SPATIAL ARRANGEMENT AND NUTRIENT MANAGEMENT OF GRAIN COWPEA-FODDER MAIZE INTERCROPPING IN SUMMER RICE FALLOWS

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Spatial arrangement and nutrient management of grain cowpea-fodder maize intercropping in summer rice fallows" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title at any other University or Society.

Vellayani,
18th July, 1990.

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CERTIFICATE

Certified that this thesis entitled "Spatial arrangement and nutrient management of grain cowpea-fodder maize intercropping in summer rice fallows" is a record of research work done independently by Miss. Sunitha, S. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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CONTENTS

LIST OF TABLES

List of Tables (contd.)

LIST OF ILLUSTRATIONS

List of illustrations (contd.)

LIST OF PLATES

INTRODUCTION

INTRODUCTION

The success of modern agriculture largely depends on the availability of energy. Under pressure of population and shortage of energy, emphasis should be laid on techniques that can increase food production without using large quantities of energy. Pulses are crucial to the balance of nature as many of them have the ability to fix atmospheric nitrogen.

Pulses occupy an area of about 0.28 lakh hectares in Kerala. Among the pulses, cowpea dominates the scene under Kerala conditions. It is difficult to accurately estimate the cultivated area due to its association with other crops. It is grown in large areas as a third crop in summer rice fallows. On a global basis, it is estimated that cowpea is cultivated in over 7.7 million hectares. Pulse production in the country continued to stagnate between 10 and 13 million tonnes during 1953-'54 to 1989-'90.

Livestock population of India is the largest in the world but the production of milk and other livestock products is the lowest. This could be ascribed to acute shortage of nutritious green forage, which has positive relationship with animal health and consequently on their productivity. The area under cultivated food crops in the State remained stagnant for the last many years and the prospects of diverting a part of food growing areas for fodder crops are bleak due to growing human population and consequently heavy pressure on land for food crops. Considering the importance of livestock in Indian Agriculture, the present position of forage availability, its requirement and the competition between food and fodder crops for cultivated land, new crop production system need to be tailored to augment forage production along with food crops, particularly in rainfed areas.

Rice-rice-grain cowpea is a very common cropping system in Kerala State. Thus, in summer, when there is ample sunshine, introduction of a C_4 plant like maize along with cowpea can harvest solar radiation more efficiently than the sole crop of cowpea which is a C_3 crop. It is in this context the introduction of fodder maize along with cowpea in summer rice fallows becomes highly significant. Maize is well known for its drought tolerance and hence can be successfully raised as a summer crop in rice fallows. Moreover, the soil and climatic conditions of Kerala are favourable for the growth of maize (Jaleesa, 1987).

Maize which can be successfully raised as a summer crop in rice fallows, gives high tonnage of nutritious fodder of good palatability within a short period of 60 days. Cropping systems with maize (fodder) as summer crop produced more biomass than those having cowpea as summer fodder (Mercy George and Rajendra Prasad, 1989). The maize-legume combination can use the resources efficiently and through beneficial annidations, can increase the production potential of the rice fallows. Thus introduction of fodder maize with cowpea in the popular rice-rice-cowpea cropping system can increase the returns.

The present study will help to get information on suitable spatial arrangement of cowpea and fodder maize and to work out an appropriate nutrient combination for the intercropping system as a whole. Cowpea is considered as the base crop. It is tried in different spatial arrangements with varying populations of fodder maize.

Adequate fertilizer application is an important factor for the better performance of any system. The nutritional requirements of cowpea and fodder maize have been investigated separately in Kerala. But the nutrient requirements of these crops when grown in association need detailed investigation.

Moreover the production potential of cowpea + maize mixtures and the additional income that can be generated by the system have not been investigated in detail. Hence, the present study is undertaken with the following main objectives:

1. To test the possibilities of introducing with grain cowpea, a C_4 crop like fodder maize for efficient utilisation of resources in summer rice fallows.

2. To assess the optimum cowpea-maize ratio for maximum grain yield and fodder production.

3. To work out suitable fertilizer doses for the different grain cowpea + fodder maize combinations.

4. To work out the economics of combining fodder maize with grain cowpea at different levels of fertilization.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Farmers in the developing world have been growing two or more crops together on the same piece of land for many centuries. Intercropping appears to make better use of the natural resources of sunlight, land, and water. The advantage of mixing a legume with a nonlegume to save on the use of nitrogenous fertilizers needs no emphasis. New technological modifications in time, technique, and pattern of planting crops grown in association have made intercropping an economically viable and feasible practice. Intercropping maize with cowpea is generally found to increase the yield of the total system, to provide better returns to the farmer and to produce a better quality fodder for the cattle than the practice of growing maize alone. The major works conducted in India and abroad on cowpea + maize intercropping and related fields are reviewed here.

2.1. Legume-Maize Interactions

The harmful or beneficial effect of a particular cropping system is the net result of different types of interaction between the component crops, viz., competition, complementary effect, supplementary effect, annidation, allelopathy etc. So two plant species with contrasting morphological and physiological characters will together be able to exploit their total environment more effectively than their monoculture and will thereby give increased yield and net returns.

2.1.1. Effect of legume on maize/other grasses

2.1.1.1. Effect on growth and growth characters

Guljaev and Ronsal (1962) reported that growth of maize was stimulated by secretions from the roots of cowpeas and soybeans. Meenakshi _et al._ (1975) observed no adverse effect on the growth of maize crop when it was intercropped with cowpea.

Gangwar and Kalra (1978) found that growing of _mung_ and _urd_ with maize helped in greater ramification of root system in maize which might be due to early nodulation in _mung_ and _urd_ and release of nitrogen for the development of maize root. Singh and Guleria (1979) found that intercropping soybean in maize did not affect adversely the growth and development of maize measured in terms of plant height, functional leaves per plant and leaf area index.

Height of forage grasses was higher when mixed with legumes and intercropping increased the leaf-stem ratio of grasses (Chandini, 1980). Daimon and Chujo (1986) reported a reduction in nitrogen content of maize tops in legume mixtures than when grown alone, the reduction being greater with cowpea or late maturing soybean than with *Phaseolus vulgaris* or early maturing soybean.

Patra *et al.* (1986) observed that 28 per cent of total N uptake by maize was of atmospheric origin and was obtained by transfer of fixed nitrogen by cowpea grown in association with maize. Uddin and Irabagen (1986) reported that the height of corn plants intercropped with soybean was significantly higher than that of corn with cowpea. Corn plants intercropped with *mung* bean or peanut were comparable in height with corn intercropped with either soybean or cowpea. Davis and Garcia (1987) found that in a corn + bean mixture the increase in plant density of beans was found to reduce lodging in maize due to anchoring effect of the climbing beans.

2.1.1.2. Effect on yield and dry matter production

Ahlawat *et al.* (1964) reported that cowpea as a companion crop significantly increased the yield of grasses like jowar, bajra and sudangrass and the effect on jowar was the most marked. A slight increase in yield of maize was reported in a maize + cowpea mixture (Gautam *et al.*, 1964). But, this apparently higher yield with leguminous intercrops was not statistically different from that without any intercrop.

Sharma and Singh (1972) reported that alternating one row of maize with one row of cowpea decreased the total drymatter yield in comparison with planting maize alone.

Meenakshi et al. (1974) reported no adverse effect on the maize crop when it was intercropped with cowpea. A higher fodder yield of maize alone rather than their mixture with cowpea was reported (Anon., 1975). Bogdan (1977) found that the increase in total yield of mixed herbage was mainly contributed by the legumes grown in the mixture.

The yield of sorghum was not affected by intercrops and among the intercrops cowpea gave the maximum yield (Morachan et al., 1977). Ahmed and Gunasena (1979) reported that as a general rule, maize yields were slightly depressed by intercropping particularly at low nitrogen levels. Chandini (1980) reported an increase in green matter yields of forage grasses and legumes due to intercropping.

The companion cropping of maize with cowpea produced significantly higher total drymatter yield compared to growing of maize alone or in association with cluster beans (Chauhan and Dungarwal, 1980). Gangwar (1980) reported that intercrops offered virtually no competition with the main crop, but legumes augmented maize production.

On the contrary, Remison (1980) reported that pure crop of maize gave greater yield than mixtures, when it was intercropped with cowpea at various frequencies. Davis and Garcia (1983) reported a 15-30 per cent reduction in maize yield when it was intercropped with beans. But Singh and Singh (1984) reported that intercropping of maize with soybean and blackgram under Tarai (humid) conditions of Uttar Pradesh increased maize yield by 17-22 per cent.

Chang and Shibles (1985 a) reported that in a maize + cowpea mixture, the drymatter productivity was greater in the mixture than in sole cultures. But, in a study on intercropping of maize with blackgram, greengram, cowpea and groundnut, Mittal et al. (1985) reported that mean maximum yield of maize was obtained when grown as pure crop at 60 cm spacing. All intercrops reduced maize yield. The total production in terms of maize equivalent was the highest with groundnut and was the least with cowpea. Tariah and Wahua (1985) also reported 8 per cent reduction in maize yield when it was intercropped with cowpea.

There was a reduction in the green fodder yield of maize when grown in combination with Dolichos and Horsegram compared to sole maize. However, there was no effect of cowpea, blackgram, soybean, kidneybean, clusterbean and greengram on maize yield in mixture (Angadi, 1986). Ofori and Stern (1986) reported that yields of maize and cowpea were significantly reduced by intercropping. Morgado (1986) reported that the yield of intercropped maize was 30 per cent lower than the sole crop.

Yields and nutrient contents of silage maize were compared with or without soybean by Baran and Lazar (1988). The biomass yields of the mixture were equivalent to those of maize grown alone, but nutrient contents were higher in the mixture. In a cowpea + maize intercropping study, Lee (1988) concluded that intercropping system could give increased protein yield without decreasing the drymatter yield. When cowpea was intercropped with pearl millet, early maturing erect cultivars of cowpea had the least effect on millet yields (Ntare, 1989).

The above review shows that generally there is a favourable influence of legume on maize when grown in association though in some cases, unfavourable effects are also noticed.

2.1.2. Effect of maize on legume

2.1.2.1. Effect on growth and growth characters

Agboola and Fayemi (1970) observed no suppression of legumes by maize when they were grown together. However, a depression in the growth of legumes due to maize was noted by Agboola and Fayemi (1971).

Dalal (1974) noted that in a legume and non-legume mixture, growth of legumes was usually depressed more than non-legumes. Maizel (1974) noticed that when maize was intercropped with cowpea, the former was found to be more competitive than the latter upto the time of tasselling. Thereafter cowpea was more competitive than maize.

Thomas (1975) found that maize crop could be used to alter the competitive balance in favour of legumes when they were grown together. An increase in growth and growth characters of plants in a maize + legume intercropping system was observed by Chand (1977).

Singh and Relwani (1978) reported that the competitive effect was the highest when the seeds of maize and legumes were mixed together and sown in the same row. The results of another experiment to study the competitive ability and growth habit of indeterminate beans and maize in intercropping had shown that the most competitive bean varieties yielded the most when intercropped with maize, but these varieties were not necessarily the highest yielding in sole culture (Davis and Garcia, 1983).

Kessel and Roskoski (1988) observed that nitrogen transfer from cowpea to maize was minimal in intercropping and maize did not increase N-fixation in cowpea through competition for soil nitrogen.

2.1.2.2. Effect on yield and drymatter production

Donald (1963) reported that in a mixed cropping the yield of legume was depressed more than that of non-legumes. Syarifuddin et al. (1974) obtained decreased yield of legumes which were grown as intercrops in maize, but the high yields of maize compensated for the reduction in yields of these legumes. But Remison (1980) reported that the yield of cowpea was no less when grown in mixture with maize than when grown alone and when grown in a 50 : 50 mixture.

Tariah and Wahua (1985) noted drastic yield reduction in cowpea by about 52 per cent in mixtures with maize. On the other hand, Cheng and Shibles (1985 a) observed that the greatest seed yields resulted when cowpea showed strong competition with little yield reduction per plant.

Morgado (1986) reported that the yield of intercropped cowpea with maize was 30-53 per cent lower than the sole crop. Intercropping beans with maize in the same row and between two maize rows significantly reduced pod number per plant, seed number and seed dry weight. Ofori and Stern (1986) also reported that yields of cowpea were significantly reduced by intercropping. Compared to sole crops, intercropping, on an average, reduced cowpea seed yields by about 45 per cent.

Intercropping cowpea with pearl millet reduced cowpea yields significantly, but the degree of reduction varied among cultivars. Early maturing erect cultivars exhibited greater yield reduction than the indeterminate spreading types (Ntare, 1989).

From the foregoing review it is seen that intercropping generally reduces the yield of legumes in the legume + maize intercropping system.

2.2. Effect of spatial arrangement and plant population on legume + maize intercropping

Willey and Osiru (1972) found that mixtures of fodder crops require a higher population pressure to produce their maximum yield.

Sowing crops in the normally recommended uniform row distance would afford little or no opportunity for accommodating a companion crop. On the other hand, modification of a planting pattern of the base crop would make intercropping more feasible and often more remunerative. Keeping the plant population per unit area of the base crop constant, no deviation in its yield could be noted by altering the orientation of rows (Do et al., 1978).

From the experiments conducted in N.E. Brazil, Lima and Lopes (1979) concluded that the best spatial arrangement for maize-bean intercropping was 1:3, comprising 12,500 plants/ha of maize and 150,000 plants/ha of beans. Tariah and Wahua (1985) conducted an experiment to study the effects of component populations on yields and land equivalent ratios of intercropped maize and cowpea. They observed that maize yields in pure and mixed stands increased as the maize population increased. The cowpea yields also increased approximately in a linear manner as the cowpea population increased in pure and mixed stands, but the rate of increase was much less in the mixture. The suggested optimum component populations were 20,000 plants ha^{-1} for maize and 33,000 plants ha^{-1} for cowpea. Tijan and Theodore (1985) observed that some cowpea cultivars had an apparently linear seed yield response to density between 40,000 and 250,000 plants/ha while some others showed no significant response to density.

Maize and soybean grown in separate rows of a pair of rows 20 cm apart with an interspace of 70 cm between the two pairs of rows gave maximum fresh fodder (Umarov *et al.*, 1985). Chang and Shibles (1985 b) reported that there was no advantage in using a full cowpea population density when it was intercropped with maize, as the maize population density generally imposed a limit on cowpea seed productivity. Stoop (1986) reported that even a cowpea population of 5000 plants ha^{-1} could significantly reduce sorghum and maize yields on moisture-stressed soils.

A field experiment to determine the fodder production potential of maize as affected by different biotectural arrangement and population density of maize-mungbean as an intercrop (Abdur Razzaque and Elpidio, 1987) indicated considerable potential of producing maize fodder without affecting its normal economic yield. Increasing maize population from 100,000 to 300,000/ha and gradually reducing it to a normal population of 50,000 plants/ha increased total maize fodder yield from 1.76-8.29 tons/ha on drymatter basis.

Kumar *et al.* (1987) reported that in maize + cowpea intercropping, single row intercrop gave more yield and financial advantage over double row system. When maize was grown alone, or intercropped with one or paired rows of cowpea, net income was maximum when grown with one row of cowpea (Mutanal, 1987). Sayagavi (1987) also reported that cowpea population influenced the total fodder yield of mixtures. South African maize mixed with cowpea at high population recorded more green fodder yield whereas cowpea mixed at low population recorded more total crude protein yield.

Ofori and Stern (1987 a) reported that in a maize + cowpea mixture increasing the density of either crop resulted in increases in total yield. Jayakumar (1988) observed that for increased fodder production, fodder quality, soil fertility and net income, of a forage based cropping system involving six rows of cowpea grown in the interspace of paired row planted (30 x 30/90 cm) guinea grass would be the ideal.

Total nitrogen yield of monocropped and intercropped plants depended on row spacing and cropping system (Kessel and Roskoski, 1988) the lowest density produced the highest total nitrogen for intercropped maize, whereas plant density had no effect on total nitrogen in intercropped cowpea. Odongo <u>et al</u>. (1988) reported that shading by maize reduced yields of intercrop soybean, especially at higher maize density.

Srinivas and Lingam (1988) observed that fodder sorghum sown as sole crop at 45 cm spacing produced more green and dry fodder yields. Rout *et al.* (1989) reported that maize + cowpea in 2:1 ratio produced more green fodder, drymatter and crude protein.

From the above it is clear that the yield of either crops in the mixture is a function of its density. The plant arrangement also has some precise effects on the total cropping system.

2.3. Effect of nutrients on cowpea + maize intercropping

Balanced application of fertilizer elements is essential for getting higher yields. In an intercropping system involving two different crops like legumes and grasses, the nutrient supply system involves greater dynamics.

2.3.1. Nitrogen

2.3.1.1. Effect on growth and growth characters

Gill *et al.* (1972) showed that sorghum grown on red gravelly soil responded to nitrogen application upto 75 kg/ha when it was grown mixed with cowpea.

Chatterjee *et al.* (1978) recommended the use of low level of nitrogenous fertilizer in mixed cropping to favour the growth of legumes. The root growth of maize was highly associated with nitrogen application and this was essential in order to counteract the competitive effect of legumes on root growth of maize (Gangwar and Kalra, 1978).

Significant effect of nitrogen on plant height of maize at all stages of growth was reported by Lincy Xavier (1986). Nitrogen at 200 kg/ha recorded the maximum number of leaves.

2.3.1.2. Effect on yield and drymatter production

Dobrovodsky (1968) from his field trials conducted in two seasons with fodder maize concluded that there was no response to nitrogen application in the year of below average rainfall, while there was response to nitrogen application in the year of above average rainfall. He also suggested that optimum response was at 100-150 kg N/ha.

The effects of intercropping maize with cowpea and mung bean at varying nitrogen levels were studied by Agboola and Fayemi (1970) and they found that maize yield was not decreased by intercropping.

Singh and Chand (1980) observed a significant and consistent increase in stover yields of maize with increase in nitrogen level upto 120 kg/ha. Application of 20 kg N/ha as basal along with 10 kg N/ha as foliar spray at midpod fill stage could give higher grain yields in cowpea

(Sheela, 1985). Morgado (1986) reported a detrimental effect on sole cropped maize yield by high nitrogen rate. Intercropped cowpea yield was 30-53 per cent lower than in sole cropping and yield for intercrop maize was 30 per cent of that of sole cropped maize.

Ezumah *et al.* (1987) reported that maize yield increased by 62 per cent with nitrogen rates from 0-120 kg/ha while average cowpea yields declined by 27 per cent. Increased drymatter yield of maize with increase in nitrogen rate was also reported by Nnoham and Odurukwe (1987).

Ofori and Stern (1987 b) reported that maize was more efficient than cowpea in the utilization of N to produce grain. But Brayan and Peprah (1988) reported no effect of applied N on maize-legume forage production.

