1855 (865)			NS (913)	
Main plot means at same or different sub plot levels			NS (152)			1816 (842)			NS (960)	

Figures in parenthesis are S.Em.

increased application of N greatly increased the dry matter accumulation. As observed with respect to height of plants, rice following black gram and receiving only 75% N was found to record a lower dry matter accumulation, and was significantly inferior to rice following sannhemp and rice bean and receiving 100% of the recommended N dose.

It can be concluded that dry matter accumulation increased with age. Except at 50% flowering, the main plot and sub-plot treatments did not differ much, probably due to the beneficial effect of the preceding legumes.

4.5. Nutrient content and its uptake

4.5.1. Nitrogen content

The N content of the leaf blades, stems and panicles were separately determined at three stages and the data are given in Tables 16, 17 and 18. At all stages, the N content in these plant parts was lowest in the crop raised after fallow.

The N content of the blades decreased with age, and in the initial stage, the content was lowest in the rice crop following velvet bean, and in the last two stages, it was highest in that following black gram. Application of N did not exert a significant influence on the N content of the leaf blades.

Table 16. Nitrogen content in rice leaf blades as influenced by the preceding legume crops and fallows under two levels of N

Treatment		N content (%) of leaf blades								
		At p.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	2.04	2.57	2.31	0.62	0.42	0.52	0.40	0.30	0.35
Soya bean	(L_2)	2.15	2.95	2.55	0.70	1.06	0.88	0.60	0.55	0.57
Rice bean	(L_3)	2.02	2.83	2.43	0.63	0.65	0.64	0.57	0.46	0.51
Velvet bean	(L_4)	2.57	3.47	3.02	0.73	0.60	0.67	0.60	0.42	0.51
Cowpea	(L_5)	2.24	2.52	2.38	0.57	0.82	0.69	0.37	0.43	0.40
Black gram	(L_6)	2.37	3.03	2.70	0.87	0.92	0.89	0.70	0.62	0.66
Fallow	(F)	1.79	2.14	1.97	0.30	0.25	0.28	0.20	0.23	0.22
Mean		2.17	2.79		0.63	0.67		0.49	0.43	
C.D. at 5% level and S.Em ±										
Main plot means		NS (0.20)			0.14 (0.04)			0.19 (0.06)		
Sub plot means		NS (0.07)			NS (0.04)			NS (0.03)		
Sub plot means within same main plot		NS (0.27)			NS (0.14)			NS (0.13)		
Main plot means at same or different levels of sub plots		NS (0.30)			NS (0.13)			NS (0.13)		

Figures in parenthesis are S.Em.

Table 17. Nitrogen content of rice stems as influenced by the preceding legume crops and fallows under two levels of N

Treatment	N content (%) of stems								
	At P.I. stage			At 50% flowering			At harvest		
	N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp (L_1)	0.52	0.73	0.63	0.27	0.57	0.42	0.27	0.33	0.30
Soya bean (L_2)	0.91	1.04	0.98	0.27	0.35	0.31	0.27	0.33	0.30
Rice bean (L_3)	0.63	1.19	0.91	0.13	0.39	0.26	0.13	0.50	0.32
Velvet bean (L_4)	0.68	0.98	0.83	0.32	0.62	0.47	0.37	0.43	0.40
Cowpea (L_5)	0.78	0.83	0.81	0.33	0.48	0.41	0.30	0.38	0.34
Black gram (L_6)	0.60	0.95	0.78	0.42	0.30	0.36	0.30	0.33	0.32
Fallow (F)	0.32	0.43	0.38	0.13	0.27	0.20	0.10	0.20	0.15
Mean	0.63	0.88		0.27	0.43		0.25	0.36	
C.D. at 5% level and S.Em ±									
Main plot means		0.30 (0.10)			NS (0.06)			NS (0.06)	
Sub plot means		NS (0.04)			0.08 (0.03)			0.09 (0.03)	
Sub plot means within same main plot		NS (0.14)			NS (0.10)			NS (0.12)	
Main plot means at same or different levels of sub plot		NS (0.15)			NS (0.10)			NS (0.12)	

Figures in parenthesis are S.Em.

Table 18. Nitrogen content of rice panicles as influenced by the preceding legume crops and fallows under two levels of N

Treatment		N content (%) of panicles					
		At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	0.13	0.23	0.18	0.27	0.57	0.42
Soya bean	(L_2)	0.27	0.27	0.27	0.37	0.66	0.51
Rice bean	(L_3)	0.40	0.33	0.37	0.49	0.69	0.59
Velvet bean	(L_4)	0.17	0.23	0.20	0.83	0.79	0.81
Cowpea	(L_5)	0.40	0.37	0.38	0.50	0.40	0.45
Black gram	(L_6)	0.20	0.27	0.23	0.63	0.47	0.55
Fallow	(F)	0.13	0.17	0.15	0.23	0.37	0.30
Mean		0.24	0.27		0.48	0.56	
C.D. at 5% level and S.Em ±							
Main plot means		0.15 (0.05)			NS (0.10)		
Sub plot means		NS (0.02)			NS (0.05)		
Sub plot means within same main plot		NS (0.07)			NS (0.18)		
Main plot means at same or different levels of sub plots		NS (0.07)			NS (0.18)		

Figures in parenthesis are S.Em.

The N content of the stems also decreased with age. It was lowest in the crop raised after fallow at all stages. At panicle initiation (P.I. stage), the maximum N content was seen after black gram. At 50% flowering, rice grown in the velvet bean cropped plots had the highest N content. At this stage, N application produced significant response. At harvest, the rice crop succeeding velvet bean had the highest N content in stems, followed by those succeeding cowpea. N application significantly increased the N content of the stems.

The N content of the panicles increased greatly from 50% flowering to harvest. At 50% flowering, N content of panicles of the crop following rice bean and cowpea was significantly higher than that of those of the crop following sannhemp, velvet bean and fallow. Application of N was found to increase the N content, but the increase was not significant. At harvest, panicles of rice following velvet bean recorded the highest N content.

Apart from the leaf blades, the other plant parts showed more or less the same pattern of influence due to treatments. Though the preceding legumes enriched the soil in total and available N, application of N exerted a significant influence on the N content. With application of 100% of the N dose recommended, there was a significant increase in the N content of the plant. Higher rates of applied N must have resulted in more available N in the soil and a high uptake of N. The general decrease in the N content of the plant parts (excluding the panicles) with advanced stages of growth has to be expected as carbohydrate is incorporated through photosynthesis at a faster rate than the rate of N uptake by the plant at later growth stages (Tanaka, 1965). In other words, as dry matter accumulation increased, the N content decreased.

4.5.2. Nitrogen uptake

It was observed that at all stages of growth of rice, N uptake by the leaf blades was lowest in the crop following fallow (Tables 19, 20 and 21 and Figs. 9 a, 9 b and 9 c). At P.I. stage, the highest uptake was recorded in the rice crop following velvet bean, while at 50% flowering and harvest, it was in the crop following soya bean. Significant response to N application was noticed only at the first stage.

In stems also, the lowest N uptake was noticed in the rice crop raised after fallow, at all stages. Increased N application resulted in significant increase in the N uptake by the stems.

The N uptake by panicles was highest in the rice plants raised after rice bean and cowpea at 50% flowering, and after

Table 19. Uptake of N by rice leaf blades as influenced by the preceding legume crops and fallows under two levels of N

Treatment		N uptake (kg/ha) by leaf blades								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	10.73	16.13	13.43	13.89	9.62	11.76	8.12	7.27	7.69
Soya bean	(L_2)	11.13	20.99	16.06	13.75	21.03	17.39	14.24	10.46	12.35
Rice bean	(L_3)	9.85	24.28	17.07	10.88	14.06	12.47	9.41	10.20	9.81
Velvet bean	(L_4)	15.09	20.48	17.78	11.81	11.81	11.81	13.84	9.83	11.84
Cowpea	(L_5)	13.77	14.93	14.35	9.55	13.99	11.77	6.80	14.97	10.89
Black gram	(L_6)	10.88	16.79	13.84	13.36	15.75	14.55	12.73	14.99	13.86
Fallow	(F)	11.06	13.73	12.40	10.00	5.41	7.71	5.44	6.46	5.95
Mean		11.79	18.19		11.89	13.10		10.08	10.60	
C.D. at 5% level and S.Em ±										
Main plot means			NS (2.22)			NS (1.80)			4.59 (1.49)	
Sub plot means			2.52 (0.83)			NS (1.10)			NS (1.20)	
Sub plot means in same main plot			NS (3.11)			NS (4.11)			NS (4.50)	
Main plot means in same or different sub plots			NS (3.33)			NS (4.04)			NS (4.31)	

Figures in parenthesis are S.Em.

Table 20. Uptake of N by rice stems as influenced by the preceding legume crops and fallows under two levels of N

Treatment		N uptake (kg/ha) by stems								
		AT P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	2.54	2.84	2.69	10.47	25.59	18.03	6.97	9.34	8.16
Soya bean	(L_2)	3.83	4.45	4.14	10.94	12.26	11.60	8.44	11.01	9.73
Rice bean	(L_3)	1.95	5.28	3.62	4.95	15.54	10.24	3.26	15.14	9.20
Velvet bean	(L_4)	2.84	3.36	3.10	10.79	23.55	17.17	11.71	12.96	12.33
Cowpea	(L_5)	3.37	2.51	2.94	16.18	25.08	20.63	7.44	13.16	10.30
Black gram	(L_6)	2.56	2.87	2.71	15.10	10.73	12.91	7.23	9.09	8.16
Fallow	(F)	1.22	1.83	1.53	3.87	9.86	6.87	2.88	5.68	4.28
Mean		2.62	3.31		10.33	17.51		6.85	10.91	
C.D. at 5% level and S.Em ±										
Main plot means			1.39 (0.45)			NS (2.98)			NS (1.99)	
Sub plot means			0.61 (0.20)			4.32 (1.42)			3.03 (1.00)	
Sub plot means in same main plot			1.60 (0.75)			NS (5.33)			NS (3.74)	
Main plot means in same or different sub plot			1.67 (0.77)			NS (5.39)			NS (3.78)	

Figures in parenthesis are S.Em.

Table 21. Uptake of N by rice panicles as influenced by the preceding legume crops and fallows under two levels of N

Treatment		N uptake (kg/ha) by panicles					
		At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	0.63	0.88	0.75	6.64	12.80	9.72
Soya bean	(L_2)	1.45	1.03	1.24	11.12	20.35	15.74
Rice bean	(L_3)	1.97	2.38	2.18	12.21	14.89	13.55
Velvet bean	(L_4)	0.85	0.92	0.89	23.17	22.39	22.78
Cowpea	(L_5)	2.11	2.02	2.06	10.58	18.59	14.59
Black gram	(L_6)	0.86	1.36	1.11	9.63	10.43	10.03
Fallow	(F)	0.75	0.82	0.78	6.76	5.42	6.09
Mean		1.23	1.34		11.44	14.98	
C.D. at 5% level and S.Em ±							
Main plot means			0.77 (0.25)			8.96 (2.91)	
Sub plot means			NS (0.08)			NS (1.28)	
Sub plot means in same main plot			NS (0.31)			NS (4.77)	
Main plot means in same or different sub plots			NS (0.35)			NS (4.94)	

Figures in parenthesis are S.Em.