Jeyaraman *et al.* (1988) reported that simultaneously and staggered sown maize + cowpea systems with additional dose of 25 kg N/ha were more productive. Thorat and Ramteke (1988) reported that N fertilization significantly influenced the drymatter production in forage maize at all the crop growth stages. Application of 180 kg N/ha was on par with the dose of 120 kg N/ha.

2.3.1.3. Effect on nutrient content and uptake

Under different intercropping systems, N content and uptake increased significantly by the application of N except at early stages of growth (Chand, 1977). Morachan et al (1977) observed that about 30 kg N/ha could be reduced from the fertilizer requirement of sorghum by growing blackgram, greengram or cowpea as intercrop.

Aggarwal et al. (1978) reported that the total N uptake was significantly related to the above ground bio-mass production. Nitrogen uptake in herbage was greater than applied N fertilizer with the exception of the highest rates of N applied without phosphorus (Nuttal, 1980).

Ofori and Stern (1986) reported that the N uptake in maize and cowpea was reduced by intercropping cowpea and maize, but the plant N concentration was not affected. In two year trials with maize intercropped with greengram, best utilisation of N was achieved when it was applied broadcast and incorporated or applied in bands near the maize rows.

2.3.1.4. Effect on quality

Shaaban (1968) indicated that 200 kg nitrogen increased crude protein content by 50 per cent and crude protein yield by 65-75 per cent. Similar trend of increase in the crude protein content with increase in nitrogen levels was also reported by Sharma and Mudgal (1968);

Kalinina and Bessonova (1970); Tripathi (1971); Gill et al. (1972); Sharma and Singh (1973) and Rajagopal et al. (1974) in maize fodder.

Ahmed and Gunasena (1979) reported that the crude protein content of cowpea was not affected by N levels but that of maize increased in both monocrop and intercrop systems. They also found that the crude protein content of the intercrop system was much higher than that of the maize monocrop at all N levels. But Reddy et al. (1985) reported that increasing fertilizer N had no beneficial affect on maize fodder. Growing maize with legumes resulted in early maturity and increased protein content (Gangwar and Kalra, 1988).

2.3.2. Phosphorus

2.3.2.1. Effect on growth and growth characters

The growth of maize in a maize + legume mixture treated with single superphosphate was the same as that of solecropped maize given single superphosphate plus 80 kg N/ha (Agboola and Fayemi, 1970).

Garg et al. (1970) found an increase in the number of leaves in cowpea with increase in phosphorus application. Progressive increase in leaf area index of cowpea was reported by Balakumaran (1981) and Mercy George (1981) while Geethakumari (1981) recorded increase in plant height with P application.

2.3.2.2. Effect on yield and drymatter production

A significant increase in the drymatter yield of maize by phosphorus application was reported by Bhandari and Virmani (1972). Average drymatter yield of cowpea was increased from 772 to 964 kg/ha by an increase in applied phosphorus from 0-20 kg/ha (Faroda, 1973).

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

Tripathi et al. (1984) reported that application of 60 kg P_2O_5/ha to cowpea grown in rows of 25 and 75 cm apart for fodder and seed production respectively gave the highest yields. Mnoham (1986) reported the higher mean grain yield of cowpea from applying 60 kg P_2O_5/ha which was on par with 30 kg P_2O_5/ha.

2.3.2.3. Effect on nutrient content and uptake

Maloth and Prasad (1976) reported that application of superphosphate at 50 kg P_2O_5/ha almost doubled the uptake of P by cowpea. Nuttal (1980) found that phosphorus uptake (6.3 to 18.9 kg P/ha) was less than applied phosphorus (20 kg/ha) in a mixture of brome grass and alfalfa.

In a maize + legume mixture upto 40 DAS, the legumes, the fertilizer levels and their interaction had significant effects on phosphorus uptake by maize (Mercy George, 1981).

From an experiment to study the performance of maize and beans in separate or associated cropping systems under the influence of phosphate fertilization, Barrato and Serpa (1986) found that application of 300 kg P_2O_5/ha gave the same values of tissue P contents for both species in both cropping systems indicating that a single application would suffice for both crops.

2.3.2.4. Effect on quality

Protein content of cowpea was increased due to P fertilization (Omueti and Oyenuga, 1970; ~~and~~ Gill et al., 1972). Hutton (1970) reported that phosphorus application decreased the nitrogen and potash content of grasses but did not affect the calcium content and increased magnesium content of most species.

Chandini (1980) reported that P addition increased the crude protein content of grasses and legumes, but decreased the fibre content in grass-legume mixtures.

2.3.3. Potassium

2.3.3.1. Effect on growth and growth characters

Castle and Holmes (1960) reported that application of 0.4 to 0.8 kg K was required for every kilogram nitrogen to maintain herbage production satisfactorily. In a three year field trial with soybean, Groneman (1974) observed that K fertilizers had little effect on growth. John (1979) reported that in a grass legume mixture, the grass was favoured by condition of high P and low K while low P and high K gave the legume a competitive advantage.

The vegetative growth of switch grass was favoured by N fertilization but not by K (Smith, 1979). Annamma George (1980) obtained an increase in height and number of leaves of blackgram with the application of potassium fertilizer upto 30 kg/ha.

2.3.3.2. Effect on yield and drymatter production

The yield of fodder maize was increased with increasing levels of exchangeable K in the soil (Mengel and Braunschweig, 1972).

Application of potassium fertilizer produced better effect than it did formerly due to increased use of nitrogen and phosphorus in fodder crops (Chang and Liang, 1981).

Patel et al. (1985) reported that maize hybrid Gangasafed gave the highest yields with 120 kg K_2O and irrigation at 25 per cent depletion of available soil moisture.

2.3.3.3. Effect on nutrient content and uptake

Mudd (1976) found that when grasses received K fertilization they showed a low Ca and P content in the early stages. The use of large quantities of K fertilizer reduced the Ca and Mg contents of the hay crop, whereas increasing the amount of N fertilizer caused them to rise. A high level of K significantly raised the K : (Ca + Mg) ratio from 2.9-3.6 (Jokinen, 1979).

In a maize + legume mixture it was seen that the legumes, the fertilizer levels and their interaction had significant effect on the uptake of K by maize at 20 and 40 DAS (Mercy George, 1981).

Singh and Ghosh (1984) reported that uptake of K was minimum for light textured soils having comparatively lower amount of available K. ~~Level of applied K~~ Potassium at different levels yielded significantly higher than control in case of maize and total potassium uptake by maize was also significantly increased over control. Potassium uptake by cowpea progressively increased with applied potassium.

2.3.3.4. Effect on quality

Stewart and Reed (1969) found that application of potassium to peas decreased the Ca and Mg contents in the forage. Gill *et al.* (1971) reported that K tended to decrease the crude protein content of maize and sorghum but increased the crude protein content of cowpeas.

The use of large quantities of K fertilizers reduced the Mg content of the hay crop and K content had a greater effect on K : (Ca + Mg) ratio than any other nutrient content (Jokinen, 1979).

2.3.4. Combined effect of nitrogen, phosphorus and potassium on growth, yield, quality and uptake of nutrients

In field trials with fodder maize, Glogov (1969) found that the contents of N, P and K decreased from the early stages of growth to the milk stage, the decrease in P being the smallest. The content and uptake of these three nutrients were more at higher rates of fertilizers.

Fodder yield of maize was significantly increased by application of N, P and K, more so when N and P were applied as three splits (Kuznetsov, 1970). Application of NPK fertilizers increased fodder yield and crude protein content both in maize and soybean (Girenko and Livenskii, 1974).

Deshmukh *et al.* (1974) found that NPK fertilizers and FYM increased the crude protein yield of cowpea. Viswanath (1975) showed that 200 kg N + 80 kg P_2O_5 + 40 kg K_2O/ha markedly increased the growth of shoots and roots, drymatter production and uptake of N, P, K, Ca and Mg in fodder maize.

Kalra and Khokhar (1979) observed that in a sorghum + legume mixture application of 120 kg N/ha increased total forage production, crude protein and mineral matter content. Potash application did not affect the green fodder yield. In a field trial, Meera Bai (1982) got the maximum profit from sorghum-velvet bean combination at fertilizer level 100:60:60.

Accumulation of N, P, K and Ca was determined for intercropped maize and cowpeas treated with different fertilizer combination (Wahua, 1983). Both species competed for these four elements, with cowpeas suffering relatively more than maize. The highest fodder yield of the maize-legume mixture was obtained when a fertilizer dose of 160:80:80 kg N, P_2O_5 and K_2O/ha was given and this dose was on par with the 140:70:70 kg levels (Mercy George and Mohamed Kunju, 1983).

It was found that the maize-cowpea mixture gave the highest crude protein yield at 120:60:60 kg N, P_2O_5

and K_2O/ha while in the maize-velvet bean mixture the crude protein yield was maximum at 160:80:80 kg N, P_2O_5 and K_2O/ha (Mercy George and Kunju, 1984).

Menhilal and Tripathi (1987) recommended a narrow NPK ratio for fodder crops such as maize, sorghum, bajra etc. Shivanand (1987) reported that total forage yields of sorghum were highest at high and medium fertilizer levels (150-90-60 and 100-60-40).

Application of 125 per cent of the recommended fertilizer dose recorded significantly higher yields of both the crops in a maize + soybean intercropping system (Chakor and Varinderkumar, 1988). Kawamoto et al. (1988) reported that in a sorghum-soybean mixture, the content of nutrients (N, P, K, Ca and Mg) of sorghum tended to be higher than those in pure sorghum.

From an appraisal of the details stated above, it is seen that growth, yield, quality and uptake of nutrients in fodder crops and grain crops are improved by a combined application of the major nutrients.

2.4. Beneficial effects of cowpea + maize intercropping on soil fertility

The legumes have been given a prominent place in crop mixtures for their role in the build up of soil fertility. Fox (1960) stated that cowpea could be grown in comparatively poor soils and could improve the soil structure as well as nitrogen status.

Chand (1977) found no significant difference in total N in the soil after the harvest of a maize + legume mixture among the treatments involving different legumes and N levels. Increase in the total and available nitrogen content of the soil due to intercropping of sorghum with legume was reported by Morachan et al. (1977).

Singh and Guleria (1979) reported that soybean could be sown as intercrop with maize to minimise the economic losses. Part of the N fixed by the legume might have been made available to the nearby maize crop (Chauhan and Dungarwal, 1980). Bhatia et al. (1980) observed an efficient soil moisture conservation by including legumes in a mixture.

Gangwar (1980) reported that by growing maize + legume varieties in association, the productivity could be increased considerably without a proportionate increase in the use of nitrogenous fertilizers. This might be due to the inhibition of N fixation by the application of higher levels of N. But Singh (1980) observed that inclusion of legumes like cowpea, quar, urd, mung etc. in a cereal crop improved the soil fertility through N-fixation. Improvement in the soil physical status, more particularly in the soil structure was noticed due to the inclusion of legumes (Biswas, 1982).

Hassan et al. (1986) studied the effect of intercropping oats and a legume on the distribution of N in forage at different stages of growth. The oat/lupin mixture had the highest N concentration and produced a higher N yield/unit area than the oat/pea mixture or any single crop.

Patra et al. (1986) observed that intercropped legumes fix significantly higher amount of N as compared with legumes in sole cropping if the intercropped cereal-legume received the same dose of fertilizer N as the sole cereal crop.

Yields of above ground biomass and total nitrogen were determined in summer grown maize and cowpea as solo crops or intercrops; with or without supplementary N fertilizer (Ofori et al., 1987). Comparable fixation by sole cowpea was higher, but this advantage was outweighed by greater land use efficiency by the intercrops than by sole crops.

An increased N-fixation by cowpea when grown in alternate rows with pearl millet was reported by Dakora *et al.* (1988). Transfer of fixed N to pearl millet was about 5.3 per cent. Patil and Mahendra Pal (1988) observed that intercropping with legumes except clusterbean improved the bulk density of soil over sole cropping of pearl millet. Intercropped pearl millet with Cowpea was more effective and enhanced water stable aggregates of size greater than 0.25 mm in top 15 cm depth by 34.5 per cent and raised organic carbon and nitrate nitrogen content over that in sole ~~pearl millet~~ crop.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

A field investigation was carried out during the summer season of 1988-'89 to assess the feasibility of raising fodder maize as an intercrop with grain cowpea in summer rice fallows and to work out a suitable combination of fertilizers for grain cowpea + fodder maize intercropping system. The materials used and methods adopted are detailed below:

3.1. Materials

3.1.1. Location

The experiment was conducted in the rice fallows of the Instructional Farm attached to the College of Agriculture, Vellayani. The Farm is located at 8° 18' N latitude and 76° 57' E longitude at an altitude of 29 m above MSL.

3.1.2. Soil

The soil of the experimental area comes under the textural class of sandy clay loam. The data on the mechanical and chemical analysis of the soil are given below:

Soil characteristics of the experimental area

3.1.2.1. Mechanical composition (%) - International pipette method (Piper, 1950)

Coarse sand	-	46.0
Fine sand	-	10.4
Silt	-	6.6
Clay	-	33.0

3.1.2.2. Chemical composition (kg/ha)

Available nitrogen	-	362.6 (Alkaline permanganate method - Subbiah and Asija, 1956)
Available phosphorus	-	8.8 (Bray's method - Jackson, 1967)
Available potassium	-	121.5 (Ammonium acetate method - Jackson, 1967)
pH	-	5.8 (1:2 soil water ratio using pH meter)

3.1.3. Cropping history of the field

The experimental area was cultivated with a bulk crop of paddy during the previous season. The crop had received the normal package of practices recommendations of the Kerala Agricultural University.

3.1.4. Season

The experiment was conducted during the summer season of 1988-'89. The crops were sown on 1-3-1989. Fodder maize was harvested on 22-4-1989 and cowpea harvest started on 10-5-1989 and was over by 31st May, 1989.

3.1.5. Weather conditions during the cropping period

The meteorological parameters recorded are rainfall, maximum and minimum temperatures, relative humidity and

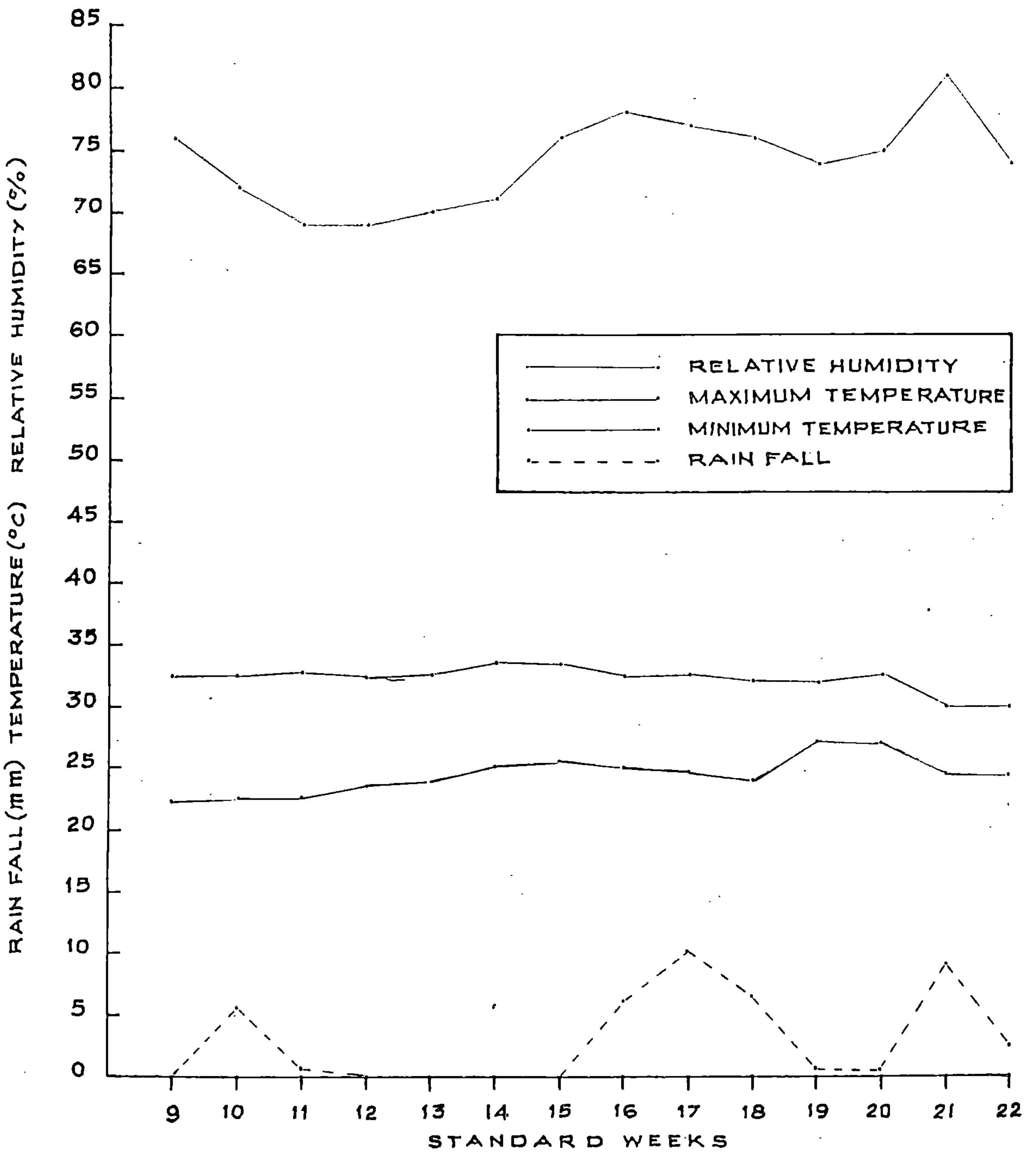


FIG. 1. WEATHER CONDITIONS DURING THE CROP SEASON 26th FEBRUARY TO 3rd JUNE, 1989.

number of rainy days. The average weekly values and their variation from the average of past 15 years (Normal values of these weather parameters) from sowing to harvest are worked out and presented in Appendix and illustrated graphically in Figure 1.

During the cropping period a mean maximum temperature of 32.15°C was observed, while the mean minimum temperature was 24.27°C. The average relative humidity recorded was 73.5 per cent. A total of ~~280.9~~ 41.43 mm rainfall was received during the experimental period, distributed over ~~24~~ 23 rainy days. On an average the season was normal.

3.1.6. Varieties

3.1.6.1. Cowpea

The variety used was C-152, a high yielding grain type having a duration of 90 days.

3.1.6.2. Maize

The variety used was Co-H-2. It is an excellent fodder variety of maize.

3.1.7. Seed materials

The seeds of cowpea were obtained from National Seeds Corporation, Palghat and those of maize from Super Seeds, Coimbatore. The seeds were tested for viability

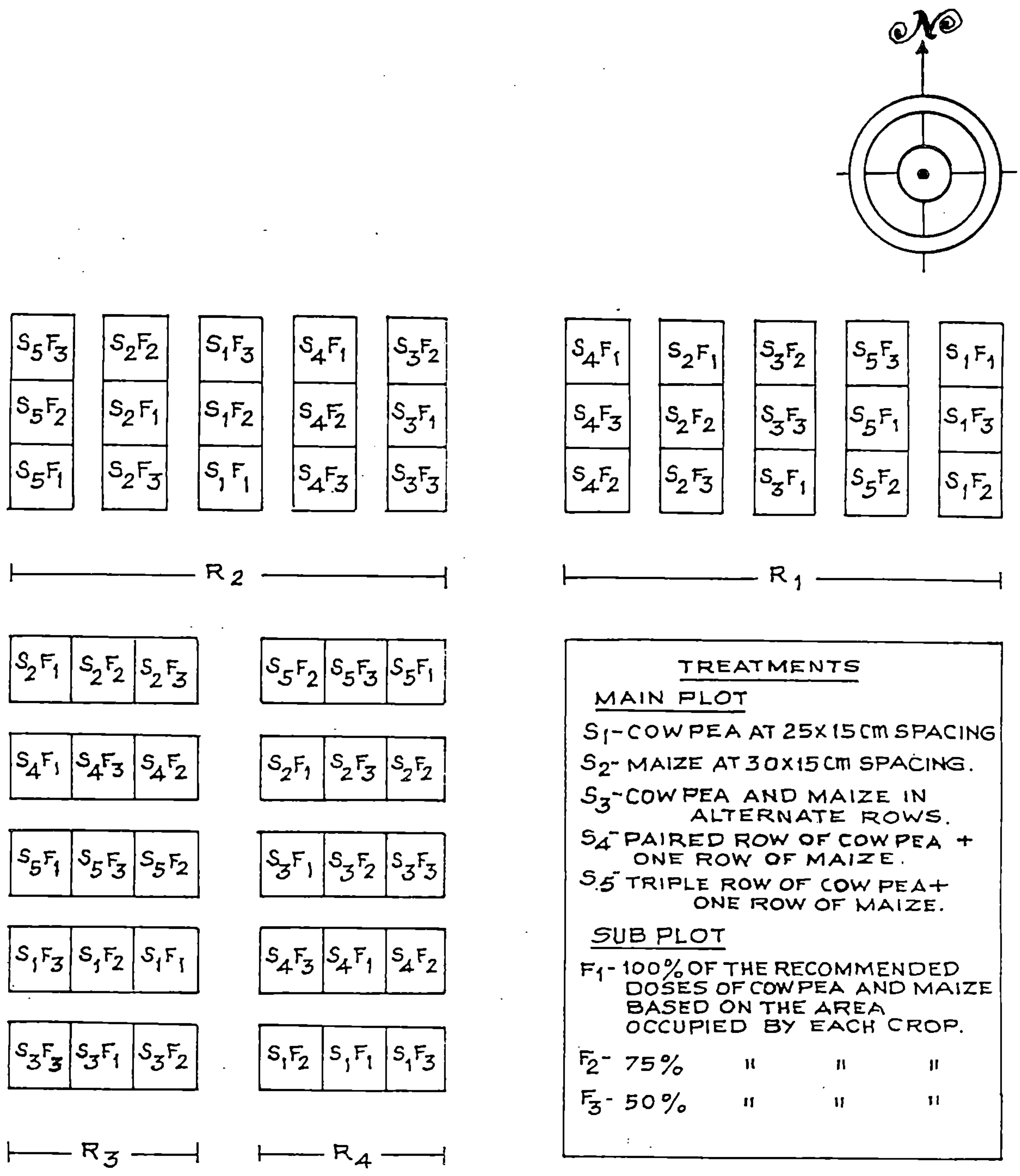


FIG. 2. LAY OUT - SPLIT PLOT DESIGN.

and were found to give 99 to 100 per cent germination.

3.1.8. Fertilizers

Fertilizers analysing to the following nutrient contents were used.

Urea	:	46 per cent N
Super phosphate	:	16 per cent P_2O_5
Muriate of potash	:	60 per cent K_2O

3.2. Methods

3.2.1. Design and Layout

The experiment was laid out as a split-plot design with four replications. The layout plan of the experiment is given in Fig. 2.

3.2.2. Treatments

The treatments consisted of five types of crop arrangements and three fertilizer levels. The crop arrangements were allotted to the main plots and the fertilizer levels, to the subplots.

3.2.2.1. Main plot treatments

Crop arrangements (Fig. 3)

1. Cowpea at 25 x 15 cm spacing (S_1)
2. Maize at 30 x 15 cm spacing (S_2)

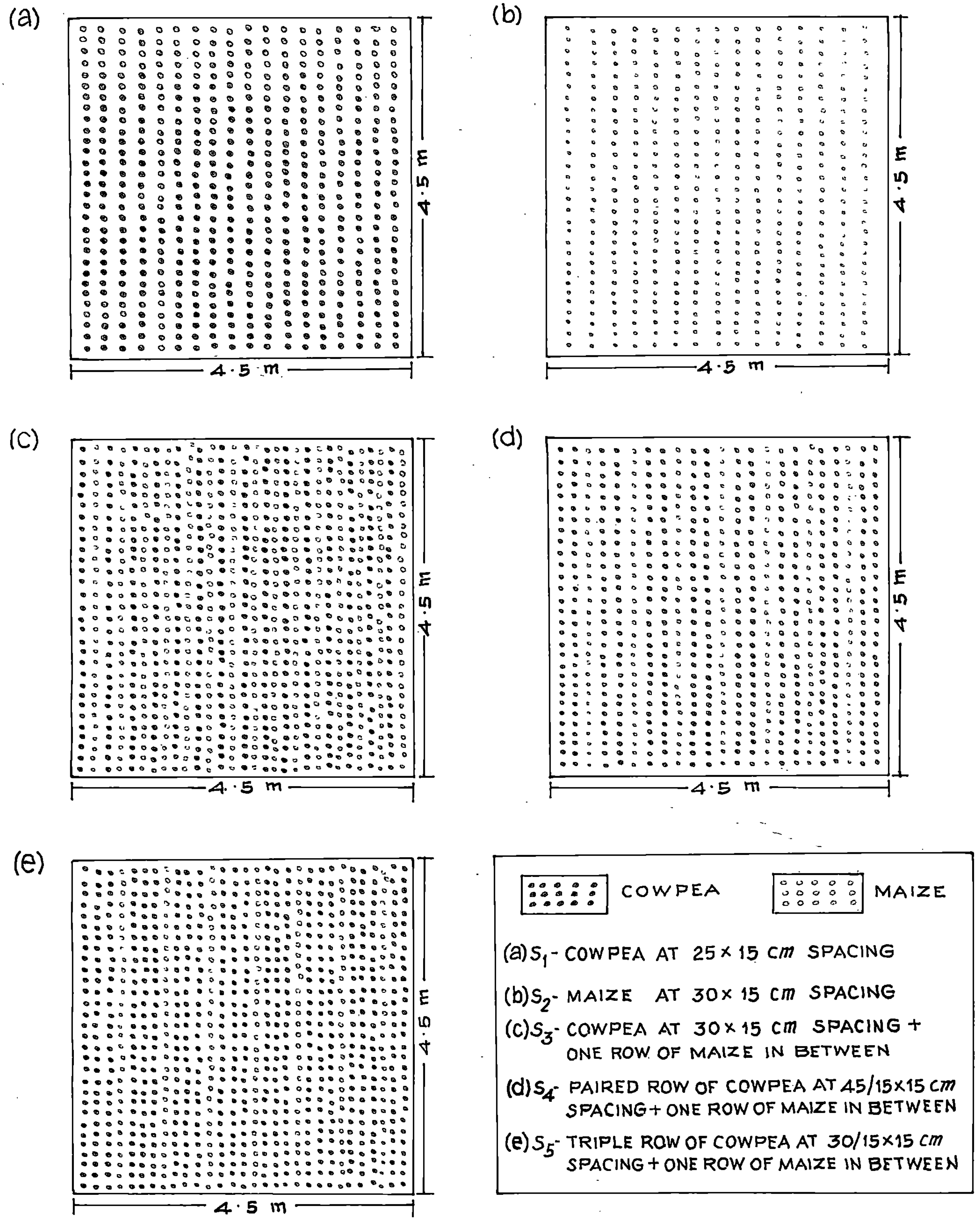


FIG. 3. PLAN OF CROP ARRANGEMENTS.

3. Cowpea and Maize in alternate rows with cowpea rows at 30 x 15 cm spacing and maize rows at 30 x 15 cm spacing (S_3)

4. Paired row of Cowpea + 1 row of Maize in between with cowpea rows at 45/15 x 15 cm spacing and maize rows at 60 x 15 cm spacing (S_4)

5. Triple row of Cowpea + 1 row of Maize in between with cowpea rows at 30/15 x 15 cm spacing and maize rows at 60 x 15 cm spacing (S_5)

3.2.2.2. Sub plot treatments

Fertility levels

1. 100 per cent of the recommended doses of Cowpea and Maize based on the area occupied by each crop (F_1)
2. 75 per cent of the recommended doses of Cowpea and Maize based on the area occupied by each crop (F_2)
3. 50 per cent of the recommended doses of Cowpea and Maize based on the area occupied by each crop (F_3)

The recommended dose of fertilizers as per the package of practices recommendations, KAU (1986) for Cowpea is 20:30:10 kg N, P_2O_5 and K_2O/ha respectively while that for fodder maize is 120:60:40 kg N, P_2O_5 and K_2O/ha respectively. The fertilizers were applied to each plot based on the crop arrangement and the area occupied by each crop. The nutrient requirements in the different

Table 1. Nutrient requirements in the different treatments (kg/ha)

Crop arrangements	Fertility levels								
	F_1			F_2			F_3		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
S_1	20.00	30.00	10.00	15.00	22.50	7.50	10.00	15.00	5.00
S_2	120.00	60.00	40.00	90.00	45.00	30.00	60.00	30.00	20.00
S_3	137.10	85.00	48.00	102.80	63.70	36.00	68.50	42.50	24.00
S_4	74.10	54.70	27.00	55.60	41.00	20.30	37.00	27.40	13.50
S_5	81.40	66.20	31.20	61.10	49.70	23.40	40.70	33.10	15.60

treatments are given in Table 1.

Treatment combinations

1. S_1F_1	4. S_2F_1	7. S_3F_1	10. S_4F_1	13. S_5F_1
2. S_1F_2	5. S_2F_2	8. S_3F_2	11. S_4F_2	14. S_5F_2
3. S_1F_3	6. S_2F_3	9. S_3F_3	12. S_4F_3	15. S_5F_3

Number of replication - 4

Total number of plots - 60

3.2.3. Plot size

The gross main plot size was 13.5 x 4.5 m and the gross subplot size was 4.5 x 4.5 m. The net plot size was calculated, after leaving two rows of cowpea all around the plot, for all the arrangements except S_2 and S_3. In S_2, the pure crop of maize, the net plot size was calculated after leaving two rows of maize all around the plot. In S_3, cowpea and maize in alternate rows, the net plot size was taken after leaving one row each of cowpea and maize all around the plot. So there was variation in the net plot size with different crop arrangements. The net plot size is given in Table 2.

Table 2. Net plot size for different treatments

Crop arrangements	Net plot size (sq.m)	
	Main	Sub
S_1	10.5 x 3.9	3.5 x 3.9
S_2	9.9 x 3.9	3.3 x 3.9
S_3	11.7 x 3.9	3.9 x 3.9
S_4	11.4 x 3.9	3.8 x 3.9
S_5	11.7 x 3.9	3.9 x 3.9

Number of plants of cowpea and maize per subplot and in one hectare in different crop arrangements are given in Table 3.

Table 3. Plant population of cowpea and maize

Crop arrange-ments	Number of plants					
	Cowpea			Maize		
	Gross plot	Net plot	Per ha.	Gross plot	Net plot	Per ha.
S_1	540	364	266666	Nil	Nil	Nil
S_2	Nil	Nil	Nil	450	286	222222
S_3	450	338	222222	450	338	222222
S_4	480	312	210526	210	182	122807
S_5	690	494	324786	210	182	119658

3.2.4. Field culture

3.2.4.1. Preparation of the field

The experimental field was dug twice, stubbles removed, clods broken and laid out into four blocks. The blocks were then subdivided into 15 plots each and the plots separated with channels of 30 cm width followed by bunds of the same width. The individual plots were thoroughly dug and levelled.

3.2.4.2. Manures and fertilizer application

The different doses of nitrogen, phosphorus and potassium were applied according to the treatment schedule.

Half the quantity of nitrogen, full dose of phosphorus and full dose of potassium were applied as basal just before sowing. The remaining half of nitrogen was applied 30 days after sowing.

3.2.4.3. Seeds and sowing

The seeds were dibbled at the rate of 2 seeds/hole at a depth of 4 cm. Crop arrangement was followed according to the treatment schedule.

Gap filling and thinning were done to get one plant/hole, on the 7th day after sowing to secure a uniform stand of the crop.

3.2.4.4. After cultivation

The soil was stirred lightly and the weeds were removed at the time of the top dressing. Light irrigations were given for the initial germination and after top dressing nitrogen.

3.2.4.5. Plant protection

Prophylatic sprays of plant protection chemicals (BHC) were given to protect the crop from pests and diseases.

3.2.4.6. Harvest

Fodder maize was harvested on 22-4-1989 at the tasselling stage. Cowpea harvest began on 10-5-1989 and the harvest was over by 31st May, 1989, by three pickings at weekly intervals.

3.2.5. Observations recorded

Observation on growth characters, yield components and yield were recorded.

3.2.5.1. Observations on growth characters

Five plants each of cowpea and maize were tagged at random as observational plants in each plot. The observations on the growth characters were taken at 20 days intervals from these plants.

3.2.5.1.1. Height of plants

The height from the base of the plant to the tip of growing point was measured in centimetres for the five cowpea plants. In the case of maize height was taken from the base of the plant to the tip of latest fully opened leaf. The mean height was then worked out and recorded in centimetres.

3.2.5.1.2. Number of leaves per plant

Total number of leaves in each of the five sample plants of cowpea and maize was recorded at 20 days interval and mean number of leaves per plant was worked out.

3.2.5.1.3. Leaf Area Index

In the case of cowpea, total leaf area of three sample plants was noted using leaf area meter and leaf area per m^2 was calculated at flowering. For maize, the length and breadth of all leaves from each sample plant at harvest were measured and LAI was calculated using the formula

$$LAI = \frac{(L \times B) \times K}{\text{land area occupied by the plant}}$$ where K = 0.75 (Hunt, 1978)

Then average LAI was worked out.

3.2.5.1.4. Leaf : stem ratio

The sample plants collected were separated into leaves and stem, oven dried at 80 ± 5°C to constant weight, weighed separately and the leaf : stem ratio was worked out for fodder maize at the time of harvest.

3.2.5.2. Observations on yield components

The observations on yield components of cowpea were taken at the time of harvest.

3.2.5.2.1. Number of pods per plant

Number of pods of sample cowpea plants was counted and the mean worked out.

3.2.5.2.2. Length of pods

The length of each pod from the sample plants was measured and the mean length worked out and expressed in centimetres.

3.2.5.2.3. Number of seeds per pod

Number of seeds per pod from the sample plants was counted and the mean calculated.

3.2.5.2.4. Test weight

Weight of fully filled 100 grains from each treatment was recorded separately in grams.

3.2.5.3. Observations on yield

3.2.5.3.1. Green matter yield of maize

At the time of harvest, the green matter yield of maize was recorded in kg/plot and expressed in t/ha.

3.2.5.3.2. Drymatter yield of maize

Five sample plants were collected, weighed, air dried in shade and then oven dried at 80 $\pm$ 5°C till constant weight was obtained. From the moisture percentage and green matter yield drymatter production was calculated and expressed in t/ha.

3.2.5.3.3. Pod yield

The total cowpea pod yield from the net plot at different pickings was recorded and expressed in kg/ha.

3.2.5.3.4. Yield of grains

The cowpea grains were separated from the pods harvested from each net plot. They were then cleaned, sundried and weight was recorded. The grain yield was expressed in kg/ha.

3.2.5.3.5. Weight of bhusa

The weight of bhusa from the net plot was recorded and expressed in t/ha.

3.2.5.3.6. Harvest index

It was worked out from the data on grain yield and biomatter yield using the formula

$$HI = \frac{\text{Economic yield (sun dried)}}{\text{Biological yield (oven dried)}}$$

3.2.6. Chemical analysis

3.2.6.1. Plant analysis

Both cowpea and maize samples collected for chemical analysis were oven dried at 80 ± 5°C and ground in a wiley mill.

3.2.6.1.1. Nitrogen content

The total nitrogen content of the plants at the harvest stage was analysed employing the modified micro-kjeldahl method (Jackson, 1967).

3.2.6.1.2. Phosphorus content

The phosphorus content was determined colorimetrically from the triple acid digested plant extract using Vanado-molybdo phosphoric yellow colour method (Jackson, 1967). The colour intensities were read in a Spectronic 2000 available in the Central Instrumentation Laboratory of the NARP (SR).

3.2.6.1.3. Potassium content

The potassium contents of the samples were determined from the triple acid digested plant extract (Jackson, 1967) using the Atomic Absorption Spectrophotometer (PE.3030) available in the Central Instrumentation Laboratory of the NARP (SR).

3.2.6.2. Uptake studies

The total uptake of nitrogen, phosphorus and potassium for cowpea and maize were calculated based on the contents of these nutrients and the drymatter produced at the time of harvest.

3.2.6.3. Quality characters

The protein content of cowpea grain and fodder maize was calculated by multiplying the percentage of nitrogen by the factor 6.25 (Simpson *et al.*, 1965).

3.2.6.4. Soil analysis

Soil analysis for the mechanical composition and chemical characteristics was carried out using the procedures already referred to.

3.2.7. Biological efficiency indices

3.2.7.1. Land Equivalent Ratio (LER)

It was worked out from the data on the yield of cowpea and maize both in mixture and pure culture. It was worked out for the mixture plots using the formula suggested by Mead and Willey (1980).

$$LER = \sum_{i=1}^{n} \frac{xi}{yi} \quad \text{where}$$

xi = yield under intercropping

yi = yield under pure cropping

n = number of crops in the treatments

3.2.7.2. Land Equivalent Coefficient (LEC)

It was worked out from the data of the yields of cowpea and maize both in mixture and pure culture. It was worked out for the mixture plots using the formula suggested by Adetiloye *et al.* (1983).