FIG. 9a UPTAKE OF NITROGEN (kg/ha) BY LEAF BLADES OF RICE AT THREE STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN

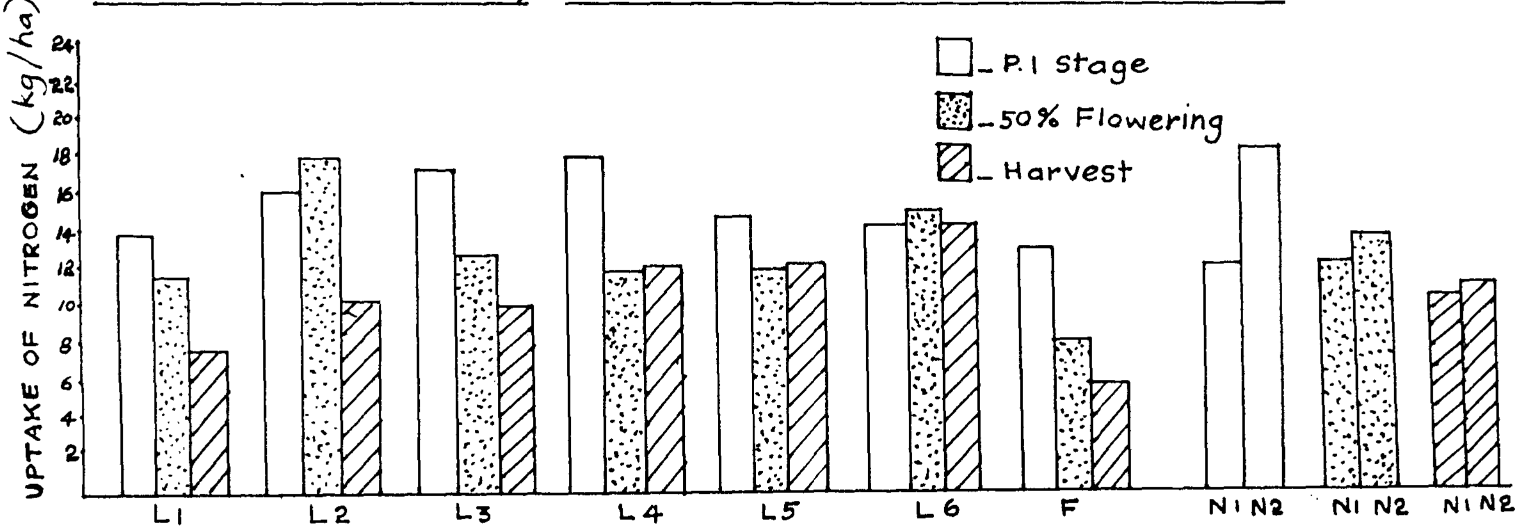


FIG. 9b UPTAKE OF NITROGEN (kg/ha) BY STEMS OF RICE AT THREE STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN

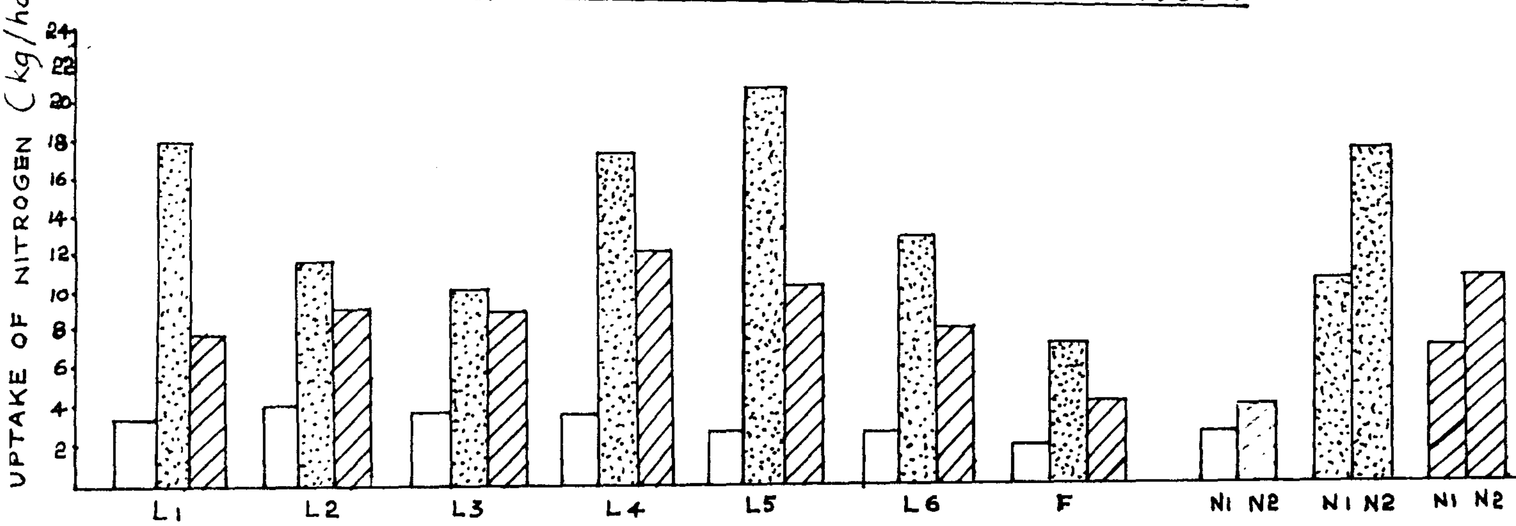
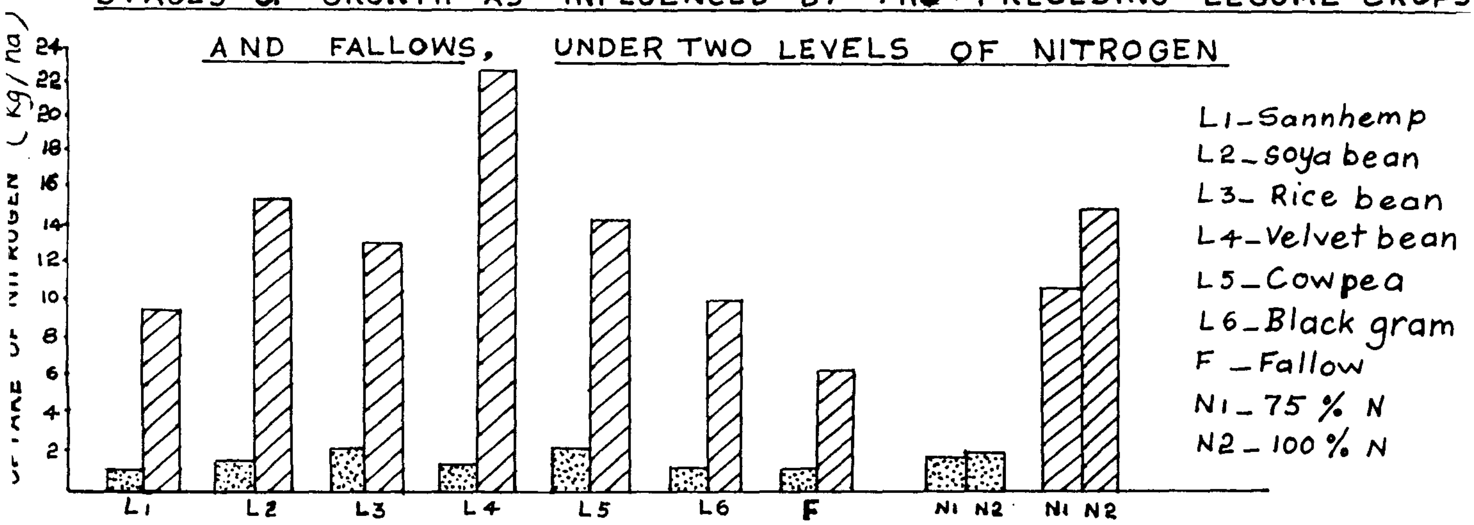


FIG. 9c UPTAKE OF NITROGEN (kg/ha) BY PANICLES OF RICE AT THREE STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN



velvet bean at harvest. In both cases, the crop following fallow recorded low values. Increased dose of N fertilisers slightly improved the N uptake by panicles, but the increase was not significant.

The N uptake is the product of dry matter accumulation and the N content in the plant. The preceding legume crops brought about a high dry matter accumulation as well as a high N content in the succeeding rice crop, as the soil was left richer in soil N and organic carbon. The better soil physical and chemical properties must have favoured better growth and higher uptake of N. A similar effect was reported in wheat by Fallal et al. (1968).

Application of N was found to have a favourable effect on the N uptake by the plant. The increase in N uptake with increased application of N is quite natural as it favoured a high N content, though the dry matter accumulation was not significantly influenced. Consequently, N uptake was also increased. Singh et al. (1982) also reported a higher N uptake in maize following summer grain and fodder legumes when N application was done.

4.5.3. Phosphorus content

Data on the P content presented in Tables 22, 23 and 24 indicate that at all stages of growth, the P content of rice

Table 22. Phosphorus content of rice leaf blades as influenced by the preceding legume crops and fallows under two levels of N

Treatment		P content (%) of leaf blades								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	0.31	0.28	0.30	0.17	0.15	0.16	0.16	0.39	0.28
Soya bean	(L_2)	0.43	0.41	0.42	0.15	0.18	0.17	0.33	0.39	0.36
Rice bean	(L_3)	0.34	0.43	0.39	0.15	0.17	0.16	0.18	0.37	0.28
Velvet bean	(L_4)	0.45	0.48	0.47	0.16	0.19	0.18	0.15	0.38	0.27
Cowpea	(L_5)	0.49	0.28	0.38	0.18	0.20	0.19	0.16	0.32	0.24
Black gram	(L_6)	0.37	0.32	0.35	0.17	0.19	0.18	0.18	0.30	0.24
Fallow	(F)	0.28	0.26	0.27	0.15	0.14	0.15	0.14	0.25	0.19
Mean		0.38	0.35		0.16	0.17		0.18	0.34	
C.D. at 5% level and S.Em ±										
Main plot means			0.06 (0.02)			NS (0.01)			NS (0.03)	
Sub plot means			0.03 (0.01)			NS (0.00)			0.07 (0.02)	
Sub plot means within same main plot			0.08 (0.04)			NS (0.02)			NS (0.08)	
Main plot means at same or different levels of sub plots			0.08 (0.04)			NS (0.02)			NS (0.08)	

Figures in parenthesis are S.Em.