LEC = LC x LM where

LC = LER of cowpea

LM = LER of maize

3.2.8. Economic evaluation

The following economic indices were used to evaluate the system. These are calculated on the basis of current prices of produce, labour charge and fertilizer costs (Palaniappan, 1985).

3.2.8.1. Cost of cultivation

It was calculated by adding the expenditure incurred on different items such as labour, seeds, fertilizers and other chemicals and expressed in Rs./ha, based on which the following were worked out.

3.2.8.2. Net returns

This was calculated by subtracting total (variable) cost of cultivation from the gross returns for different treatments.

3.2.8.3. Return per rupee invested (Benefit/cost ratio)

This was calculated using the formula,

$$\text{Return per rupee invested} = \frac{\text{Gross returns}}{\text{Total (variable) cost of cultivation}}$$

3.2.8.4. Return per rupee invested on labour

This was calculated using the formula

Return per rupee invested on labour =

$$\frac{\text{Gross return} - \text{Cost of cultivation except that incurred on labour}}{\text{Cost of labour}}$$

3.2.8.5. Return per rupee invested on fertilizers

This was calculated using the formula

Return per rupee invested on fertilizers =

$$\frac{\text{Gross return} - \text{Cost of cultivation except that incurred on fertilizers}}{\text{Cost of fertilizers}}$$

3.2.8.6. Per day return

Per day return of the cropping system during the cropping period was calculated using the formula

$$\text{Per day return} = \frac{\text{Net return}}{\text{Cropping period in days}}$$

3.2.8.7. Income Equivalent Ratio (IER)

This was calculated using the formula of IER substituting the monetary values of the produce in the place of the respective yields.

3.2.9. Statistical analysis

Data relating to the different parameters were analysed statistically by applying the technique of analysis of variance for Split Plot Design and significance was tested by 'F' test (Snedecor & Cochran, 1967). Analysis was made using the 'Keltron Versa IWS Computer' of the College of Agriculture, Vellayani.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

An investigation was carried out during the summer season of 1988-'89, in the College of Agriculture, Vellayani with the object of selecting the best crop arrangement under different fertility levels for a cowpea + fodder maize intercropping system. Observations were made on growth and yield characters and different biological and economic efficiency indices were worked out to determine the best system. The data recorded were analysed statistically and the results are discussed here. The mean values are given in Tables 4 to 13.

4.1. Growth characters

4.1.1. Height of plants

The mean height of plants recorded at various growth stages are presented in Tables 4 and 6.

4.1.1.1. Cowpea

The different crop arrangements produced marked differences in the height of plants at 20 DAS. Intercropping resulted in taller plants than the sole crop of cowpea. S_3 (cowpea and maize in alternate rows) was on par with S_5 (triple row of cowpea + 1 row of maize in between) and S_4 (paired row of cowpea + 1 row of maize in between). The latter was on par with S_1 (sole crop of cowpea). The fertilizer levels as well as the interaction of crop arrangements with fertilizer levels had no significant influence on plant height at 20 DAS.

The different crop arrangements and fertilizer levels produced marked differences in the height of cowpea at 40 DAS while their interaction was not significant. S_3 produced the maximum height and was superior to all other treatments and the heights in S_5, S_4 and S_1 were on par. Among the fertilizer levels, F_1 (100 per cent of recommended dose) produced the maximum height and was superior over other two levels while the effects of F_2 (75 per cent of recommended dose) and F_3 (50 per cent of recommended dose) were on par.

At harvest, different crop arrangements and interaction of crop arrangement with fertilizer level had no significant influence on plant height. Among fertilizer levels, F_1 and F_2 were on par and were superior to F_3.

The results revealed significant differences in the height of cowpea due to different crop arrangements at all stages of growth except at harvest. Intercropping usually resulted in taller plants. In the early stages of growth, the presence of fodder maize might induced cowpea in

Table 4. Height and number of leaves of cowpea at different stages of growth

Treatments	Height (cm)			Number of leaves		
	20 DAS	40 DAS	Harvest	20 DAS	40 DAS	Harvest
Main Factor(S)						
S_1	30.12	64.69	145.26	5.63	25.08	23.30
S_3	34.88	87.97	128.94	5.15	13.37	27.68
S_4	32.81	71.95	137.16	5.43	18.87	33.93
S_5	34.16	73.48	138.35	6.30	15.12	22.37
SE ±	0.871	3.575	8.308	0.332	2.956	5.060
CD (0.05)	2.786	11.438	NS	NS	9.459	NS
Sub Factor(F)						
F_1	33.48	85.48	141.74	5.79	21.68	31.99
F_2	31.94	68.59	143.22	5.74	18.71	27.72
F_3	33.56	69.50	127.33	5.35	13.94	20.76
SE ±	0.804	3.893	4.867	0.144	1.325	2.535
CD (0.05)	NS	11.363	14.208	0.421	3.868	7.399
S x F						
S_1F_1	29.70	69.15	146.80	5.60	28.35	28.22
S_1F_2	29.58	64.73	150.40	5.75	24.80	21.23
S_1F_3	31.08	60.20	138.58	5.55	22.10	20.45
S_3F_1	35.18	103.45	142.47	5.20	14.05	32.55
S_3F_2	32.95	78.85	131.40	5.45	14.40	26.77
S_3F_3	36.50	81.60	112.95	4.80	11.65	23.73
S_4F_1	33.85	86.55	140.90	5.70	26.25	37.63
S_4F_2	32.38	63.75	146.78	5.30	18.35	41.13
S_4F_3	32.20	65.55	123.80	5.30	12.00	23.05
S_5F_1	35.19	82.75	136.78	6.65	18.05	29.55
S_5F_2	32.85	67.05	144.30	6.45	17.30	21.75
S_5F_3	34.45	70.65	133.98	5.80	10.00	15.80
SE ±	1.603	7.785	9.735	0.289	2.650	5.070
CD (0.05)	NS	NS	NS	0.843	NS	NS

putting forth a greater height as a competitive interaction. Thus the crop arrangement where cowpea was alternated with one row of maize and was thus subjected to greater interspecific competition resulted in the tallest plants while the sole crop of cowpea gave the shortest plants. But as growth progressed towards the later stages, the maize crop which had also put forth good growth and had become taller has suppressed the growth of cowpea plants as is evident from the results. The data shows that alternate rows, paired row of cowpea plus one row of maize, triple row of cowpea plus one row of maize and sole crop of cowpea gave plant heights increasing in the above order although the effect was not significant.

Even though there was no significant difference in height due to fertilizer levels at 20 DAS, maximum height was produced by the higher fertilizer levels at 40 DAS and at harvest. At the time of harvest, the 100 per cent level was on par with the 75 per cent level and they were superior to the 50 per cent level. In the very early stage of 20 DAS the effect of the absorbed fertilizers could not have become manifest. But as plants progressed in growth the higher levels of nutrients could meet their requirements better and hence taller plants could have resulted in the plots given full recommended dose and 75 per cent dose of fertilizers. Similar increase in plant height of cowpea at high levels of nitrogen was reported by Mohan Kumar (1978).

4.1.1.2. Maize

The different crop arrangements showed significant difference in the height of maize plants at 20th day, while the fertilizer levels and the interaction of crop arrangements with fertilizer levels showed no marked influence on this character. The crop arrangement S_3 (cowpea and maize in alternate rows) produced maximum plant height and was on par with all other crop arrangements except S_2 (sole crop of maize).

The different fertilizer levels alone produced significant differences in the height of maize plants at harvest. F_1 (100 per cent dose) which produced maximum height was markedly superior to F_2 (75 per cent dose). But F_2 and F_3 (75 per cent & 50 per cent dose respectively) were on par.

The results revealed significant differences in the height of maize plants due to different crop arrangements at 20 DAS whereas at harvest, different fertilizer levels significantly influenced this character. But the interaction of crop arrangement with fertilizer level was not significant at different stages of growth. At 20 DAS, the crop arrangement, where cowpea was alternated with one row of maize showed maximum height and was on par with other intercrop arrangements. Pure crop gave the shortest plants. The increased height of maize in intercrop treatments might be due to the competitive interaction with the other species. Chandini (1980) noted that height of forage grasses were higher when mixed with legumes. Moreover, Guljaev and Ronsal (1962) reported that growth of maize was stimulated by secretions from the roots of legumes in the intercropping system. At harvest, the effect of different crop arrangements on the height of maize plants was not significant. At this time most of the maize plants had grown to such an extent that they were much above the cowpea canopy and hence no further competitive interaction was needed. Haizel (1974) and Mercy George (1981) observed that when maize was intercropped with legumes, upto the time of tasselling, maize was more competitive than legumes, but this has been changed in favour of legumes from tasselling to maturity of maize crop.

Even though different fertilizer levels were not significant on height at 20 DAS, maximum height was produced by the highest fertilizer level at harvest and was markedly different from the second level. Height being a character dependent on nutrition, increased application of fertilizers would have encouraged the root growth which in turn resulted in higher rate of nutrient absorption which was manifested in an increase of plant height. Chand (1977) also observed similar increase in height of plants by the application of higher doses of nitrogen in a maize + legume intercropping system.

4.1.2. Number of leaves per plant

The mean number of leaves per plants at different growth stages of the crops are presented in Tables 4 and 6.

4.1.2.1. Cowpea

Number of leaves produced by cowpea at 20 DAS was found to be unaffected by different crop arrangements while fertilizer levels and interaction effects were significant. Among fertilizer levels, F_1 (100 per cent dose) produced the maximum number of leaves and was on par with F_2 (75 per cent dose). F_3 (50 per cent dose) produced minimum number of leaves. Among treatment combinations, S_5F_1 was superior which was on par with S_5F_2.

Different crop arrangements and fertilizer levels significantly influenced the number of leaves at 40 DAS.

but their interaction was not significant. S_1, the pure crop of cowpea produced maximum number of leaves which was on par with S_4 (paired row cowpea + 1 row maize). The full recommended level of fertilizers (F_1) produced the highest number of leaves and this was followed by F_2 (75 per cent dose). The effects of F_1 and F_2 were on par.

At harvest, the number of leaves produced was found to be unaffected by different crop arrangements and interaction of crop arrangements with fertilizer levels. There was significant effect due to fertilizer levels. F_1 (100 per cent dose) produced the highest number of leaves. F_1 and F_2 were on par. F_3 produced the minimum number of leaves.

At all stages of growth, the number of leaves in cowpea was found to be unaffected by different crop arrangements except at 40 DAS. Both interspecific competition in interculture and intraspecific competition in pure culture were found to be almost similar in effecting their influence on the performance of cowpea with regard to this character.

The highest fertilizer level produced the maximum number of leaves in cowpea at all stages of growth. The increased dose of fertilizers, would have increased the growth of plants and the number of leaves. Singh and Jain

(1966), Garg et al. (1970) and Mercy George (1981) also reported the influence of increased application of nutrients in increasing the number of leaves of legumes in the inter-cropping and pure cropping systems. Increased leaf number due to phosphorus application has been reported in cowpea by Tarilla et al. (1977). The results obtained in the present investigation are in agreement with the results of the above workers.

4.1.2.2. Maize

The different crop arrangements had significant influence on the number of leaves at 20 DAS whereas the fertilizer doses and interaction effects were not significant. The crop arrangement S_3 (cowpea and maize in alternate rows) gave the highest number of leaves and was on par with other intercrop arrangements.

At harvest, the number of leaves of maize was influenced by different fertilizer levels and interaction of crop arrangements with fertiliser levels. Among the three fertilizer levels, F_1 (100 per cent dose) produced maximum number of leaves which was on par with F_2 (75 per cent dose). F_3 (50 per cent dose) produced minimum number of leaves. Among treatment combinations, S_2F_2 recorded the maximum and S_4F_3 the minimum.

From the results it could be seen that at 20 DAS, where the crop arrangements influenced the number of leaves, maize grown with cowpea in alternate rows recorded the maximum number of leaves in maize as this arrangement might have caused no ill effect on the foliage production of maize. Moreover, being a legume and with adequate fertilization it might have provided some beneficial effects to the non-legume.

According to Garg and Kayande (1962) and Chand (1977) the nutrients especially nitrogen influenced the crop favourably in all its growth phases and in the production of leaves. This might be the reason why higher doses of fertilizers gave more number of leaves. The effect could have become more pronounced with advancement in growth of maize plants bringing the effect from a non-significant level at 20 DAS to a significant level at harvest.

The sole crop of maize with higher levels of fertilizers, recorded the maximum number of leaves. Increased interspecific competition might be the reason for reduced number of leaves in later stages in the intercropping situations. So the sole crop of maize with adequate level of nutrition produced the maximum number of leaves.

4.1.3. Leaf Area Index

The mean leaf area indices of crops at flowering are presented in Tables 5 and 6.

4.1.3.1. Cowpea

Leaf Area Index of cowpea at flowering was affected by different crop arrangements and fertilizer doses while their interaction was not significant. S_1, the sole crop recorded the maximum value which was on par with S_3 (cowpea and maize in alternate rows) and S_5 (triple row of cowpea + 1 row of maize) while the latter two treatments were on par with S_4. Among different fertilizer levels, F_2 (75 per cent dose) resulted in the maximum LAI, but was on par with F_1 (100 per cent dose) and F_1 in turn was on par with F_3.

The number of leaves produced was maximum for the sole crop of cowpea at the time of flowering. This might have resulted in the maximum LAI for that treatment as it could have increased the total leaf area.

Higher fertilizer levels increased the LAI and this might be due to the higher number of leaves produced by the application of nutrients especially nitrogen. Increased application of nutrients might have also increased the metabolic activity of plants and this in turn might have

Table 5. LAI at flowering, drymatter yield and uptake of N, P and K of cowpea at harvest

Treatments	LAI	Drymatter yield (t/ha)	Uptake of nutrients (kg/ha)		
			N	P	K
Main factor(S)					
S_1	5.45	4.64	67.76	14.73	56.91
S_3	4.77	3.45	70.59	12.02	35.92
S_4	3.60	4.08	77.60	11.58	35.51
S_5	4.96	4.81	75.08	13.97	44.69
SE ±	0.469	0.762	3.178	1.189	3.468
CD (0.05)	1.499	NS	NS	NS	11.094
Sub factor(F)					
F_1	4.99	4.84	85.96	14.70	47.42
F_2	5.24	4.04	73.73	12.43	42.52
F_3	3.64	3.85	58.58	12.10	39.83
SE ±	0.464	0.320	3.353	0.546	2.391
CD (0.05)	1.353	0.932	9.788	1.594	6.979
S x F					
S_1F_1	5.43	4.80	73.94	15.53	54.33
S_1F_2	6.41	4.42	71.18	13.20	54.66
S_1F_3	4.49	4.70	58.16	15.45	61.75
S_3F_1	5.56	4.82	77.74	13.86	35.13
S_3F_2	5.06	3.31	71.12	11.70	45.51
S_3F_3	3.67	2.21	62.90	10.52	27.10
S_4F_1	4.27	4.38	81.47	14.04	36.73
S_4F_2	4.07	4.03	88.55	10.31	38.88
S_4F_3	2.46	3.83	62.79	10.38	30.93
S_5F_1	4.71	5.38	110.68	15.37	63.48
S_5F_2	5.42	4.39	64.08	14.50	31.04
S_5F_3	4.75	4.67	50.47	12.03	39.54
SE ±	0.927	0.639	6.706	1.092	4.783
CD (0.05)	NS	NS	19.576	NS	13.959

increased the LAI. Ezedinma (1965), Cooper (1977) and Balakumaran (1981) also observed similar increase in LAI due to increased application of nutrients.

4.1.3.2. Maize

The effects of crop arrangements, fertilizer levels and their interactions on LAI of maize were significant at harvest (flowering). Maximum LAI was recorded by S_2, the sole crop which was on par with S_3 (cowpea and maize in alternate rows) and were superior to S_4 and S_5. S_5 (triple row cowpea + 1 row maize) recorded the lowest value which was on par with S_4 (paired row cowpea + 1 row maize).

The higher two levels of fertilizers were on par and gave higher values of LAI. The treatment combination S_2F_1 noted the maximum LAI and S_5F_3 the lowest.

Results showed clearly that the sole crop of maize recorded the maximum LAI and intercropping in between paired and triple rows of cowpea resulted in the minimum LAI values because maize population was low in these treatments. Enyi (1973) observed a reduction in LAI when maize was intercropped with cowpea.

Higher levels of fertilization increased the number of leaves and total leaf area and thereby the LAI. Increase

Table 6. Height and number of leaves of maize at different stages of growth, LAI and leaf : stem ratio of maize at the time of harvest

Treatments	Height (cm)		Number of leaves		LAI	Leaf : stem ratio
	20 DAS	Harvest	20 DAS	Harvest		
Main factor(S)						
S_2	51.27	152.62	6.57	11.48	9.36	1.31
S_3	61.08	161.80	7.30	10.93	7.99	1.22
S_4	54.16	138.52	6.79	10.47	3.73	0.99
S_5	54.72	144.77	6.88	10.28	3.49	1.28
SE ±	2.252	7.541	0.186	0.531	0.538	0.109
CD (0.05)	7.203	NS	0.595	NS	1.723	NS
Sub factor(F)						
F_1	56.44	159.76	7.01	11.26	6.80	1.31
F_2	56.54	144.70	6.97	11.04	6.15	1.14
F_3	52.94	143.81	6.67	10.08	5.48	1.14
SE ±	2.154	3.561	0.244	0.248	0.374	0.065
CD (0.05)	NS	10.394	NS	0.725	1.093	NS
S x F						
S_2F_1	48.25	161.30	6.65	11.45	10.06	1.60
S_2F_2	55.00	144.65	6.30	12.15	9.08	1.20
S_2F_3	50.55	151.90	6.75	10.85	8.94	1.13
S_3F_1	64.20	169.25	7.15	11.50	8.91	1.53
S_3F_2	64.30	161.25	7.75	11.10	7.81	1.16
S_3F_3	54.75	154.90	7.00	10.20	7.24	0.98
S_4F_1	58.78	150.75	7.13	11.20	4.19	0.95
S_4F_2	52.75	136.35	6.95	10.65	3.71	0.85
S_4F_3	50.95	128.45	6.30	9.56	3.30	1.17
S_5F_1	54.55	157.75	7.10	10.90	4.05	1.18
S_5F_2	54.10	136.55	6.88	10.25	4.00	1.35
S_5F_3	55.50	140.00	6.65	9.70	2.43	1.30
SE ±	4.308	7.122	0.488	0.497	0.749	0.129
CD (0.05)	NS	NS	NS	1.450	2.185	0.379

in LAI with increased dose of nutrients was reported by Cooper (1977) and Bunpromma and Mobbayad (1978).

The superiority of individual effects might have contributed to the maximum LAI of treatment combination involving the sole crop of maize and highest level of fertilizers.

4.1.4. Leaf : stem ratio

The mean values on the leaf : stem ratio of maize are presented in Table 6.

The leaf : stem ratio of maize at the time of harvest was analysed statistically and from the results it was seen that the effects of different crop arrangements and fertilizer levels were not marked even though their interaction was significant. S_2F_1 recorded the maximum value (1.6) which was on par with S_3F_1, S_5F_2 and S_5F_3. S_4F_2 recorded the minimum value.

Even though not significant individually sole crop of maize and full dose of fertilizers recorded higher values. Maximum LAI was also obtained for the sole crop. The pure crop of maize had produced larger number of leaves in this treatment towards later stages. This combined with adequate nutrition might be the reason for the increased ratio of S_2F_1.

4.1.5. Drymatter yield

4.1.5.1. Cowpea

The mean values on drymatter yields of cowpea are presented in Table 5.

Different crop arrangements and interaction effects did not significantly influence the drymatter yield of cowpea. Considering the fertilizer levels, F_1 (100 per cent dose) recorded the maximum value and was on par with F_2 (75 per cent dose). These treatments had produced taller plants with greater number of leaves, LAI and nutrient uptake (Tables 4 and 5) thus due to better growth of plants higher drymatter yields could have resulted from the better absorption of nutrients from the higher doses given.

4.1.5.2. Maize

The mean values on drymatter yields of maize are presented in Table 7.

The drymatter yield of maize was influenced by different crop arrangements and interactions of crop arrangements with fertilizer doses while fertilizer levels had no significant effect. S_2, the pure crop of maize recorded the maximum drymatter yield and was on par with

S_3 and S_4. S_5 (triple row cowpea + 1 row maize) recorded the minimum which was on par with S_4 (paired row cowpea + 1 row maize).

Even though not significant, drymatter yield decreased with decreasing level of fertilizers. Among the treatment combinations S_2F_1 recorded the maximum value followed by S_3F_2 and S_2F_2. S_5F_3 recorded the minimum.

The pure crop of maize recorded the maximum drymatter yield on par with the alternate row arrangement. The drymatter yields of maize planted in between paired and triple rows of cowpea were on par and recorded the minimum values. This can be explained by the variation in population of maize and consequent green matter yields.

Similarly the treatments which received higher doses of fertilizers registered more drymatter yield than those with lower fertilizer levels even though the effect was not significant. Similar increase in drymatter accumulation in forage maize by increased nitrogen levels was reported by Nnoham and Odurukwe (1987) and Thorat and Ramteke (1988). It was seen that the drymatter yield was very closely related to the green matter yield. In the above mentioned treatments when drymatter yields were higher, the green matter yields were also higher.

4.2. Uptake studies (Figures 4 and 5)

The data on the uptake of nitrogen, phosphorus and potassium by cowpea and maize at the time of harvest were analysed and the mean values are presented in Tables 6 and 7.

4.2.1. Nitrogen uptake

4.2.1.1. Cowpea

Different crop arrangements had no influence on the nitrogen uptake by cowpea. The uptake of nitrogen was affected by different fertilizer doses and the interaction of crop arrangements with fertilizer doses.

F_1 recorded the highest uptake (85.96 kg/ha) which was significantly superior to other 2 levels. F_2 was superior to F_3. Of the treatment combinations, S_5F_1 recorded the highest value (110.68 kg/ha). The lowest value was recorded by S_5F_3 and was on par with S_1F_3, S_4F_3 and S_3F_3.

Perhaps because there was no significant variation in drymatter yields of cowpea with differing crop arrangements, nitrogen uptake also did not vary with crop arrangements. This was in agreement with earlier findings of Aggarwal <u>et al</u>. (1978) who reported that the total nitrogen uptake was significantly related to the above ground biomass production.

The nitrogen uptake of cowpea was maximum at highest level of applied fertilizers. Similar results were earlier reported by Bains (1969) and Rajesh Chandran (1987). Increased nutrient supply in the higher dose of fertilizers could have increased the growth of roots, enhanced absorption of nutrients and thus resulted in higher uptake values.

The low uptake in the combinations involving the smallest dose of fertilizers might be because of less absorption due to limited supply of the nutrients. The highest cowpea population along with the full dose of fertilizers resulted in the maximum uptake of nitrogen in S_5F_1.

4.2.1.2. Maize

The uptake of nitrogen by maize was affected by different crop arrangements and interaction of crop arrangements with fertilizer levels while fertilizer levels were not significant.

The treatment S_3 (cowpea and maize in alternate rows) recorded the maximum nitrogen uptake which was on par with all other crop arrangements except S_5 (triple row cowpea + 1 row maize). S_4 and S_5 were on par.

Table 7. Green matter yield, drymatter yield, uptake of N, P and K and protein content of maize at harvest

Treatments	Green matter yield (t/ha)	Dry-matter yield (t/ha)	Uptake of nutrients (kg/ha) N	P	K	Protein content (%)
Main factor(S)						
S_2	32.99	6.24	76.85	13.49	56.99	7.76
S_3	30.71	5.88	76.92	16.17	43.42	8.23
S_4	22.14	4.31	56.82	10.33	28.09	8.34
S_5	19.04	3.51	46.37	9.23	34.43	8.40
SE ±	2.898	0.687	8.382	2.008	3.644	0.276
CD (0.05)	9.272	2.197	26.814	6.424	11.657	NS
Sub factor(F)						
F_1	29.59	5.30	70.33	11.79	49.27	8.40
F_2	24.94	5.22	60.56	11.38	36.21	8.62
F_3	24.14	4.43	61.81	13.75	36.72	7.53
SE ±	1.431	0.424	5.845	1.066	2.891	0.219
CD (0.05)	4.177	NS	NS	NS	8.438	0.640
S x F						
S_2F_1	34.14	6.73	72.45	10.12	57.53	7.17
S_2F_2	31.18	6.31	81.09	12.72	54.41	8.93
S_2F_3	33.66	5.68	77.01	17.66	59.05	7.18
S_3F_1	37.80	5.75	104.14	18.04	55.67	9.63
S_3F_2	29.69	6.66	65.49	15.52	42.08	8.05
S_3F_3	24.66	5.23	61.11	14.96	32.50	7.00
S_4F_1	23.62	5.08	52.65	9.63	29.75	8.05
S_4F_2	21.38	4.21	51.98	7.96	27.31	8.93
S_4F_3	21.42	3.65	65.83	13.41	27.19	8.05
S_5F_1	22.79	3.64	52.09	9.39	54.12	8.75
S_5F_2	17.50	3.71	43.70	9.31	21.04	8.58
S_5F_3	16.81	3.17	43.31	8.97	28.13	7.88
SE ±	2.862	0.848	11.691	2.132	5.782	0.439
CD (0.05)	8.354	2.476	34.124	6.224	16.877	1.280

Of the treatment combinations, S_3F_1 recorded maximum uptake (104.14 kg/ha) and S_5F_3 the minimum (43.31 kg/ha).

In S_3, intercropping in alternate rows, the increased competitive ability of maize plants would have resulted in higher uptake of nitrogen. Similar result was also reported by Waghmare and Singh (1984) in sorghum + legume intercropping system.

Severe competition from cowpea with least drymatter production and lowest dose of fertilizers resulted in the low nitrogen uptake by maize when it was planted in between triple rows of cowpea and with 50 percent of recommended fertilizer dose.

4.2.2. Phosphorus uptake

4.2.2.1. Cowpea

Phosphorus uptake of cowpea showed pronounced variations due to fertilizer doses and was not affected by the crop arrangements and interaction effects.

The fertilizer level F_1 (100 per cent dose) was significantly superior to other 2 levels in phosphorus uptake. F_2 and F_3 were on par.

Legumes are considered to be better absorbers of phosphorus (Kanwar, 1978 and Chhidda Singh, 1989). Hence even though the crop arrangements varied, it could not influence the phosphorus uptake values markedly. It may also be borne in mind that the uptake of this immobile nutrient is more influenced by root surface sorption zone competition rather than root system sorption zone competition seen in the case of mobile nutrients (Bray, 1954). Hence competition for phosphorus would have been slower in setting in and by the time the maize crop would have been harvested.

Moreover since there was no significant difference in drymatter yields with variation in crop arrangements and interaction effects the uptake of phosphorus also did not differ.

The maximum phosphorus uptake was recorded by the highest level of fertilizers and it was in line with the findings of Faroda and Tomer (1975) and Maloth and Prasad (1976). The increased nutrient supply associated with the higher levels of fertilizers could have improved root growth and nodulation and increased the absorption of phosphorus giving higher contents in plants and along with increased drymatter yields this could have contributed to increased phosphorus uptake values.

FIGURE 4.1
NUTRIENT UPTAKE BY COWPEA
Effect of Crop Arrangements

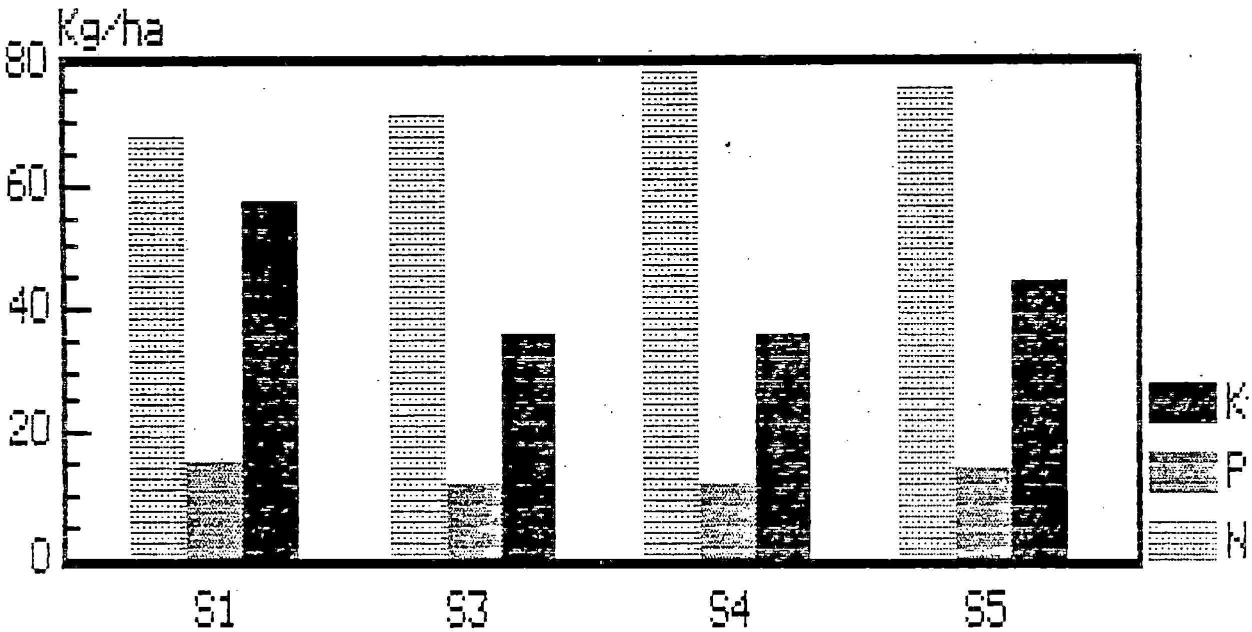


FIGURE 4.2
NUTRIENT UPTAKE BY COWPEA
Effect of Fertilizer Levels

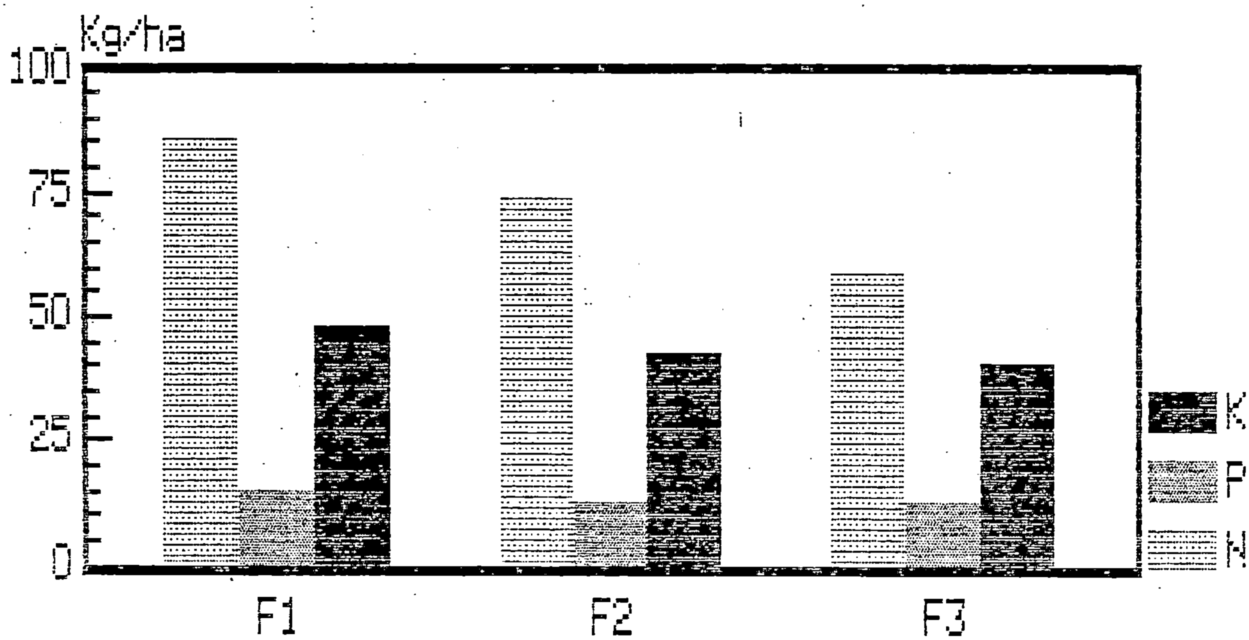
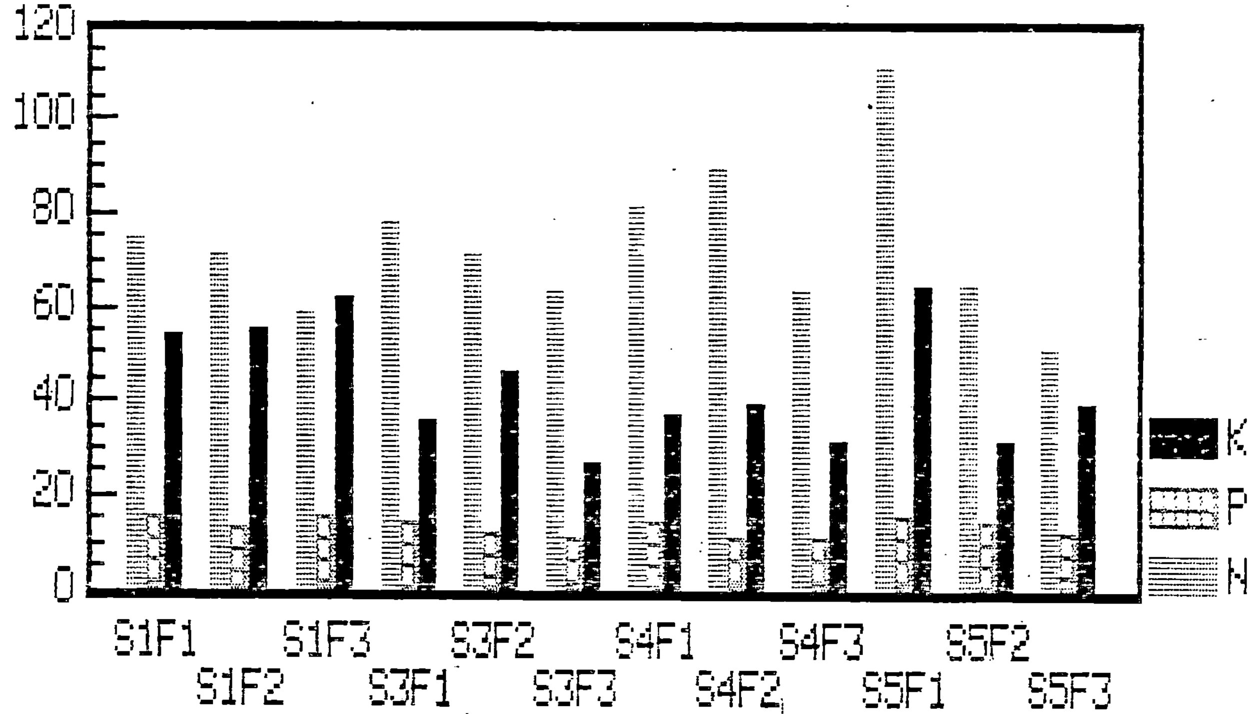


FIGURE 4.3
NUTRIENT UPTAKE BY COWPEA (Kg/ha)
Combined Effects



4.2.2.2. Maize

The effects due to different crop arrangements and interaction of crop arrangements with fertilizer doses were significant on this character.

The crop arrangement S_3 (cowpea and maize in alternate rows) resulted in the maximum value for phosphorus uptake which was on par with S_2 and S_4. S_4 and S_5 were also on par.

Fertilizer levels were not significant in influencing the phosphorus uptake by maize. The treatment combination S_3F_1 recorded the highest phosphorus uptake and S_4F_2, the lowest.

Phosphorus being an immobile nutrient in the soil, it is absorbed when growing roots come in contact with organic and inorganic materials containing available forms of the element. When maize was grown in alternate with cowpea the uptake of nitrogen was also maximum. So with better absorption of nitrogen, the maize crop could have foraged well producing an extensive root system which in turn resulted in the maximum uptake of phosphorus. Maize planted in between paired and triple rows of cowpea were on par and recorded low phosphorus uptake because of the severe competition from the associated leguminous crop of cowpea, which was better equipped for absorption of phosphorus (Kanwar, 1978 and Chhidda Singh, 1989).

Individual superiority of the treatments might have resulted in the maximum uptake of phosphorus in the treatment combination S_3F_1.

4.2.3. Potassium uptake

4.2.3.1. Cowpea

Different crop arrangements, fertilizer levels and their interactions had a pronounced effect on this parameter.

S_1 recorded the maximum value and was significantly superior to the intercrop arrangements. Maximum potassium uptake was noted for F_1 and was on par with F_2 which in turn was on par with F_3.

Among the treatment combinations, S_5F_1 recorded the maximum potassium uptake and S_3F_3 the minimum.

Grasses are better competitors for monovalent ions like potassium than legumes since the root CEC of the latter is higher (Tisdale et al., 1985). Hence in a pure crop of cowpea, the plants could absorb greater potassium than in the intercropping situation with maize which would have been at a greater competitive advantage to absorb potassium. This might be the reason why potassium uptake was higher in the sole crop of cowpea.

With regard to the fertilizer treatment it is quite understandable that the higher fertilizer dose increased potassium uptake since the absorption of this nutrient could have been higher in this treatment with higher supply of the nutrient. Similar results have been reported by Groneman (1974).