Table 23. Phosphorus content of rice stems as influenced by the preceding legume crops and fallows under two levels of N

Treatment		P Content (%) of stems								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	0.29	0.28	0.29	0.26	0.26	0.26	0.15	0.16	0.16
Soya bean	(L_2)	0.38	0.44	0.41	0.25	0.23	0.24	0.17	0.17	0.17
Rice bean	(L_3)	0.40	0.41	0.41	0.22	0.25	0.23	0.15	0.19	0.17
Velvet bean	(L_4)	0.36	0.41	0.38	0.25	0.28	0.26	0.15	0.18	0.16
Cowpea	(L_5)	0.38	0.34	0.36	0.25	0.27	0.26	0.17	0.18	0.17
Black gram	(L_6)	0.33	0.40	0.36	0.26	0.26	0.26	0.17	0.21	0.19
Fallow	(F)	0.29	0.29	0.29	0.22	0.24	0.23	0.12	0.14	0.13
Mean		0.35	0.37		0.24	0.26		0.15	0.18	
C.D. at 5% level and S.Em ±										
Main plot means		0.07 (0.02)			NS (0.01)			NS (0.02)		
Sub plot means		0.02 (0.01)			0.01 (0.00)			0.01 (0.00)		
Sub plot means within same main plot		0.05 (0.02)			NS (0.01)			NS (0.01)		
Main plot means at same or different levels of sub plot		0.06 (0.02)			NS (0.02)			NS (0.01)		

Figures in parenthesis are S.Em.

Table 24. Phosphorus content in rice panicles as influenced by the preceding legume crops and fallows under two levels of N

Treatment		P content (%) of panicles					
		At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	0.13	0.16	0.15	0.15	0.17	0.16
Soya bean	(L_2)	0.13	0.15	0.14	0.17	0.18	0.18
Rice bean	(L_3)	0.15	0.17	0.16	0.13	0.17	0.15
Velvet bean	(L_4)	0.14	0.17	0.16	0.15	0.16	0.16
Cowpea	(L_5)	0.20	0.16	0.18	0.15	0.17	0.16
Black gram	(L_6)	0.14	0.17	0.16	0.16	0.17	0.17
Fallow	(F)	0.13	0.15	0.14	0.11	0.12	0.12
Mean		0.15	0.16		0.14	0.16	
C.D. at 5% level and S.Em ±							
Main plot means			NS (0.01)			0.03 (0.01)	
Sub plot means			NS (0.01)			0.01 (0.00)	
Sub plot means within same main plot			NS (0.03)			NS (0.01)	
Main plot means at same or different levels of sub plot			NS (0.03)			NS (0.01)	

Figures in parenthesis are S.Em.

plants raised after fallow was lowest, compared to other treatments. The P content of the leaf blades was highest at P.I. stage, then decreased at 50% flowering and again increased with maturity. It was observed that at P.I. stage, application of a higher N dose decreased the P content of the blades, whil at the other two stages, the content was increased.

The P content of the stems was also lowest after fallow, and at all stages it was seen that increased N application increased the P content.

As in the leaf blades and stems, the P content of the panicles was lowest in the rice crop succeeding fallow. There was not much difference in the P content of the panicles at 50% flowering and at harvest. While increased N application did not affect the P content of the panicles at 50% flowering, at harvest it significantly increased the P content.

Though the P content of the different plant parts was high when grown after legumes, application of N exerted a significant influence on the P content of the plant. Application of the full dose of N was significantly superior to application of 75% of the recommended dose, at almost all the stages. Even though the effect of preceding legumes was not significant, a trend for high P content in the rice plants grown after legumes was maintained throughout the growth period. The significant effect of N application on the P content may be due to the complementary effect of N on P uptake by the plants.

4.5.4. Phosphorus uptake

At all stages of growth, it was observed that P uptake by leaf blades was comparitively lower when rice was grown after fallow than after legumes. There was an increase in the P content of the blades with age, the highest being at harvest (Tables 25, 26 and 27 and Figs. 10 a, 10 b & 10 c). At 50% flowering and at harvest, enhanced N application increased the P uptake.

The uptake of P by the stems was low at P.I. stage, increased greatly at 50% flowering, and again decreased at harvest. At 50% flowering and at harvest, the P uptake by the stems was greatly accelerated by the application of a higher dose of N. Increased N application, however, had no significant effect at P.I. stage.

The P uptake by panicles at 50% flowering was higher than at harvest. Unlike other cases, the P uptake at 50% flowering was lowest by rice following sannhemp followed by that after soya bean, while the highest uptake was recorded by rice succeeding rice bean. At harvest, the lowest uptake was in the crop following fallow. Application of a higher dose of N had significant effect on the P uptake by panicles

Table 25. Uptake of phosphorus by rice leaf blades as influenced by the preceding legume crops and fallows under two levels of N

Treatment		P uptake (kg/ha) by leaf blades								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sunnhemp	(L_1)	1.64	1.76	1.70	3.96	3.36	3.66	3.02	8.83	5.93
Soya bean	(L_2)	2.25	2.81	2.53	3.0	3.54	3.27	8.75	7.47	8.11
Rice bean	(L_3)	1.65	3.69	2.67	2.58	3.70	3.14	3.02	8.26	5.64
Velvet bean	(L_4)	2.65	2.84	2.74	2.48	3.81	3.14	3.66	8.78	6.22
Cowpea	(L_5)	2.97	1.63	2.30	3.09	3.38	3.23	2.97	8.31	5.64
Black gram	(L_6)	1.66	1.76	1.71	2.64	3.28	2.96	3.20	7.23	5.21
Fallow	(F)	1.75	1.67	1.71	3.01	3.22	3.12	3.51	6.57	5.04
Mean		2.08	2.31		2.97	3.47		4.02	7.92	

C.D. at 5% level and S.Em ±	At P.I. stage	At 50% flowering	At harvest
Main plot means	0.83 (0.27)	NS (0.46)	NS (0.94)
Sub plot means	NS (0.10)	0.37 (0.12)	2.17 (0.72)
Sub plot means within same main plot	0.76 (0.36)	NS (0.46)	NS (2.68)
Main plot means at same or different levels of sub plot	0.84 (0.39)	NS (0.55)	NS (2.58)

Figures in parenthesis are S.Em.

Table 26. Uptake of phosphorus by rice stems as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		P uptake (kg/ha) by stems								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	1.37	1.09	1.23	9.42	11.73	10.57	3.72	4.93	4.33
Soya bean	(L_2)	1.59	1.92	1.75	9.83	8.30	9.07	5.03	5.32	5.18
Rice bean	(L_3)	1.33	1.89	1.61	7.80	10.66	9.23	3.67	5.63	4.65
Velvet bean	(L_4)	1.40	1.45	1.43	8.61	10.54	9.57	4.48	4.93	4.71
Cowpea	(L_5)	1.65	1.02	1.34	9.31	12.16	10.74	4.12	5.95	5.03
Black gram	(L_6)	1.33	1.25	1.29	7.50	10.28	8.89	4.16	5.55	4.86
Fallow	(F)	1.16	1.13	1.15	8.46	10.06	9.26	3.48	4.26	3.87
Mean		1.40	1.39		8.70	10.53		4.10	5.22	
C.D. at 5% level and S.Em ±										
Main plot means		0.34 (0.11)			NS (1.05)			NS (0.74)		
Sub plot means		NS (0.07)			1.58 (0.52)			0.52 (0.17)		
Sub plot means within same main plot		NS (0.25)			NS (1.94)			NS (0.64)		
Main plots means at same or different levels of sub plot		NS (0.24)			NS (1.97)			NS (0.81)		

Figures in parenthesis are S.Em.

Table 27. Uptake of phosphorus by rice panicles as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		P uptake (kg/ha) by panicles					
		At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	0.64	0.58	0.61	3.66	3.79	3.72
Soya bean	(L_2)	0.71	0.67	0.69	4.83	5.72	5.27
Rice bean	(L_3)	0.74	1.24	0.99	3.07	3.80	3.43
Velvet bean	(L_4)	0.69	0.73	0.71	4.11	4.84	4.48
Cowpea	(L_5)	1.06	0.89	0.98	3.34	5.34	4.34
Black gram	(L_6)	0.57	0.94	0.75	3.70	4.18	3.94
Fallow	(F)	0.76	0.73	0.74	3.41	2.80	3.11
Mean		0.74	0.83		3.73	4.35	
C.D. at 5% level and S.Em ±							
Main plot means		0.24 (0.08)			NS (0.56)		
Sub plot means		NS (0.06)			0.55 (0.18)		
Sub plot means within same main plot		NS (0.22)			NS (0.68)		
Main plot means at same or different levels of sub plot		NS (0.22)			NS (0.76)		

Figures in parenthesis are S.Em.

FIG.10a UPTAKE OF PHOSPHORUS (kg/ha) BY LEAF BLADES OF RICE AT THREE STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN

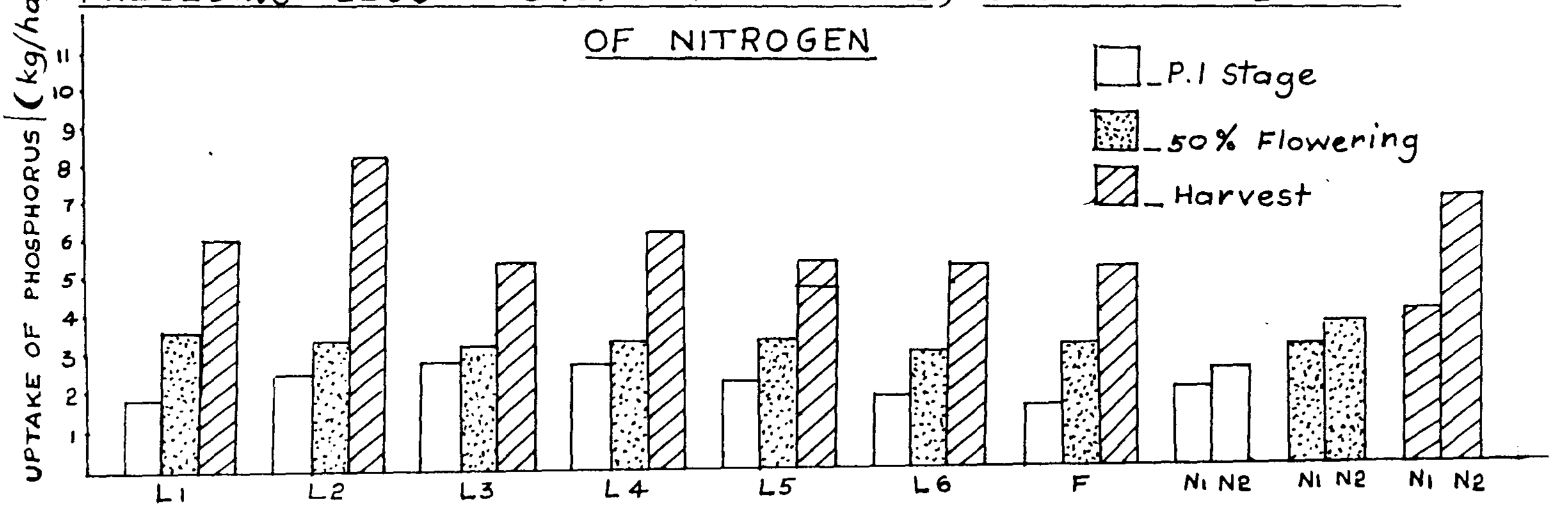


FIG.10b UPTAKE OF PHOSPHORUS (kg/ha) BY STEMS OF RICE AT THREE STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN

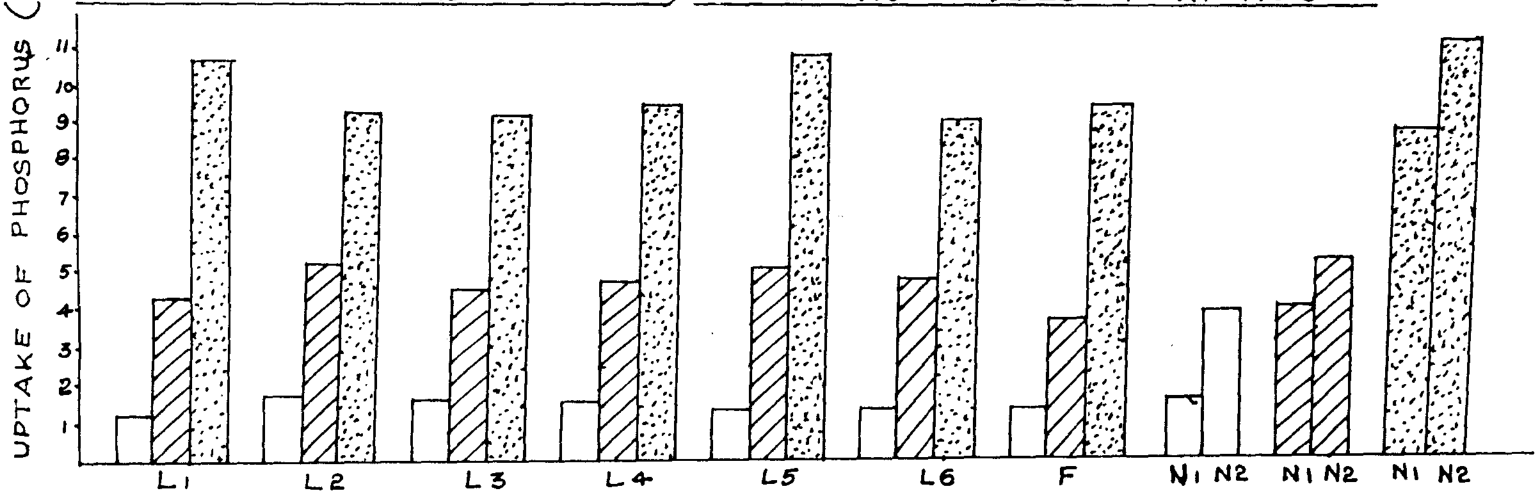
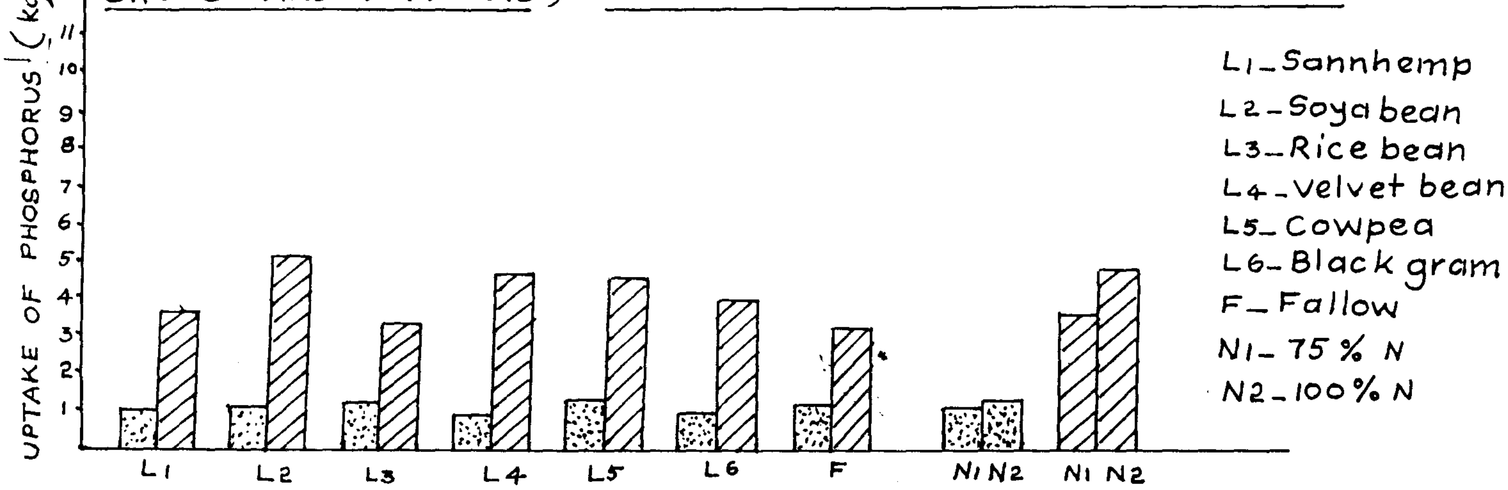


FIG.10c UPTAKE OF PHOSPHORUS (kg/ha) BY PANICLES OF RICE AT TWO STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN



only at the last stage.

As in the case of the P content, the P uptake was not significantly influenced by the preceding legume crops. However, as the P uptake is a reflection of dry matter accumulation and P content of the plant, and as application of N had a significant favourable influence on the P content of rice, the uptake of P was also favourably influenced by a higher dose of N.

In general, the uptake of P by rice following legumes was comparitively high, and this is in conformity with the findings of Ballal et al. (1968).

4.5.5. Potassium content

The potassium content of the leaf blades showed a decreasing trend with age. At all growth stages, the content was lowest in the rice crop raised after fallow. At all stages, the content increased with greater N application, though the increase was not significant at P.I. stage (Tables 28, 29 and 30).

The K content of the stems was lower at 50% flowering than at P.I. stage, but on maturity, the content increased in all treatments, except in the sannhemp and soya bean cropped plots. At all stages, the lowest K content was in the rice

Table 28. Potassium content of rice leaf blades as influenced by the preceding legume crops and fallows under two levels of N

Treatment		K content (%) of leaf blades								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	2.17	2.43	2.30	1.57	1.90	1.73	0.67	1.53	1.10
Soya bean	(L_2)	2.13	2.08	2.11	2.17	2.57	2.37	0.97	1.82	1.39
Rice bean	(L_3)	2.35	2.40	2.38	1.70	1.87	1.78	1.00	1.80	1.40
Velvet bean	(L_4)	2.07	2.03	2.05	1.88	2.20	2.04	1.40	1.82	1.61
Cowpea	(L_5)	2.03	2.30	2.17	2.03	2.15	2.09	1.08	1.65	1.37
Black gram	(L_6)	2.23	2.20	2.22	2.00	2.00	2.00	0.93	1.80	1.37
Fallow	(F)	1.77	1.73	1.75	1.37	1.47	1.42	0.73	0.98	0.86
Mean		2.11	2.17		1.82	2.02		0.97	1.63	
C.D. at 5% level and S.Em ±										
Main plot means			NS (0.13)			0.47 (0.15)			0.40 (0.13)	
Sub plot means			NS (0.05)			0.10 (0.03)			0.20 (0.07)	
Sub plot means within same main plot			NS (0.20)			NS (0.12)			NS (0.25)	
Main plot means within same or different levels of sub plot			NS (0.21)			NS (0.16)			NS (0.25)	

Figures in parenthesis are S.Em.

Table 29. Potassium content of rice stems as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		K content (%) of stems								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	2.88	3.02	2.95	2.13	1.93	2.03	2.32	0.62	1.47
Soya bean	(L_2)	2.70	2.78	2.74	1.93	2.05	1.99	1.97	1.03	1.50
Rice bean	(L_3)	2.55	2.73	2.64	1.87	1.88	1.88	2.22	1.98	2.10
Velvet bean	(L_4)	2.63	2.90	2.77	1.70	2.37	2.03	2.15	2.25	2.20
Cowpea	(L_5)	2.50	2.78	2.64	2.47	2.57	2.52	1.70	2.10	1.90
Black gram	(L_6)	2.80	2.98	2.89	1.53	1.73	1.63	1.62	2.25	1.93
Fallow	(F)	2.40	2.55	2.48	1.23	1.57	1.40	1.73	1.92	1.83
Mean		2.64	2.82		1.84	2.01		1.96	1.74	
C.D. at 5% level and S.Em ±										
Main plot means		NS (0.11)			0.31 (0.10)			NS (0.28)		
Sub plot means		0.13 (0.04)			0.15 (0.05)			NS (0.10)		
Sub plot means within same main plot		NS (0.15)			NS (0.18)			0.77 (0.36)		
Main plot means within same or different levels of sub plot		NS (0.16)			NS (0.19)			0.86 (0.39)		

Figures in parenthesis are S.Em.

Table 30. Potassium content of rice panicles as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		K content (%) of panicles					
		At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	0.48	0.50	0.49	0.29	0.37	0.33
Soya bean	(L_2)	0.43	0.44	0.44	0.25	0.39	0.32
Rice bean	(L_3)	0.37	0.39	0.38	0.22	0.25	0.23
Velvet bean	(L_4)	0.36	0.41	0.39	0.23	0.27	0.25
Cowpea	(L_5)	0.35	0.44	0.39	0.24	0.76	0.50
Black gram	(L_6)	0.36	0.39	0.37	0.30	0.36	0.33
Fallow	(F)	0.33	0.36	0.35	0.24	0.27	0.26
Mean		0.38	0.42		0.25	0.38	
C.D. at 5% level and S.Em ±							
Main plot means			0.06 (0.02)			NS (0.07)	
Sub plot means			0.01 (0.00)			NS (0.05)	
Sub plot means within same main plot			0.03 (0.01)			NS (0.19)	
Main plot means within same of different levels of sub plot			0.04 (0.02)			NS (0.19)	

Figures in parenthesis are S.Em.

crop following fallow. With application of 100% N, there was significant increase in the K content of stems at P.I. and 50% flowering, but the effect was not significant at maturity.

Except in the rice crop preceded by cowpea, the K content of panicles in all the treatments decreased from 50% flowering to harvest. Nitrogen application had a significant effect at 50% flowering when it was seen that K content increased with an enhanced N dose. At both stages, the K content was least in the fallow preceded plots.

The preceding legume had some effect on the K content as is evident from the lower K content in the fallow plots. However, none of the treatments showed any clear cut dominance. In most of the cases, application of N was seen to increase the K content of the plant parts, and this may be due to some complementary effect of N application on K uptake. The better growth of the plants when N was applied may have resulted in increased K uptake, and hence in increased K content.

4.5.6. Potassium uptake

The data on the uptake of K by leaf blades (Table 31 and Fig. 11 a) indicate that the uptake decreased with age.