Triple row of cowpea treatment where maize population was relatively less coupled with highest dose of nutrients might have resulted in the superiority of interaction S_5F_1. The alternate row arrangement where cowpea population was less together with lowest level of fertilizers recorded the minimum uptake of potassium.

4.2.3.2. Maize

Potassium uptake by maize was influenced by different crop arrangements, fertilizer levels and their interactions.

S_2 recorded the maximum value for potassium uptake and was significantly superior to all other crop arrangements. S_3 and S_5 were on par while the latter treatment was in turn on par with S_4.

Among the fertilizer doses, F_1 recorded the highest value and the two lower levels were on par. The treatment

FIGURE 5.1
NUTRIENT UPTAKE BY MAIZE
Effect of Crop Arrangements

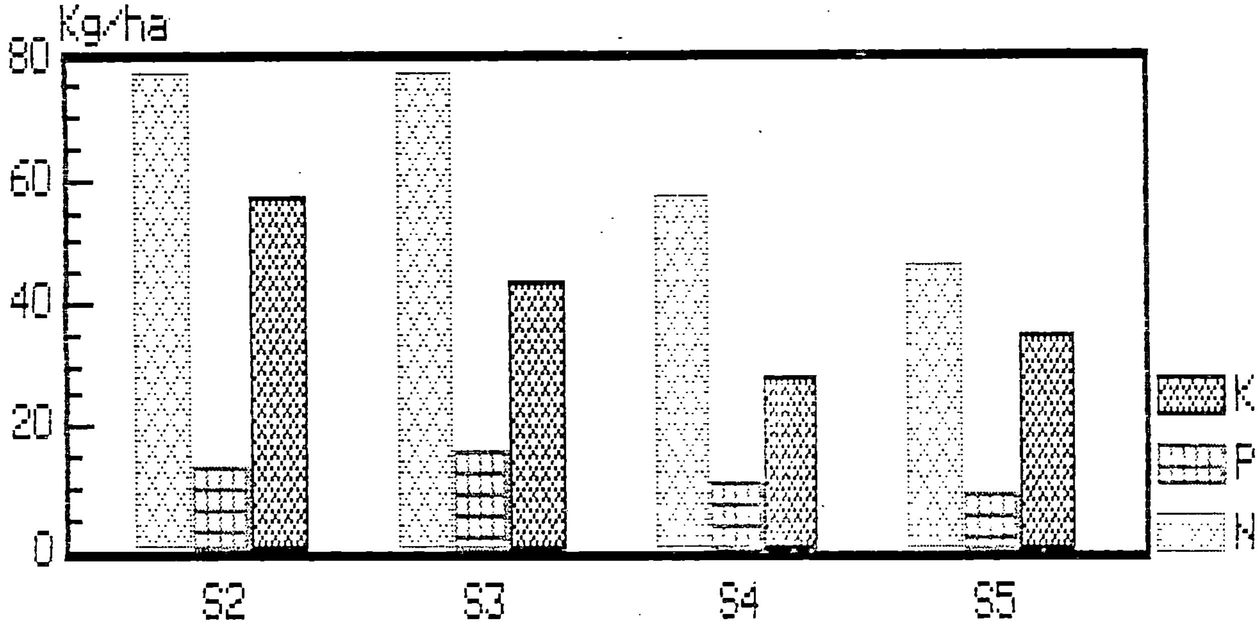


FIGURE 5.2
NUTRIENT UPTAKE BY MAIZE
Effect of Fertilizer Levels

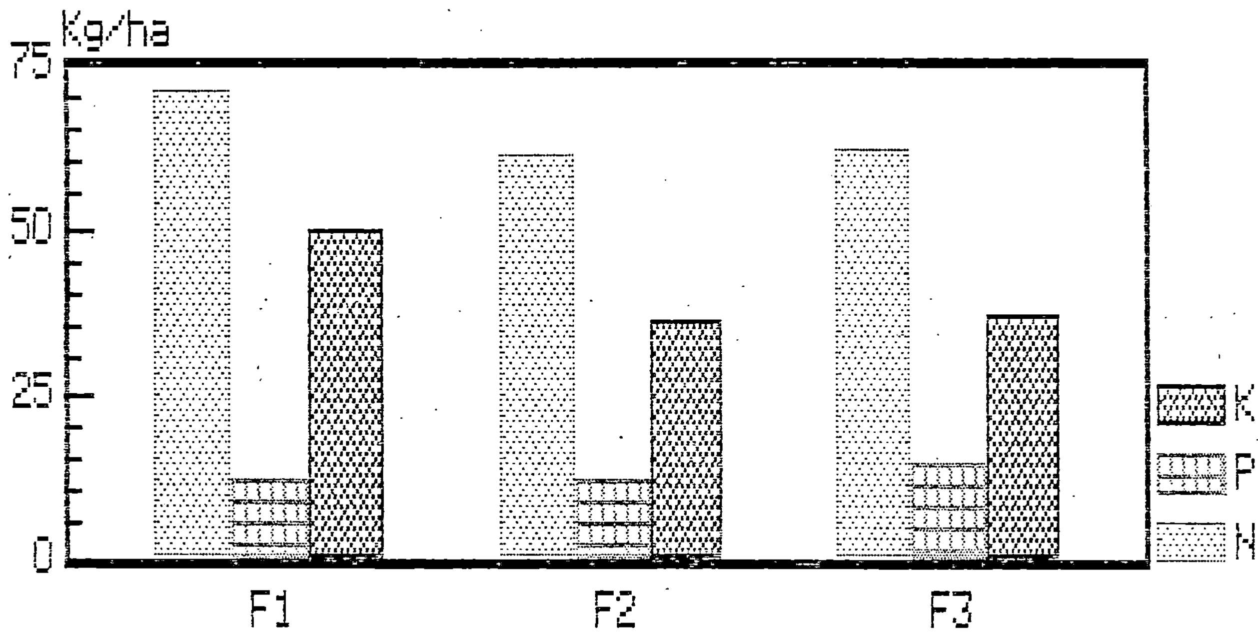
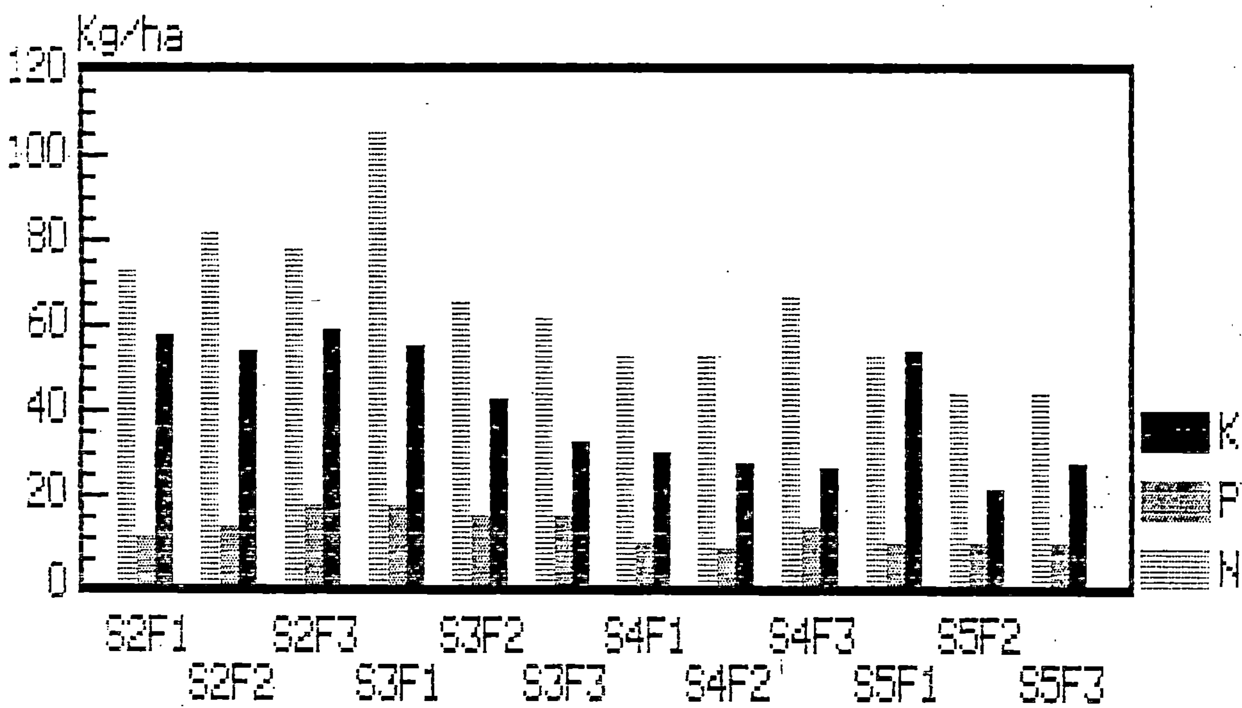


FIGURE 5.3
NUTRIENT UPTAKE BY MAIZE (Kg/ha)
Combined Effects



combination S_2F_3 recorded maximum uptake and S_5F_2 the minimum.

The maximum plant population of maize and higher drymatter production might have contributed to the increased potassium uptake in the pure crop of maize. Highest level of fertilizers significantly increased the potassium uptake by maize. Tiwana et al. (1978), Mercy George (1981) and Geethakumary (1989) reported similar increase in potassium uptake with increased application of N, P and K. Moreover maize being a grass is well equipped for better absorption of this nutrient (Tisdale et al., 1985).

The treatment combination where maize population was relatively less, recorded low potassium uptake because of the greater interspecific competition existing there.

4.2.4. Total uptake of nutrients (Figure 6)

The mean values on the total uptake of N, P and K by the different treatments are presented in Table 8.

4.2.4.1. Nitrogen

Total uptake of nitrogen by cowpea + maize was influenced by different crop arrangements, fertilizer levels as well as their interactions.

Table 8. Total uptake of nutrients by cowpea + maize at harvest

Treatments	Total uptake of nutrients (kg/ha)		
	N	P	K
Main factor(S)			
S_1	67.76	14.73	56.91
S_2	76.85	13.49	56.99
S_3	147.51	28.19	79.34
S_4	134.42	21.91	63.60
S_5	121.45	23.20	79.12
SE ±	7.632	1.935	3.654
CD (0.05)	23.523	5.962	11.261
Sub factor(F)			
F_1	156.29	26.49	96.69
F_2	134.29	23.81	78.73
F_3	120.39	25.85	76.55
SE ±	8.795	1.165	2.980
CD (0.05)	25.397	NS	8.606
S x F			
S_1F_1	73.94	15.53	54.33
S_1F_2	71.18	13.20	54.66
S_1F_3	58.16	15.45	61.75
S_2F_1	72.45	10.12	57.53
S_2F_2	81.09	12.72	54.41
S_2F_3	77.01	17.66	59.05
S_3F_1	181.88	31.90	90.80
S_3F_2	136.61	27.22	87.59
S_3F_3	124.01	25.48	59.60
S_4F_1	134.12	23.67	66.48
S_4F_2	140.53	18.27	66.19
S_4F_3	128.62	23.79	58.12
S_5F_1	162.77	24.76	117.60
S_5F_2	107.78	23.81	52.08
S_5F_3	93.78	21.00	67.67
SE ±	19.665	2.604	6.664
CD (0.05)	56.789	7.520	19.244

The crop arrangement S_3 recorded the maximum total nitrogen uptake on par with S_4 which in turn was on par with S_5. The uptake of nitrogen by the sole crops were on par.

The nitrogen uptake showed a declining trend with decreasing level of fertilizers. F_1 and F_2 were on par. F_2 was also on par with F_3.

S_3F_1 resulted in the maximum nitrogen uptake and S_1F_3 recorded the lowest.

The crop arrangement where cowpea and maize were planted in alternate rows resulted in greater annidation and better exploitation of resources and recorded the maximum uptake. The other intercrop treatments where the total plant population was relatively higher also resulted in high uptake of nitrogen. It could be clearly seen that intercropping resulted in higher uptake compared to the sole crops. Similar results have also been observed by Dalal (1974); Sanchez (1976); Selvaraj (1978); Soundararajan (1978) and Chui (1988).

Total nitrogen uptake was highest with full dose of fertilizers. Similar results were also reported by Chand (1977). The treatment combination S_3F_1 recorded the maximum total nitrogen uptake. This can be explained by the highest total drymatter yield (Tables 5 and 7) obtained in this treatment (4.82 t/ha of cowpea + 5.75 t/ha of maize = 10.57 t/ha) and the high uptake of this nutrient by the maize crop in this treatment combination. The minimum nitrogen uptake was observed in the treatment combination S_1F_3. The low drymatter yield coupled with low nitrogen uptake in this treatment may be the reason for this result.

4.2.4.2. Phosphorus

The total uptake of phosphorus was affected by the crop arrangements and interaction of crop arrangements with fertilizer doses while the effect different fertilizer doses was not significant.

S_3 recorded the maximum phosphorus uptake which was on par with S_5. S_5 and S_4 and the sole crops S_1 and S_2 were on par.

Among the treatment combinations, S_3F_1 recorded the maximum uptake value. S_2F_1 resulted in the minimum uptake.

Even though phosphorus uptake by cowpea was not affected by crop arrangements, in alternate row arrangement maize recorded the maximum uptake of phosphorus. This might have resulted in the maximum total uptake of phosphorus in this treatment. The total drymatter yield was

FIGURE 6.1
TOTAL UPTAKE OF NUTRIENTS (Kg/ha)
Effect of Crop arrangements

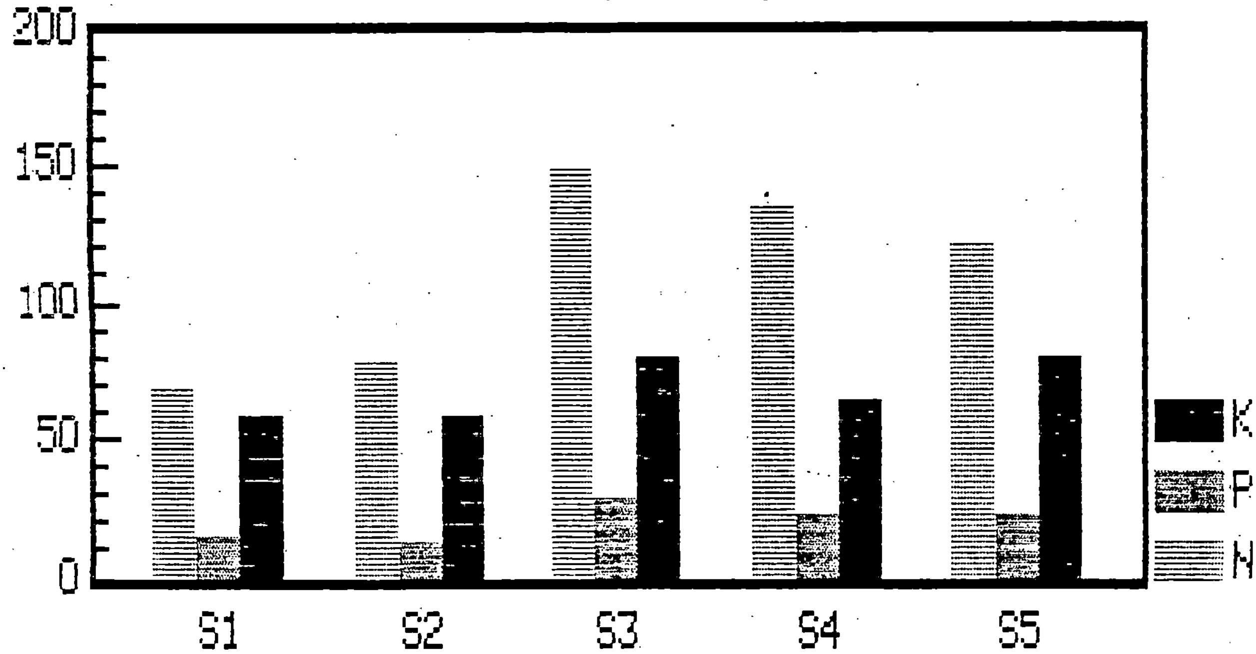
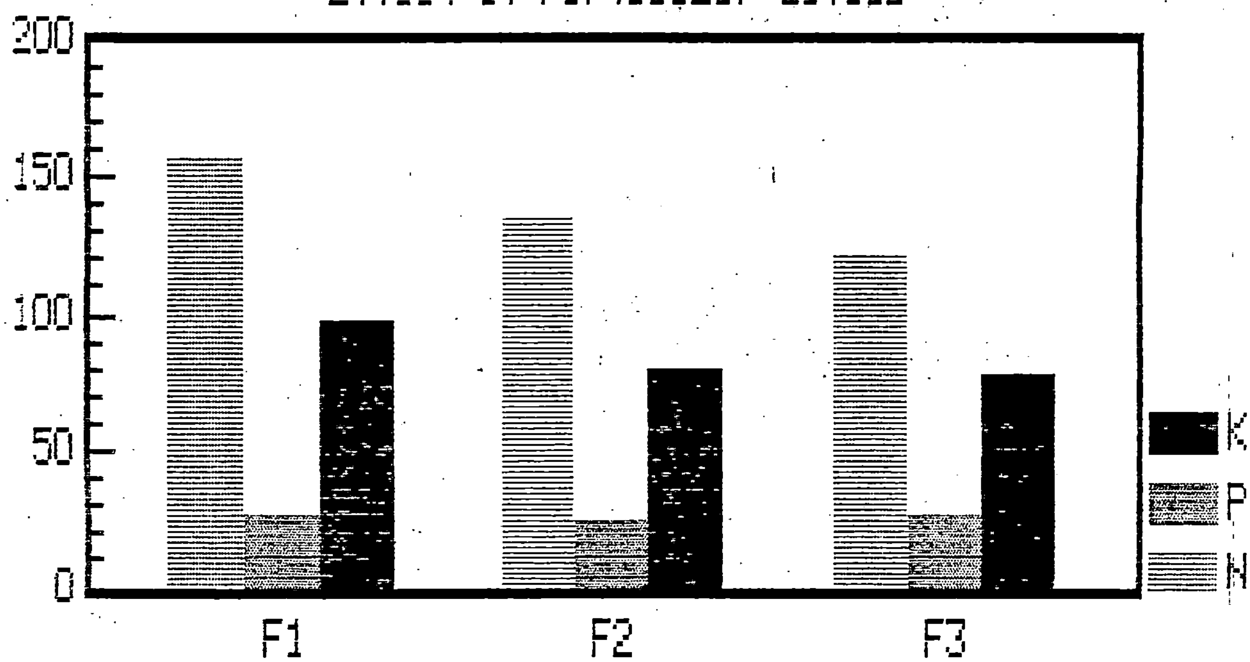


FIGURE 6.2
TOTAL UPTAKE OF NUTRIENTS (Kg/ha)
Effect of Fertilizer Levels



also highest here (Tables 5 and 7).

The high total drymatter yield and the high phosphorus uptake by maize in the treatment combination S_3F_1 could have brought about the highest uptake in this combination. Combinations involving sole crops resulted in lower uptake of the nutrient than intercropping. This is in agreement with the findings of Dalal (1974); Sanchez (1976); Selvaraj (1978) and Soundararajan (1978).

4.2.4.3. Potassium

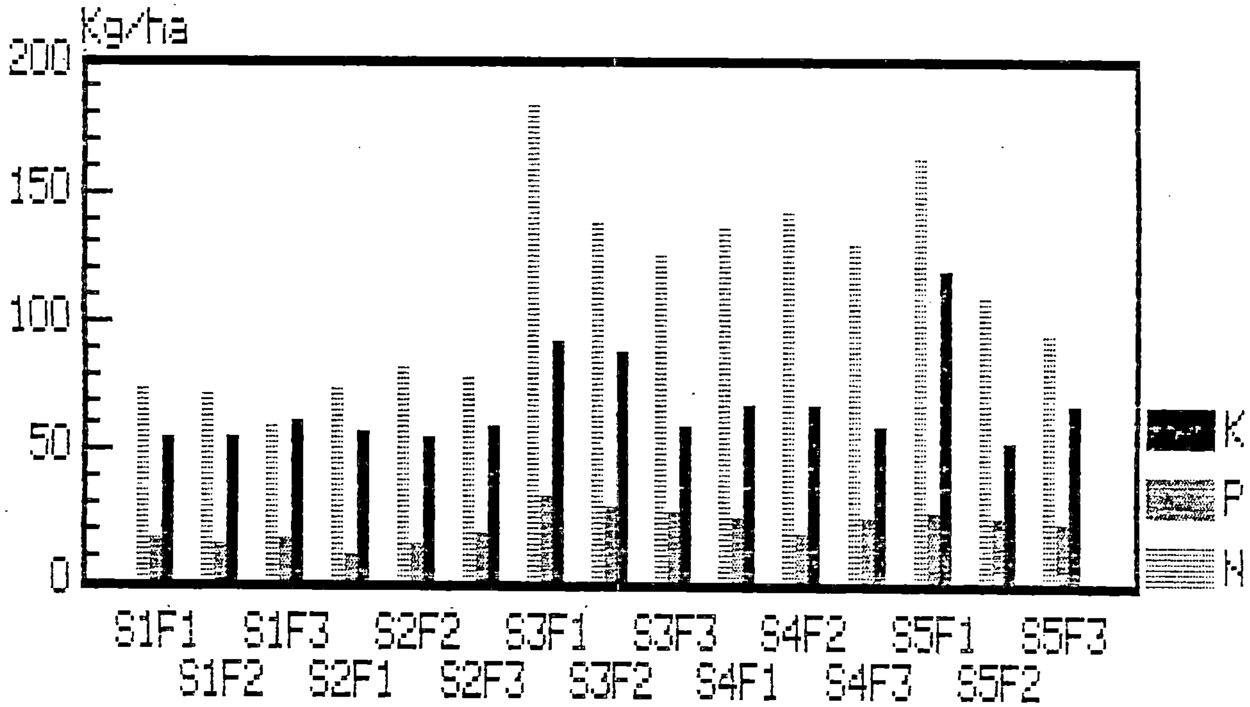
The total potassium uptake was affected significantly by different crop arrangements, fertilizer levels and their interactions.

The crop arrangement S_3 recorded the maximum total potassium uptake and was on par with S_5. Others were on par.

F_1 recorded the maximum uptake while F_2 and F_3 were on par. Of the treatment combinations, S_5F_1 resulted in the maximum uptake and S_5F_2 resulted in the lowest uptake of potassium.

The crop arrangement where cowpea and maize were planted in alternate rows resulted in greater annidation and better exploitation of available resources which in turn

FIGURE 6.3
TOTAL UPTAKE OF NUTRIENTS (Kg/ha)
Combined Effects



led to the maximum uptake of potassium along with nitrogen and phosphorus. Dalal (1974) and Soundararajan (1978) also observed that intercropped stands extract more potassium than the sole stands.

Since the individual uptake of potassium by the component crops showed a declining trend with decreasing level of fertilizers, full dose of fertilizers resulted in the maximum total uptake of potassium followed by 75 per cent dose which in turn was followed by 50 per cent dose.

The relatively high total drymatter yield and potassium uptake by maize in the combination S_5F_1 coupled with the highest potassium uptake by cowpea (Table 5) being recorded in this treatment could have resulted in this combination giving the maximum total uptake of potassium.

4.3. Yield attributes and yield

4.3.1. Number of pods per plant, length of pods, number of seeds per pod and test weight (hundred grain weight)

The mean values on number of pods per plant, length of pods, number of seeds per pod and test weight of cowpea are presented in Table 9.

Different crop arrangements, fertilizer levels and their interaction effects had no significant influence on

Table 9. Number of pods/plant, length of pod, number of seeds/pod and test weight of cowpea at harvest

Treatments	Number of pods/plant	Length of pod (cm)	Number of seeds/pod	Test weight (g)
Main factor(S)				
S_1	10.65	14.16	13.84	10.02
S_3	9.33	13.83	13.50	9.13
S_4	9.50	13.77	13.59	9.02
S_5	9.28	13.78	13.89	9.16
SE ±	1.712	0.205	0.320	0.408
CD (0.05)	NS	NS	NS	NS
Sub factor(F)				
F_1	10.15	13.87	13.90	9.06
F_2	9.58	13.94	13.65	9.55
F_3	9.35	13.84	13.57	9.38
SE ±	0.512	0.150	0.292	0.228
CD (0.05)	NS	NS	NS	NS
S x F				
S_1F_1	11.75	14.00	13.93	9.70
S_1F_2	10.60	14.30	13.65	10.61
S_1F_3	9.60	14.18	13.95	9.77
S_3F_1	9.55	13.70	13.68	8.98
S_3F_2	9.05	13.68	13.60	9.31
S_3F_3	9.40	14.13	13.23	9.10
S_4F_1	9.60	13.85	14.15	8.55
S_4F_2	9.40	13.85	13.13	9.12
S_4F_3	9.50	13.60	13.50	9.39
S_5F_1	9.70	13.93	13.85	9.02
S_5F_2	9.25	13.92	14.23	9.17
S_5F_3	8.90	13.48	13.60	9.28
SE ±	1.023	0.301	0.584	0.456
CD (0.05)	NS	NS	NS	NS

the number of pods per plant, length of pods, number of seeds per pod as well as on the test weight of cowpea.

Drymatter yields of cowpea were significantly influenced only by the fertilizer levels. Hence there was no marked effect on number of pods, length of pods, number of seeds per pod and test weight of seeds by the crop arrangements and combined effect of crop arrangements and fertilizer levels. In the case of fertilizer levels, the increased drymatter yields noticed in the treatments F_1 and F_2 could have been diverted towards the production of vegetative growth rather than towards the grain yield attributes as evidenced by the significant increase in bhusa yield in these treatments (Table 10).

4.3.2. Pod yield

The mean values on pod yield of cowpea are presented in Table 10.

The effects of different crop arrangements fertilizer levels and their interactions were not significant in influencing the pod yield of cowpea.

Since treatments had no significant effect on number of pods per plant, length of pods and on 100 grain weight, their impact on pod yield was not marked.

Table 10. Pod yield, grain yield, bhusa yield, harvest index and protein content of grains of cowpea at harvest

Treatments	Pod yield (kg/ha)	Grain yield (kg/ha)	Bhusa yield (t/ha)	Harvest index	Protein content of grains (%)
Main factor(S)					
S_1	1603.72	1373.66	15.75	0.26	21.19
S_3	1412.21	1301.83	10.60	0.30	21.33
S_4	1419.26	1255.43	11.55	0.28	20.25
S_5	1370.95	1244.82	13.97	0.25	18.64
SE ±	82.894	67.309	2.027	0.047	0.428
CD (0.05)	NS	NS	NS	NS	1.368
Sub factor(F)					
F_1	1493.37	1325.91	13.85	0.22	19.71
F_2	1428.79	1284.28	13.10	0.29	20.54
F_3	1432.44	1271.61	11.95	0.31	20.81
SE ±	32.589	21.222	0.582	0.023	0.417
CD (0.05)	NS	NS	1.699	0.0657	NS
S x F					
S_1F_1	1681.05	1414.95	15.90	0.24	21.05
S_1F_2	1607.77	1331.46	16.08	0.27	23.00
S_1F_3	1522.33	1374.55	15.28	0.27	19.53
S_3F_1	1419.33	1336.55	11.85	0.21	18.85
S_3F_2	1414.90	1334.80	11.05	0.31	21.10
S_3F_3	1402.40	1234.15	8.90	0.39	24.05
S_4F_1	1423.50	1269.08	12.33	0.22	21.33
S_4F_2	1329.25	1234.05	12.10	0.30	19.67
S_4F_3	1505.02	1263.18	10.23	0.33	19.75
S_5F_1	1449.60	1283.08	15.33	0.20	17.60
S_5F_2	1363.23	1236.80	13.18	0.29	18.40
S_5F_3	1300.03	1214.58	13.40	0.26	19.92
SE ±	65.178	42.443	1.164	0.049	0.834
CD (0.05)	NS	NS	3.398	NS	2.435

4.3.3. Yield of grains (Figure 7)

The mean grain yields of cowpea are presented in Table 10.

The effects due to different crop arrangements, fertilizer levels and their interactions were not significant in affecting the grain yield of cowpea.

Since pod yield, number of grains per pod and 100 grain weight did not differ significantly, it is quite understandable that grain yield also did not differ markedly between the treatments. The differences in drymatter yields could have reflected only through variation in bhusa yield.

From this result what becomes clearly evident is that it is very much possible to introduce a crop of fodder maize along with cowpea in summer fallows without reducing total yields of cowpea as obtained from sole cropping. Perhaps by mutual complementary effects and annidations intercropped cowpea could yield as much as in sole cropping even with slight changes in its population. Since the growth habit of leguminous cowpea differs very much from the maize crop, it could fully exploit the available spatial resources. Temporal annidation could also have played a role with the harvest of maize on the 50th day leaving

FIGURE 7.1
GRAIN YIELD OF COWPEA (Kg/ha)
Effect of Crop Arrangements

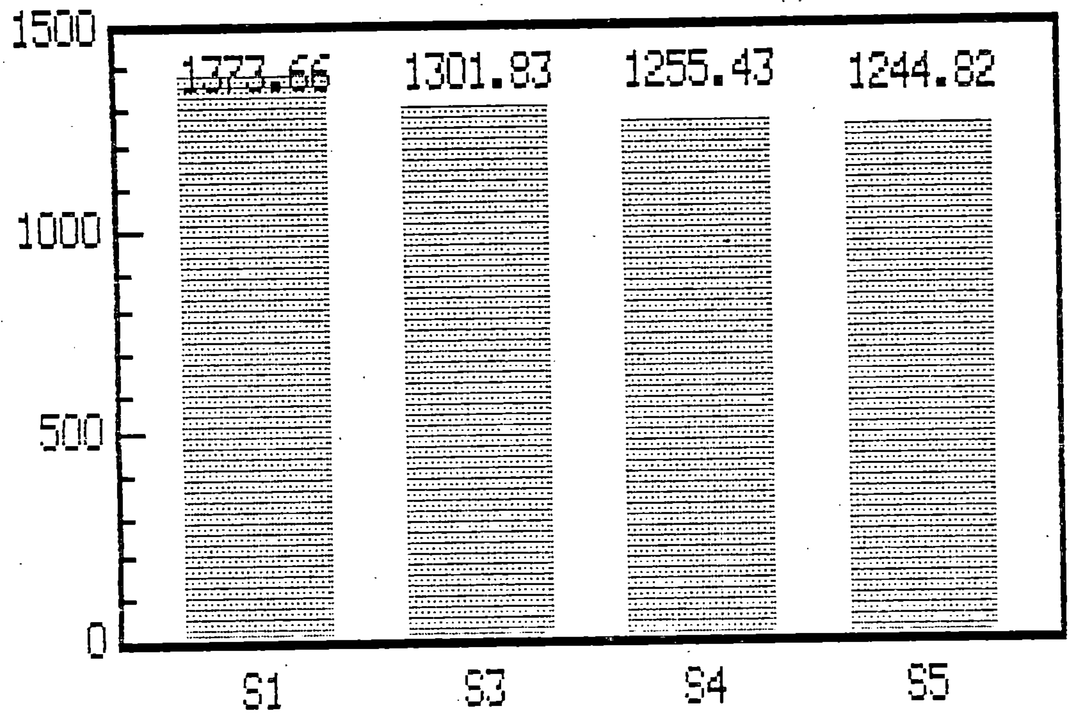
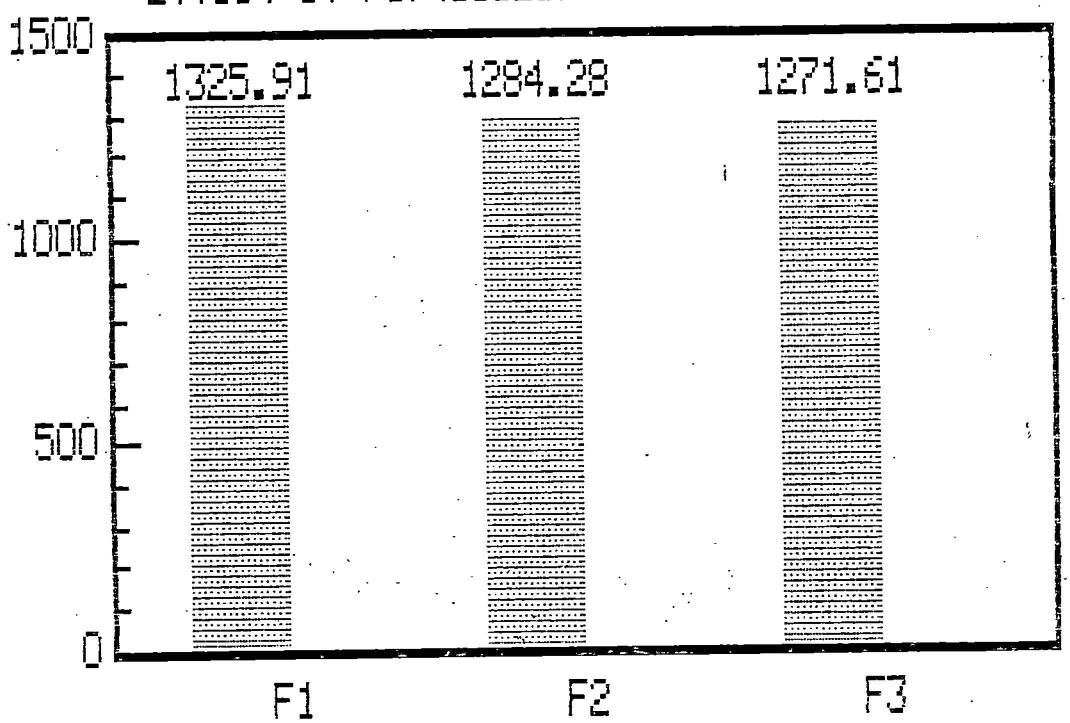


FIGURE 7.2
GRAIN YIELD OF COWPEA (Kg/ha)
Effect of Fertilizer Levels



cowpea nearly another 40 days to make up for whatever growth that had been retarded earlier. Remison (1960) and Chang and Shibles (1985a) also reported similar findings.

4.3.4. Bhusa yield

The data on bhusa yield of cowpea at the time of harvest were analysed statistically and the mean values are presented in Table 10.

The effects due to different fertilizer levels and interaction of crop arrangements with fertilizer levels were significant in affecting the yield of bhusa. Of the three fertilizer levels, F_1 (100 per cent dose) produced the maximum bhusa yield and was on par with F_2 (75 per cent dose). F_2 and F_3 were on par.

Of the treatment combinations, S_1F_2 recorded the maximum and S_3F_3 recorded the minimum bhusa yield.

Perhaps the higher nutrient doses could help the plants put forth better growth as evidenced from data on nutrient uptake and drymatter yields (Table 5) and this could have increased the bhusa yield. Since this increase in drymatter yields were not manifested through pod yields and grain yields and perhaps the higher doses of nutrients could have helped only to increase vegetative growth. The higher values of height, leaf number and LAI in these treatments point out this aspect (Table 4). In the crop arrangement where cowpea and maize were grown in alternate rows cowpea population was the lowest and this along with the lowest level of fertilizers recorded the minimum bhusa yield.

4.3.5. Harvest index

The mean values are presented in Table 10.

Different levels of fertilizers produced marked difference in harvest index values even though crop arrangements and interaction effects were not significant.

With the three fertilizer levels, 50 per cent and 75 per cent doses were on par and gave maximum harvest index values while F_1 (100 per cent dose) gave the minimum value.

Harvest index is the ratio of economic yield to biological yield. Since there was no significant influence on grain yield by various treatments and the increased drymatter yields noticed with the application of higher doses of fertilizers was associated with increased production of vegetative growth and bhusa yield as discussed earlier (Table 10), there was a marked decrease in the harvest index values for the treatments with higher levels of fertilizer application.

4.3.6. Green matter yield of maize (Figure 8)

The data on green fodder yield of maize were analysed statistically and the mean values are presented in Table 7.

The different crop arrangements, fertilizer levels as well as their interaction effects were found to influence the fodder yield of maize. S_2 (sole crop) produced the maximum fodder yield and was on par with S_3 (cowpea and maize in alternate rows). S_4 and S_5 were on par.

F_1 (100 per cent dose) produced significantly higher fodder yield than F_2 and F_3 (75 per cent and 50 per cent dose respectively) and the latter two were on par. The treatment combination S_3F_1 recorded the maximum fodder yield (37.8 t/ha) and S_5F_3 the minimum (16.81 t/ha).