Table 31. Uptake of potassium by rice leaf blades as influeced by the preceding legume crops and fallows under two levels of N

Treatment		Uptake of K (kg/ha) by leaf blades								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	11.41	15.32	13.37	34.48	43.40	38.94	12.55	34.03	23.29
Soya bean	(L_2)	11.05	14.69	12.87	43.11	48.33	45.72	28.42	35.84	32.13
Rice bean	(L_3)	11.19	19.35	15.27	28.70	40.67	34.68	17.11	39.52	28.31
Velvet bean	(L_4)	11.87	12.03	11.95	29.36	44.65	37.00	32.45	42.33	37.39
Cowpea	(L_5)	12.44	13.55	12.99	33.84	35.79	34.82	20.17	42.15	31.16
Black gram	(L_6)	10.36	11.97	11.17	30.84	34.57	32.71	17.21	42.73	29.97
Fallow	(F)	10.98	11.21	11.10	27.84	32.62	30.23	18.94	26.92	22.93
Mean		11.33	14.02		32.60	40.00		20.98	37.65	
C.D. at 5% level and S.Em ±										
Main plot means		NS (1.40)			NS (4.20)			NS (3.59)		
Sub plot means		1.69 (0.56)			4.80 (1.58)			6.49 (2.14)		
Sub plot means within same main plot		NS (2.09)			NS (5.92)			NS (8.00)		
Main plot means at same or different levels of sub plot		NS (2.21)			NS (6.33)			NS (7.89)		

Figuresin parenthesis are S.Em.

Table 32. Uptake of potassium by rice stems as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		K uptake (kg/ha) by stems								
		At P.I. stage			At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	13.60	11.67	12.64	76.74	87.22	81.98	58.55	17.83	38.19
Soya bean	(L_2)	11.44	11.78	11.61	78.16	72.63	75.40	61.57	35.24	48.40
Rice bean	(L_3)	8.89	12.51	10.70	67.65	81.04	74.34	55.51	58.82	57.17
Velvet bean	(L_4)	10.33	10.36	10.35	55.62	88.57	72.10	66.50	61.43	63.97
Cowpea	(L_5)	10.77	8.40	9.59	91.96	91.27	91.62	42.70	69.78	56.24
Black gram	(L_6)	11.42	9.22	10.32	51.76	68.56	60.16	36.06	58.81	47.44
Fallow	(F)	9.72	10.24	9.98	47.43	66.58	57.00	51.01	59.40	55.21
Mean		10.88	10.60		67.04	79.41		53.13	51.62	
C.D. at 5% level and S.Em ±										
Main plot means			NS (1.03)			NS (7.07)			NS (11.18)	
Sub plot means			NS (0.56)			NS (4.28)			NS (3.60)	
Sub plot means within same main plot			NS (2.11)			NS (16.03)			28.87 (13.46)	
Main plot means within same or different levels of sub plot			NS (2.10)			NS (15.77)			32.68 (15.06)	

Figures in parenthesis are S.Em.

Table 33. Uptake of potassium by rice panicles as influenced by the preceding legume crops and fallows, under the two levels of N

Treatment		K uptake (kg/ha) by panicles					
		At 50% flowering			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	2.27	1.83	2.05	7.15	8.70	7.92
Soya bean	(L_2)	2.27	1.92	2.10	7.08	12.24	9.66
Rice bean	(L_3)	1.88	2.83	2.35	5.35	5.49	5.42
Velvet bean	(L_4)	1.73	1.74	1.73	6.65	7.97	7.31
Cowpea	(L_5)	1.85	2.40	2.13	5.34	9.16	7.25
Black gram	(L_6)	1.64	2.15	1.90	7.10	8.68	7.89
Fallow	(F)	1.98	1.81	1.90	7.35	6.21	6.78
Mean		1.95	2.10		6.57	8.35	
C.D. at 5% level and S.Em ±							
Main plot means		NS (0.22)			NS (1.29)		
Sub plot means		NS (0.10)			1.46 (0.48)		
Sub plot means within same main plot		NS (0.38)			NS (1.79)		
Main plot means at same or different levels of sub plot		NS (0.39)			NS (1.93)		

Figures in parenthesis are S.Em.

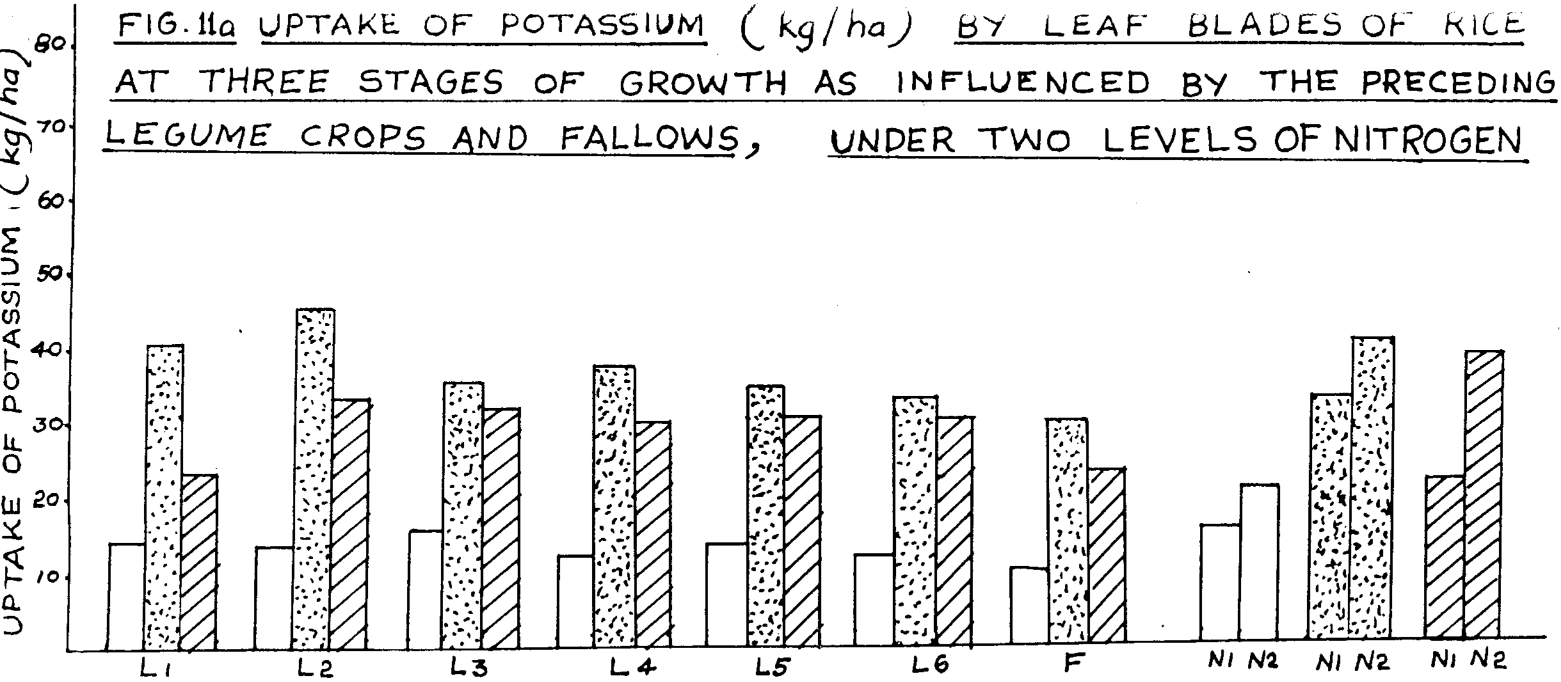


FIG. 11a UPTAKE OF POTASSIUM (kg/ha) BY LEAF BLADES OF RICE AT THREE STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN

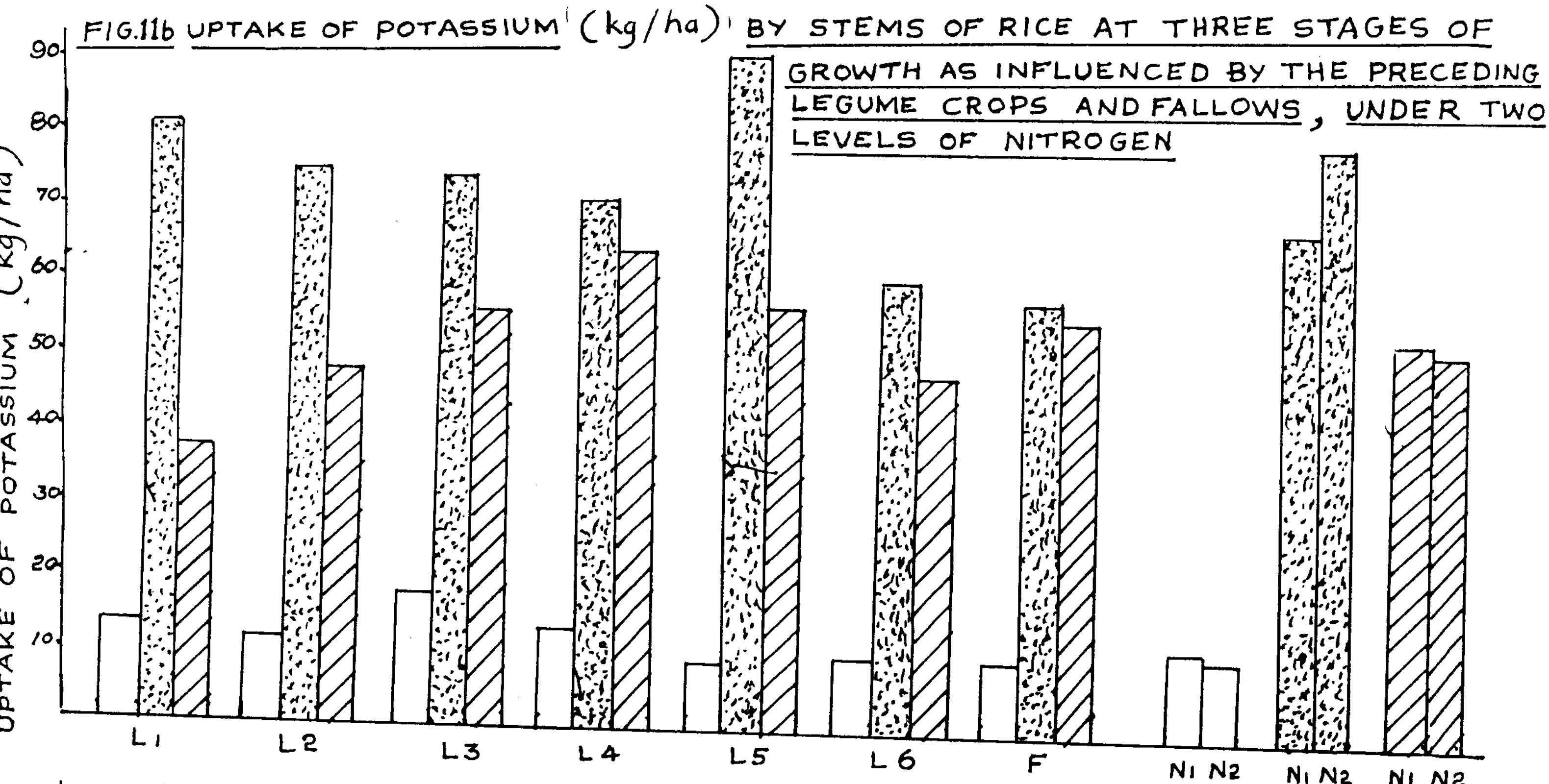


FIG. 11b UPTAKE OF POTASSIUM (kg/ha) BY STEMS OF RICE AT THREE STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN

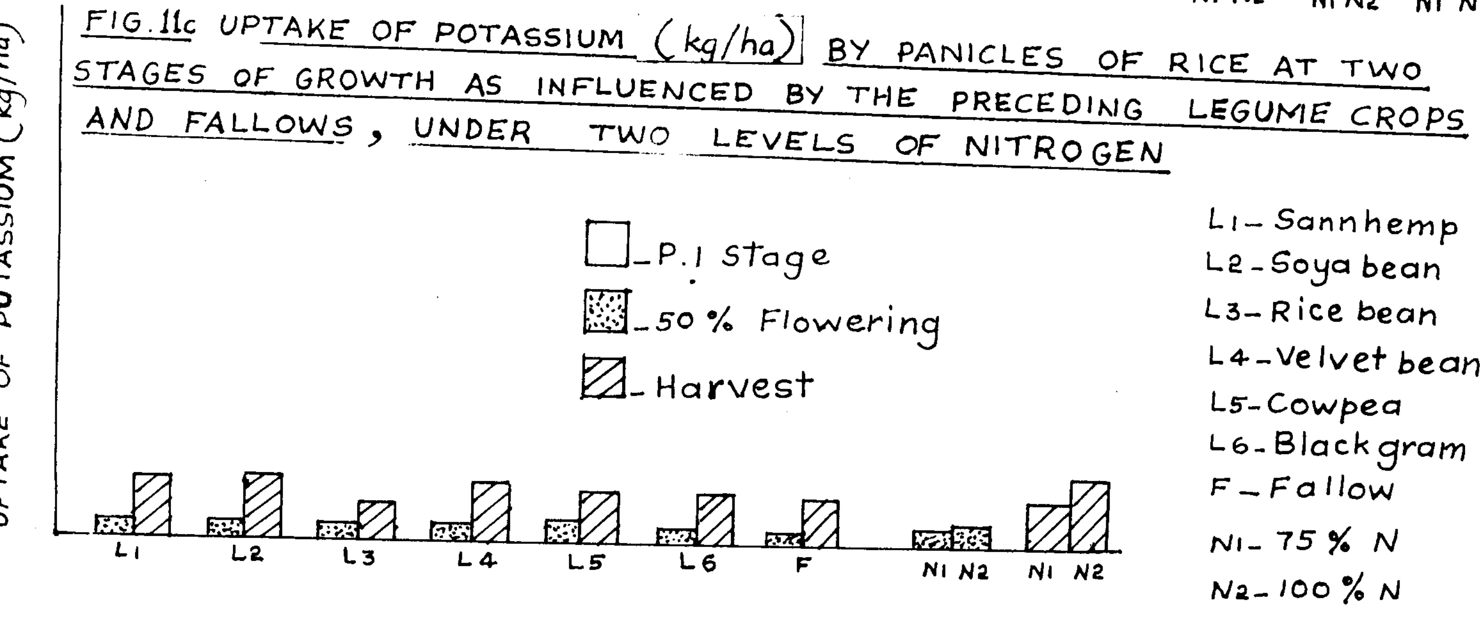


FIG. 11c UPTAKE OF POTASSIUM (kg/ha) BY PANICLES OF RICE AT TWO STAGES OF GROWTH AS INFLUENCED BY THE PRECEDING LEGUME CROPS AND FALLOWS, UNDER TWO LEVELS OF NITROGEN

At all stages, the uptake was minimum in the fallow preceded crop. The application of 100% N had a significant positive effect on the uptake of K.

The uptake of K by stems (Table 32 and Fig. 11 b) was highest at 50% flowering and lowest at P.I. stage. Contrary to other cases, the uptake of K was lowest after the fallow plots only at 50% flowering. At the mature stage, the K uptake by the rice crop succeeding fallow was comparable with other treatments. Application of N had no significant effect on the uptake of K by stems.

The panicles showed an increase in the uptake of K with time (Table 33 and Fig. 11 c). Here too, the K uptake by panicles in the fallow preceded plot was lowest compared to other treatments. Nitrogen application had significant effect on the uptake only at the maturity stage when it was found to significantly increase the uptake.

The response in K uptake due to both the main plot and sub-plot treatments was found to be highly erratic. However, an increasing trend in the uptake of K due to N application could be identified which may be due to the better growth of the plants.

4.6. Yield and yield attributes

4.6.1. Yield attributes

It is seen from Table 34 and Fig.12 that there is no significant variation in the number of productive tillers between the second month after transplanting and the maturity stage. It can be further noticed from the figure that application of N has not significantly influenced the number of productive tillers per hill at both the stages.

As far as the length of panicles is concerned, all treatments were found to be on par. The application of N did not influence the length of panicles. Similar was the case with regard to the number of grains per panicle (Table 35).

With regard to thousand grain weight, there was significant difference among the main plot and sub-plot treatments (Table 36). The lowest thousand grain weight was in the fallow preceded rice crop while the highest thousand grain weight was recorded after cowpea (28.13 g). Further, application of 100% of the recommended N dose was found to increase the thousand grain weight significantly as is evident from Fig.12.

The percentage of filled grains was also found to be significantly influenced by the preceding legumes as well as

Table 34. Number of productive tillers per hill as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		No. of productive tillers per hill					
		2 months after transplanting			At harvest		
		N_1	N_2	Mean	N_1	N_2	Mean
Sunnhemp	(L_1)	3.00	2.67	2.83	4.00	4.00	4.00
Soya bean	(L_2)	3.33	6.00	4.67	4.00	4.67	4.33
Rice bean	(L_3)	3.33	5.33	4.33	4.33	3.67	4.00
Velvet bean	(L_4)	3.67	3.33	3.50	4.33	3.67	4.00
Cowpea	(L_5)	3.33	3.33	3.33	4.00	3.67	3.83
Black gram	(L_6)	3.33	3.33	3.33	3.33	3.33	3.33
Fallow	(F)	3.67	3.33	3.50	3.67	3.67	3.67
Mean		3.38	3.90		3.95	3.81	
C.D. at 5% level and S.Em ±							
Main plot means		NS (0.65)			NS (0.24)		
Sub plot means		NS (0.39)			NS (0.12)		
Sub plot means within same main plot		NS (1.44)			NS (0.45)		
Main plot means at same or different levels of sub plot		NS (1.42)			NS (0.46)		

Figures in parenthesis are S.Em.

Table 35. Length of panicle and number of grains per panicle of rice as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		Length of panicle (cm)			No. of grains per panicle		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	15.67	17.0	16.33	46.67	50.0	48.33
Soya bean	(L_2)	17.0	16.0	16.50	53.67	45.0	49.33
Rice bean	(L_3)	16.0	15.67	15.83	48.0	48.33	48.17
Velvet bean	(L_4)	16.67	16.33	16.50	50.33	48.67	49.50
Cowpea	(L_5)	16.67	17.33	17.00	46.67	54.33	50.50
Black gram	(L_6)	16.0	16.67	16.33	42.33	46.33	44.33
Fallow	(F)	16.33	17.0	16.67	52.33	58.67	55.50
Mean		16.33	16.57		48.57	50.19	
C.D. at 5% level and S.Em ±							
Main plot means			NS (0.39)			NS (2.84)	
Sub plot means			NS (0.25)			NS (1.85)	
Sub plot means within same main plot			NS (0.93)			NS (6.90)	
Main plot means within same or different levels of sub plot			NS (0.91)			NS (6.74)	

Figures in parenthesis are S.Em.

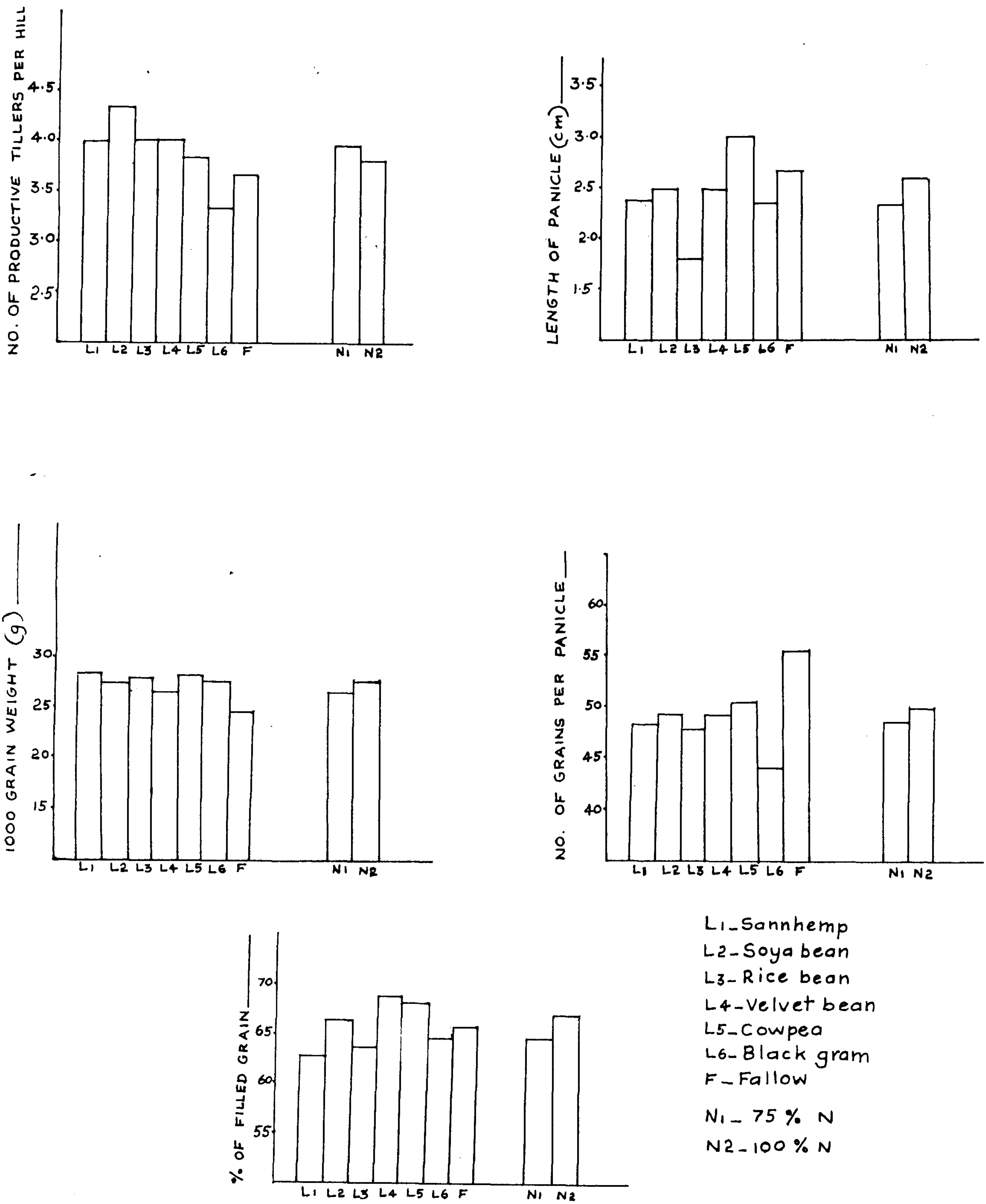
Table 36. Percentage of filled grain and 1000 grain weight as influenced by the preceding legume crops and fallows under two levels of N

Treatment		Percentage of filled grain (transformed data)*			1000 grain weight(g)		
		N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	60.62	65.28	62.95	27.43	28.50	27.97
Soya bean	(L_2)	65.57	67.59	66.58	26.83	27.90	27.37
Rice bean	(L_3)	62.88	64.87	63.88	27.23	27.87	27.55
Velvet bean	(L_4)	67.13	70.38	68.76	25.33	27.73	26.53
Cowpea	(L_5)	66.58	69.40	67.99	27.83	28.43	28.13
Black gram	(L_6)	65.34	64.18	64.76	26.23	28.30	27.27
Fallow	(F)	64.81	66.65	65.73	24.0	24.87	24.43
Mean		64.71	66.91		26.41	27.66	
C.D. at 5% level and S.Em ±							
Main plot means			3.35 (1.09)			0.85 (0.27)	
Sub plot means			1.81 (0.60)			0.35 (0.12)	
Sub plot means within same main plot			NS (2.24)			0.93 (0.43)	
Main plot means at same or different levels of sub plot			NS (2.23)			0.98 (0.45)	

Figures in parenthesis are S.Em.

*Data transformed by arc sine transformation

FIG 12 YIELD ATTRIBUTES OF RICE AS INFLUENCED BY THE PRECEDING LEGUME CROPS UNDER TWO LEVELS OF NITROGEN.



the application of N (Table 36). With regard to the main plot treatments, it can be seen that the highest filled grain percentage was recorded after velvet bean (68.76) and the lowest after sannhemp (62.98). Application of N was found to significantly increase the percentage of filled grain. The interaction effect was also significant.

Both the preceding legume crops and the application of N exerted a significant effect on the percentage of filled grain and the thousand grain weight, but the other yield attributes were not influenced significantly, though a slight increase with increase in the N dose was noticed. It is evident that the preceding legumes did not influence the number of productive tillers, length of panicles and number of grains per panicle. Similarly, N application did not exert much influence on the above characters. Though these yield attributes were not influenced by N application, the number of filled grains and the thousand grain weight were significantly influenced by the different levels of N. The beneficial effect of N application on the yield attributes of maize succeeding summer grain and fodder legumes was reported by Singh et al. (1982).

4.6.2. Grain yield

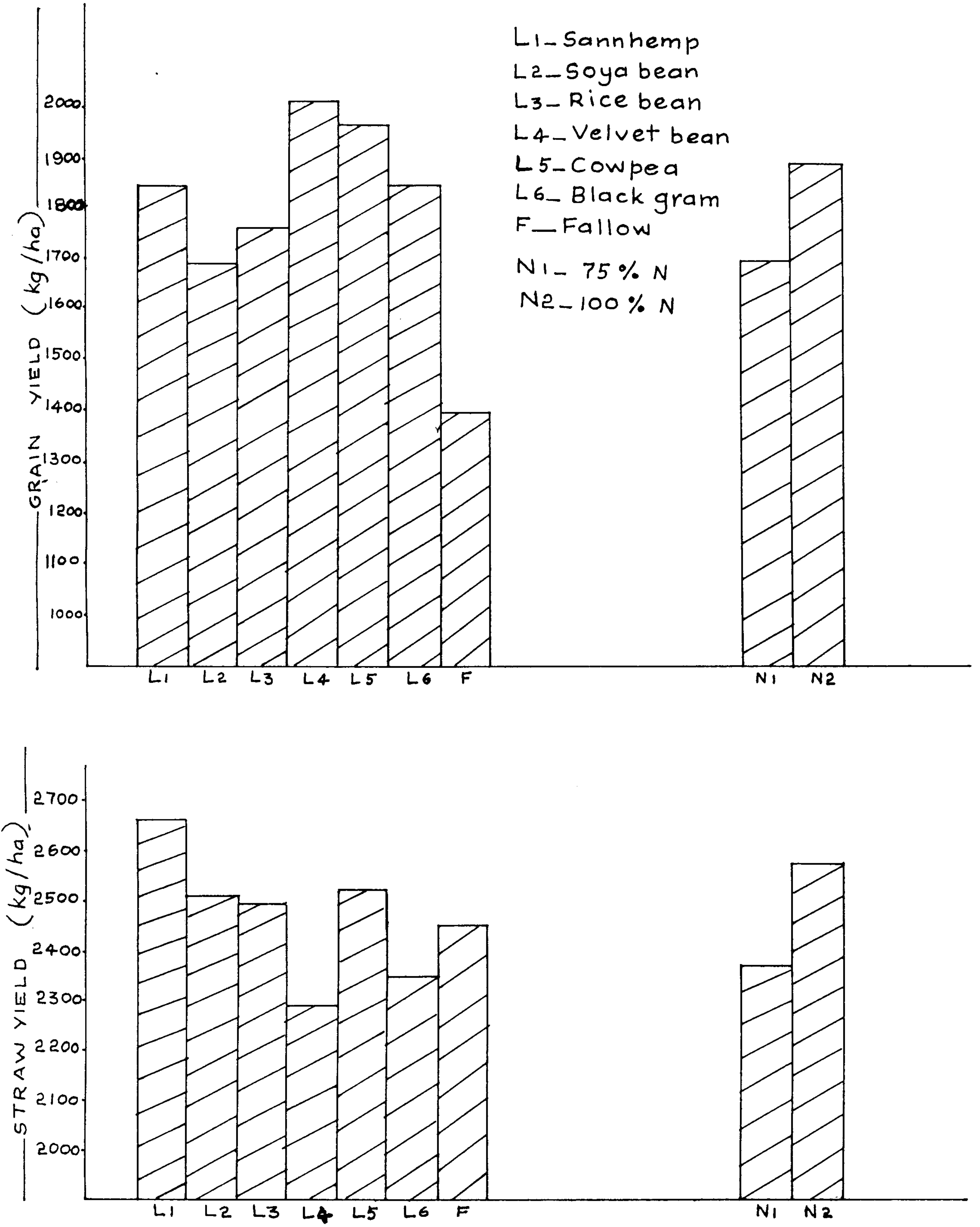
The data on the grain yield of rice are depicted in Table 37 and Fig. 13. It can be seen that the preceding

Table 37. Grain yield, straw yield and grain-straw ratio as influenced by the preceding legume crops and fallows, under two levels of N

Treatment		Grain yield (kg/ha)			Straw yield (kg/ha)			Grain-straw ratio		
		N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
Sannhemp	(L_1)	1772	1909	1841	2558	2731	2645	0.71	0.70	0.71
Soya bean	(L_2)	1671	1738	1704	2447	2569	2508	0.70	0.68	0.69
Rice bean	(L_3)	1719	1813	1766	2447	2523	2485	0.71	0.72	0.72
Velvet bean	(L_4)	1784	2238	2011	1996	2581	2288	0.90	0.90	0.90
Cowpea	(L_5)	1911	2024	1968	2332	2688	2510	0.82	0.75	0.79
Black gram	(L_6)	1761	1946	1853	2107	2558	2332	0.84	0.77	0.80
Fallow	(F)	1283	1521	1402	2539	2370	2455	0.51	0.64	0.58
Mean		1700	1884		2346	2574		0.74	0.73	
C.D. at 5% level and S.Em ±										
Main plot means			343 (111)			NS (154)			0.14 (0.04)	
Sub plot means			83 (27)			207 (68)			NS (0.17)	
Sub plot means within same main plot			NS (102)			NS (255)			NS (0.06)	
Main plot means at same or different levels of sub plot			NS (127)			NS (263)			NS (0.07)	

Figures in parenthesis are S.Em.

FIG. 13 GRAIN YIELD AND STRAW YIELD (kg/ha) OF RICE AS INFLUENCED BY THE PRECEDING LEGUME CROPS, UNDER TWO LEVELS OF NITROGEN



legume crops had a significant influence on the grain yield of rice, as compared to the grain yield in the fallow preceded plot. A significant difference in yield between the two levels of N applied is also visible. Further, it can also be seen that the treatments receiving 100% of the recommended N dose exhibited their superiority over those receiving only 75% of the dose.

The preceding legume crops left the soil richer in total and available N and organic carbon (Figs. 4 and 5) and improved the chemical and physical condition of the soil, and subsequently resulted in better growth and nutrient uptake of the rice crop. The reason for increased rice yield after velvet been could be attributed to the fact that this legume crop produced the highest number of root nodules and fixed substantial quantity of N in the available form (Table 3 and 8). This, the yield of rice following velvet bean was superior to that preceded by soya bean, rice bean and fallow. However, it was on par with those preceded by sannhemp, cowpea and black gram.

It is further to be noted that even though application of N resulted in a significant increase in the grain yield, in the rice crop following fallow, even with application of 100% of the recommended dose of N, the yield was less than that inthose treatments following the legume crops but receiving only 75% of the N dose. This conclusively proves the sonsensus of the superiority of legume cultivation to leaving the land fallow. Similar results of increased yield by growing legumes and subsequent increase in residual fertility were reported in wheat by Singh (1967), Sallal et al. (1968), Amantaey et al. (1970), Borisov et al. (1970) and Hoyt and Hennig (1971); in pearl millet by Singh and Tripathi (1975) and in rice by Tiwari et al. (1980) and Mandal and Ghosh (1984).

As mentioned under Section 4.3., the legumes increased the organic carbon, total and available N content of soil. The highest organic carbon content was observed after cowpea, followed by black gram, rice bean and velvet bean. The total N content also was highest after cowpea, followed by velvet bean, rice bean and black gram, while the available N content increased substantially after velvet bean followed by cowpea. The fallow plot recorded the lowest organic carbon, total and available N.

The increased amount of organic carbon, total and available N in the soil after cowpea, velvet bean, rice bean and black gram, probably helped to produce better crop growth and nutrient uptake by the following rice crop , which ultimately resulted in the observed yield increase.

It is also to be mentioned here that, the beneficial effect of the preceding legumes on the rice crop is reflected in the thousand grain weight and percentage of filled grain. The highest thousand grain weight was recorded in rice after cowpea followed by sannhemp, rice bean and soya bean (Table 36). The highest percentage of filled grain was seen in the rice crop after ~~soya~~ velvet bean, followed by rice bean, cowpea and ~~velvet~~ soya bean. Though the number of grains per panicle was not significantly different, among the legume preceded crops, the highest number was seen after cowpea followed by velvet bean and soya bean.

The influence of these yield attributing characters of rice is evident from the superior yields recorded after velvet bean, cowpea, black gram and sannhemp. Since the cultivation of these legumes has a positive effect on the grain yield of the succeeding rice crop; they can be recommended in rice fields in preference to leaving the land fallow. However, when the fodder yield of the legumes is also taken into consideration, the superiority of sannhemp to all other legumes is clearly seen (Table 6 and Fig. 3). Sannhemp produced more than twice the fodder yield of all other legumes. It was followed by cowpea and rice bean. Velvet bean, though it succeeded in leaving a significant residual effect, was far behind in fodder production.

Thus, when both the fodder yield and the beneficial influence on the grain yield of the succeeding rice crop are considered, among the legumes to be cultivated in rice fallows, the best choices are cowpea and sannhemp. This is more pronounced when the economics of cultivation are also considered, as seen from section 4.7.

To conclude, it can be stated that the rice crop following fallow and receiving 100% of the recommended N dose is on par with all other treatments following legumes but receiving only 75% of the recommended N dose. The residual effect of legumes is thus equivalent to 25% of the recommended N dose, and a preceding legume crop can result in a N economy of 25% in the succeeding rice crop.

4.6.3. Straw yield

The preceding legume crops did not have a significant effect on the straw yield of the rice crop (Table 37 and Fig.13). The highest straw yield was recorded in the rice crop following cowpea, and the lowest in that following velvet bean. Application of 100% of the recommended dose of N resulted in significant increase in the straw yield. This may be due to the increased vegetative growth of the plants, which is evident from the increased height of the plants on application of 100% N (Table 13).

The preceding legume crops had no effect on the straw yield of the rice crop. Hence, application of an increased dose of N could bring about significant increase in the straw yield. The increased availability of N on application of the full N dose must have resulted in better uptake of N and more vigorous growth, and increased straw yield.

4.6.4. Grain - straw ratio

The grain-straw ratio was significantly affected by the preceding legume crops, with the velvet bean cropped plot recording the highest ratio, and that following fallow recording the lowest (Table 37). Nitrogen application had no significant effect on the grain-straw ratio.

The high grain-straw ratio after velvet bean is due to the high grain yield which was recorded in the crop following velvet bean. Both the grain yield and the straw yield increased with application of 100% of the N dose, and so the grain-straw ratio was not significantly changed due to N application.

4.7. Economics of different cropping systems

4.7.1. Net income

Among the various fodder legume - rice cropping sequences, the highest total net income was obtained from the sannhemp-rice cropping sequence (Rs.1597/ha) when rice received 75% N, and Rs.1857/ha when rice received 100% N (Table 38). The next highest net income was obtained from cowpea-rice cropping sequence (Rs.762.32/ha when rice received 75% N, and Rs.1066.77/ha when rice received 100% N. Black gram-rice cropping sequence in which rice received 100% N recorded a total net income of Rs.331.99/ha, while rice bean-rice cropping sequence (with rice receiving 100% N) recorded a negligible total saving of Rs.6.30/ha. All other cropping sequences recorded a loss, with the highest loss being from velvet bean-rice with rice receiving 75% N (Rs.1311.25/ha), followed by fallow-rice with rice receiving 75% N (Rs.1013.98/ha).

When the net income from the rice crop alone was considered, the highest return was recorded after velvet bean, when rice received the full recommended N dose (Rs.815.84/ha), followed by the crop after cowpea which received 100% N (Rs.442.77/ha). Rice after sannhemp with the complete N dose recorded a net income of Rs.233.47/ha. Invariably (except the rice crop following cowpea), all cases where rice received only 75% of the recommended N dose registered a loss. Even when rice received 100% of the recommended N dose, losses were recorded by the rice crops following soya bean, rice bean and fallow. When the net income from the fodder legumes alone was considered, the maximum was from sannhemp (Rs.1624/ha), followed by cowpea (Rs.624/ha), black gram (Rs.112/ha) and

Table 38. Economics of fodder legume - rice cropping sequences

Cost of cultivation: Fodder legumes	Cost of cultivation: Rice 75% N (N_1)	Cost of cultivation: Rice 100% N (N_2)	Income from legumes (Rs./ha)		Income from rice (Rs./ha)	Net income (Rs./ha)	Returns per rupee invested (Rs.)
Rs.2520/ha	Rs.4850/ha	Rs.4950/ha	Sannhemp (L_1) : 4144	L_1 N_1 :	4823.36	1597.36	1.22
				N_2 :	5183.47	1857.47	1.25
			Soya bean (L_2) : 1952	L_2 N_1 :	4565.60	-852.40	0.88
				N_2 :	4760.18	-757.82	0.90
			Rice bean (L_3) : 2588	L_3 N_1 :	4661.20	-120.80	0.98
				N_2 :	4888.30	6.30	1.00
			Velvet bean (L_4) : 1492	L_4 N_1 :	4566.75	-1311.25	0.82
				N_2 :	5765.84	-212.16	0.97
			Cowpea (L_5) : 3144	L_5 N_1 :	4988.32	762.32	1.10
				N_2 :	5392.77	1066.77	1.14
			Black gram (L_6) : 2632	L_6 N_1 :	4575.52	-162.48	0.98
				N_2 :	5169.99	331.99	1.04
			Fallow (F) : Nil	F N_1 :	3836.02	-1013.98	0.79
				N_2 :	4227.36	-772.64	0.85

rice bean (Rs.65/ha). Soya bean and velvet bean recorded losses of Rs.568/ha and Rs.1028/ha respectively.

Even though the residual effect of velvet bean greatly increased the income from the following rice crop receiving 100% N, because of the low fodder yield, the net income was low. Sannhemp, on the other hand, produced large quantities of green matter and its residual effect was also significant in increasing the grain yield of the succeeding rice crop and that the highest total net returns were obtained from the sannhemp-rice cropping sequence.

4.7.2. Returns per rupee invested

The returns per rupee invested (Table 38) reveal that as in the case of total net income, the sannhemp-rice cropping sequence recorded the highest returns (Rs.1.22 and 1.25 for 75% N and 100% N respectively), followed by cowpea-rice cropping sequence (Rs.1.10 and Rs.1.14 for 75% N and 100% N respectively). Except for the rice crop following velvet bean and receiving 75% N which recorded a return of Rs.0.82 per rupee invested, the lowest gains per rupee invested were recorded by the crop after fallow (Rs.0.79 and Rs.0.85 for 75% N and 100% N respectively. This was in spite of the fact that the cost of cultivation was much less for the monocropping system than for the double cropping system. This indicates that the production potential of a rice crop taken after fallow is much less than that of one following legumes, and it is always better to have a legume preceding rice than to leave the land fallow. The results indicate that considering both the legume fodder yield and the grain and straw yields of rice, the best legume to be grown in rice fallows is sannhemp, followed by cowpea. Velvet bean, though it significantly increases the grain yield of the succeeding rice crop, is inferior to sannhemp and cowpea because of its comparitively low fodder production potential.

In all the cases, the total net income and the returns per rupee invested were higher when 100% N was applied than when 75% N was applied. However, except in the case of velvet bean, the rice crops following legumes and receiving only 75% N recorded higher total net income and returns per rupee invested than the rice crop taken after fallow and which received the total recommended N dose.

Summary

5. SUMMARY

An investigation on "Potential and prospects of fodder legumes in rice fallows" was undertaken at the Agricultural Research Station, Mannuthy in the third crop season of 1985-'86 and the first crop season of 1986-'87. The major objectives of the investigation were to evaluate the relative performance of fodder legumes in rice fallows, and to find out the residual effect of the legumes and subsequent nitrogen economy in *kharif* rice. The experiment also aimed to ascertain the physical and chemical changes in the soil brought about by fodder legumes and their effect on the succeeding rice crop.

The experiment was laid out in a split plot design with six fodder legumes (sannhemp, soya bean, rice bean, velvet bean, cowpea and black gram) and a fallow as main plot treatments and two levels of N, 70 kg/ha and 52.5 kg/ha (100% and 75% of the recommended dose) which were applied to rice in *kharif* as sub-plot treatments. The results obtained are summarized below.

1. Among the different fodder legumes, maximum number of nodules per plant was recorded in velvet bean.
2. Maximum fodder yield (21 t/ha) was obtained from sannhemp.

3. A decrease in bulk density and an increase in the water stable aggregates were observed in all the treatments.

4. The highest organic carbon content in soil was recorded after cowpea.

5. The total N content of the soil was maximum after cowpea and available N content was more after velvet bean.

6. There was no change in the total P content in soil after legumes. However, the available P content showed an increase and was maximum after sannhemp in the top 0-15 cm soil layer.

7. The total soil K content was not seen influenced by legume cultivation. Contrary to this, the available K content in soil was reduced after legumes, except in the case of black gram.

8. Plant height of rice increased after legumes.

9. A significant increase in the N content and N uptake of rice was noticed with application of N at 70 kg/ha.

10. The P content and P uptake of rice increased with increase in N application.

11. Highest thousand grain weight was recorded after cowpea.

12. Increased N application significantly increased the thousand grain weight.

13. The filled grain percentage was maximum after velvet bean.

14. Application of N at 70 kg/ha significantly increased the percentage of filled grain.

15. The highest grain yield was recorded after velvet bean, followed by sannhemp and cowpea.

16. Increased application of N resulted in a significant increase in grain yield.

17. The highest net income was obtained from the sannhemp-rice cropping sequence. The lowest income was recorded in the velvet bean-rice crop cropping sequence.

18. The highest returns per rupee invested were obtained when rice was cultivated after sannhemp.

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POTENTIAL AND PROSPECTS OF FODDER LEGUMES IN RICE FALLOWS

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ABSTRACT

An experiment was conducted in the Agricultural Research Station, Mannuthy, during third crop season of 1985-'86 and first crop season of 1986-'87 to evaluate the relative performance of fodder legumes in rice fallows and their residual effect on the succeeding crop of rice under graded levels of N. The experiment, replicated thrice, was laid out in a split plot design with seven treatments - six fodder legumes (sannhemp, soya bean, rice bean, velvet bean, cowpea and black gram and a fallow - as main plot treatments and two N levels (52.5 and 70 kg/ha) applied to <u>kharif</u> rice as sub-plot treatments.

The results revealed that sannhemp gave a fodder yield of 21 t/ha in rice fallows which was significantly superior to all other treatments. An increase in soil organic carbon, total and available N was also noticed. Soil organic carbon and total N was highest in the cowpea cropped plot. Available N in the soil was highest in the velvet bean cropped plot, and the fallow plot recorded the lowest values.

Increased rice grain yield was recorded after legumes compared to fallow, and the highest grain yield was recorded after velvet bean, followed by that after sannhemp, cowpea

and black gram. Application of N at the recommended dose of 70 kg/ha produced superior yields compared to N at 52.5 kg/ha. Rice crop succeeding fodder legumes, with 75% N produced grain yield comparable to that after fallow receiving 100% N. The net income and returns per rupee invested were highest after the sannhemp-rice sequence, followed by the cowpea-rice sequence.

The results proved that 25% N could be saved in the case of rice after legumes. The study also showed the superiority of sannhemp and cowpea in fodder yield and residual effect in the succeeding rice crop.