The pure crop of maize recorded the maximum value. The increased yield in this treatment was due to the higher plant population coupled with the favourable environment with regard to land and nutrition resulting in luxuriant vegetative growth. Among the intercrop arrangements, maize planted in alternate with cowpea plants recorded the highest fodder yield. Here the plant population of maize was high compared to other intercropping arrangements. In other two intercropping arrangements where the plant population of maize was same recorded yields on par. The relationship

FIGURE 8.1
GREEN MATTER YIELD OF MAIZE (t/ha)
Effect of Crop Arrangements

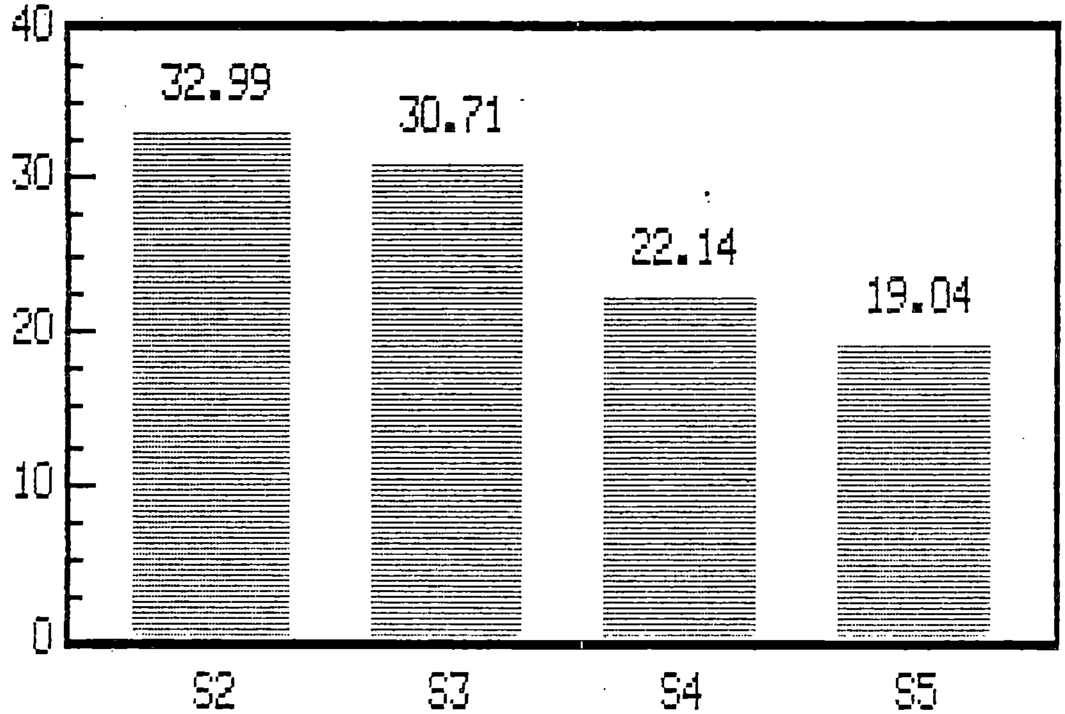


FIGURE 8.2
GREEN MATTER YIELD OF MAIZE (t/ha)
Effect of Fertilzer Levels

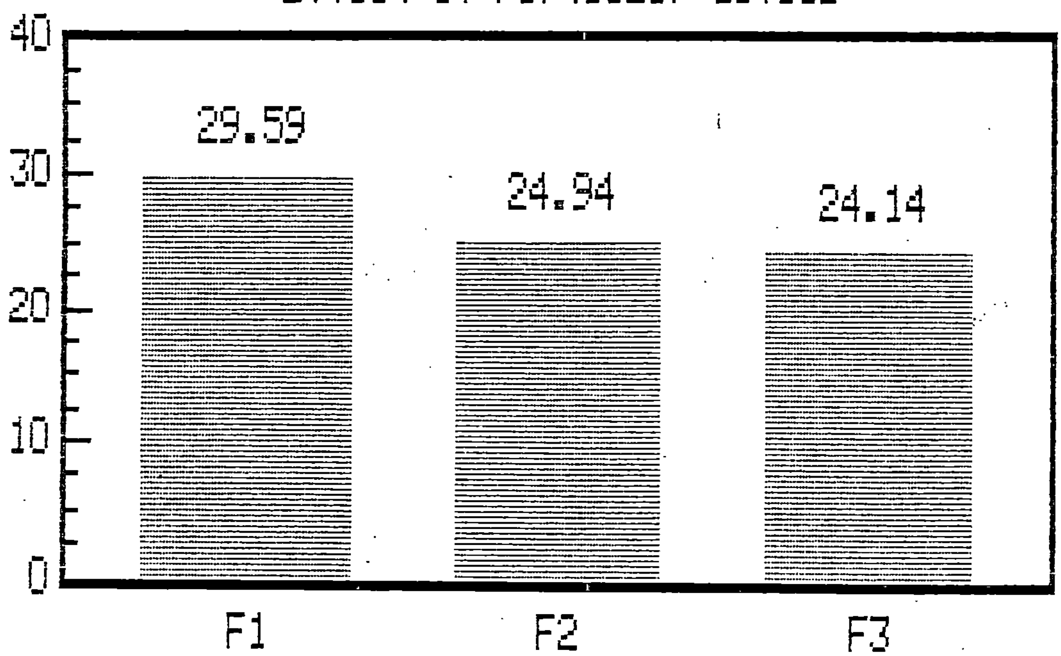
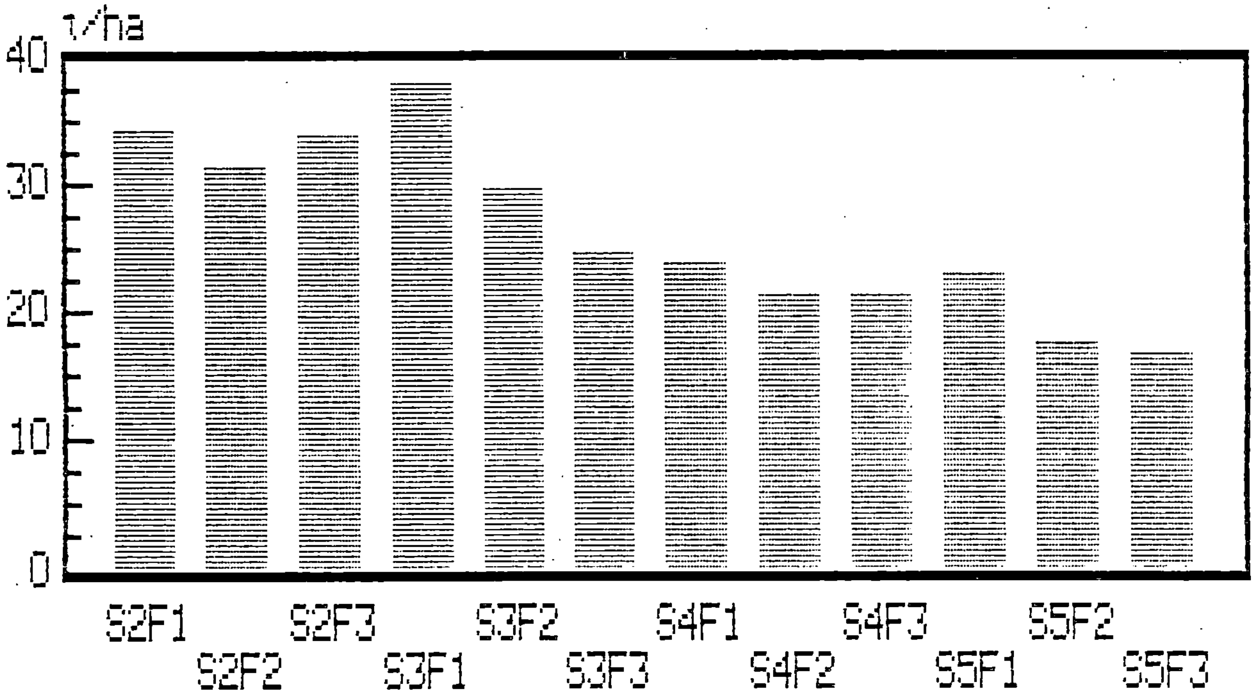


FIGURE 8.3
GREEN MATTER YIELD OF MAIZE (t/ha)
Combined Effects



between plant population and yield was found to be linear, and positive.

It was also seen that the highest yield was produced by the highest level of fertilizers. The yield attributing characters like height of plants and number of leaves per plant were maximum under the highest level of fertilizer application. From the uptake studies (Table 7) it was clear that the uptake of major nutrients was also maximum in the fertiliser level F_1. The increased uptake of major nutrients might have had positive effect on vegetative growth resulting in increased fodder yield. Shivanand (1987) also reported that total fodder yield of sorghum was highest at high and medium fertilizer levels.

Among the treatment combinations S_3F_1 recorded the maximum green matter yield on par with the combinations involving pure crop of maize indicating the favourable influence of cowpea when maize was grown in alternate rows with it and the high level of nutrition. It may be noted that in this treatment the population of maize was also higher than other intercropping treatments. This could also have played its due role in augmenting the fodder yield with adequate nutrition.

4.4. Quality aspects

4.4.1. Crude protein content

The data on crude protein content expressed as percentage of cowpea grains and maize were analysed statistically and the results are presented in Tables 10 and 7 respectively.

4.4.1.1. Cowpea

The protein content of cowpea grains was affected by different crop arrangements and by the interaction of crop arrangements with fertilizer levels, but different fertilizer levels had no significant effect.

Of the different crop arrangements, S_3 recorded the highest value (21.33 per cent) which was on par with other crop arrangements except S_5.

Considering the different treatment combinations, S_3F_3 recorded the highest value (24.05 per cent) and was on par with S_1F_2. S_5F_1 recorded the lowest value for protein content (17.6 per cent).

Triple row arrangement of cowpea which had recorded high nitrogen uptake gave low protein content in grain perhaps because most of the nutrient could have been diverted to the vegetative parts, since the treatment had given fairly high values of bhusa yield (Table 10). In the alternate row arrangement the low bhusa yield recorded shows that more of the nitrogen absorbed by cowpea could have been diverted towards the grains resulting in the higher protein content.

The low protein content associated with the full dose of fertilizers and triple row arrangement of cowpea could have together combined to give lower protein contents in this treatment combination as the nitrogen taken by the plant could have been ~~more~~ diverted more to plant parts other than the grain ~~protein~~.

4.4.1.2. Maize

The protein content of maize plant at harvest was affected by different fertilizer levels and by the interaction of fertilizer levels with the crop arrangements. Crop arrangements did not show any significant effect.

Of the three fertilizer levels, F_1 and F_2 were on par and they were significantly superior to F_3.

Considering the different treatment combinations S_3F_1 recorded the highest value. The combination S_3F_3 recorded the lowest value for protein content.

Mercy George (1981) and Geethakumary (1989) have also observed that the protein content of maize was not affected by the different crop arrangements. But the fertilizer levels had a significant influence on the protein percentage of maize. Higher levels of fertilizers were found to be on par in increasing the crude protein yields of maize. The relationship between nitrogen fertilization and protein percentage was well established by several workers (Tripathi, 1971; Rajagopal et al., 1974; Gangro, 1978 and Jaleesa, 1987).

Maize planted in alternate with cowpea and with full dose of fertilizers recorded the highest value for protein percentage showing the enhancing effect of legumes and higher levels of nitrogen on the protein content of maize. Similar results showing a higher protein yield of maize with legumes was reported by Patel et al. (1968), Relwani et al. (1976) and Sayagavi (1987).

4.5. Nutrient status of the soil after the experiment

The mean values of available nitrogen, available phosphorus and available potassium in the soil as affected by cowpea, maize and cowpea + maize arrangements and fertilizer levels are presented in Table 11.

FIGURE 7.3
GRAIN YIELD OF COWPEA (Kg/ha)
Combined Effects

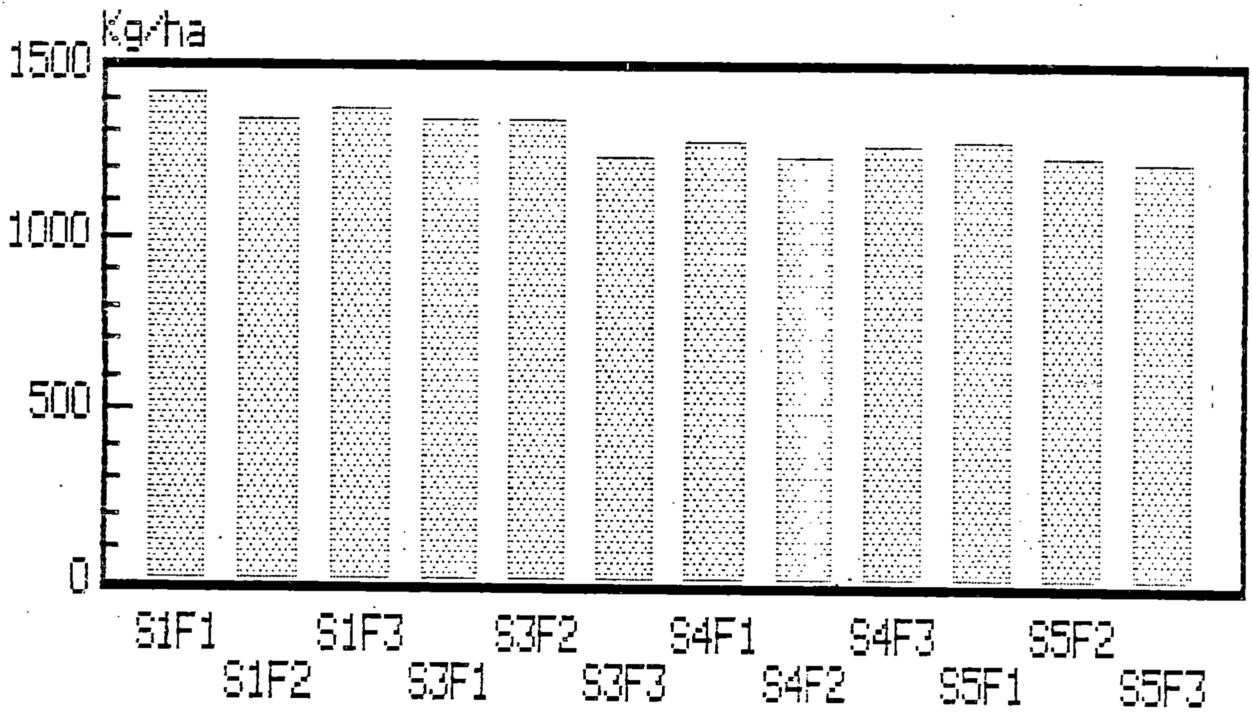


Table 11. Available N, P and K in the soil after the experiment

Treatments	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Main factor(S)			
S_1	501.20	18.99	208.83
S_2	398.53	24.37	133.08
S_3	442.67	19.63	130.33
S_4	485.33	21.97	119.33
S_5	442.32	13.65	126.00
SE ±	25.175	1.774	12.229
CD (0.05)	77.577	5.468	37.684
Sub factor(F)			
F_1	388.03	25.50	146.50
F_2	530.32	20.32	152.00
F_3	443.68	13.34	132.05
SE ±	19.858	1.271	8.441
CD (0.05)	57.345	3.671	NS
S x F			
S_1F_1	355.60	24.48	242.00
S_1F_2	618.80	15.84	211.00
S_1F_3	529.20	16.64	173.50
S_2F_1	341.60	34.24	115.50
S_2F_2	442.40	24.96	149.00
S_2F_3	411.60	13.92	134.75
S_3F_1	434.00	31.04	91.00
S_3F_2	534.80	16.48	130.50
S_3F_3	359.20	11.36	169.50
S_4F_1	473.20	18.88	177.50
S_4F_2	568.40	30.88	93.00
S_4F_3	414.40	16.16	87.50
S_5F_1	335.75	18.88	106.50
S_5F_2	487.20	13.44	176.50
S_5F_3	504.00	8.63	95.00
SE ±	44.403	2.842	16.874
CD (0.05)	NS	8.208	54.506

4.5.1. Available nitrogen in the soil

The effects on the available nitrogen in soil due to crop arrangements and fertilizer levels showed marked differences while their interactions showed no marked difference.

Among the different crop arrangements, S_1 recorded the highest value for available nitrogen in the soil after the experiment which was on par with other intercrop arrangements. S_2 recorded the lowest value.

Maximum available nitrogen in soil was noted for F_2 while the effects of F_1 and F_3 were on par.

The pure crop of cowpea recorded the maximum available nitrogen content which was on par with other intercrop situations. Comparatively higher nitrogen fixation of sole crop of cowpea in summer was also reported by Ofori et al. (1987). Maize might have competed with cowpea crop and caused a depletion of nitrogen in the soil. This might have stimulated the nitrogen fixation in legume and compensated the nitrogen exhausted from the soil bringing it on par with the sole crop of cowpea. Dakora et al. (1988) also reported this kind of enhanced nitrogen fixation by cowpea when intercropped with pearl millet. The pure crop of maize recorded the least value. Maize requires nitrogen more than any other nutrients and is a heavy feeder of nitrogen (Fayemi, 1966).

Among the fertilizer levels, 75 per cent dose of fertilizers recorded the highest value while other two levels were on par. At higher levels of nitrogen application, the added fertilizers might have increased nitrogen uptake and decreased the nodule formation and nitrogen fixation. Rhoden et al. (1987) also reported that nodule number and weight declined with increasing levels of applied nitrogen. The soil might have been more depleted of available nitrogen in the case of 50 per cent dose of fertilizers due to severe competition.

When compared to the initial status of available nitrogen in the soil (362.6 kg/ha), in general there was an increase for all the crop arrangements. Pure crop of maize showed only a slight increase due to its intensive feeding while the sole crop of cowpea and intercrop arrangements recorded fairly high values. Enrichment of soil nitrogen by sorghum-pulse intercropping in farmers field was also reported by Morachan et al. (1977).

4.5.2. Available phosphorus

Available phosphorus in the soil after the experiment was influenced by different crop arrangements, fertilizer levels and their interactions.

Among the different crop arrangements, S_2 recorded the highest value which was on par with S_4 and S_3. S_5 gave the lowest value which was on par with S_1.

Considering the fertilizer levels, F_1 recorded the highest value and F_3 the lowest.

In the case of different treatment combinations, S_2F_1 recorded the highest value and S_5F_3 recorded the lowest value.

The pure crop of maize recorded the highest value. The sole crop and triple row arrangement of cowpea where the population of cowpea was higher recorded the lowest value. Being a legume, some quantity of phosphorus might have been utilized for the root growth and activation of N fixing bacteria (Tisdale et al., 1985) resulting in a reduction in available phosphorus of soil.

As the dose of applied fertilizers increased there was a corresponding increase in the residual phosphorus in the soil. When higher levels of nutrients were applied, a small fraction of nutrients would have been left unutilized by the standing crops giving an increase in residual nutrient content of soil.

The treatment combination involving the sole crop of maize and full dose of fertilizers recorded the highest value because of the superiority of individual effects. Combination involving the highest cowpea population and lowest dose of applied fertilizers recorded the minimum available phosphorus in the soil after the experiment as more quantity of the nutrient would have been absorbed by cowpea which is well equipped to feed on phosphorus (Kanwar, 1978).

There was a build up of available phosphorus after cropping compared to the initial status (8.8 kg/ha). The added fertilizers and the residues returned to the soil would have added to the available phosphorus pool in the soil. This is in agreement with the findings of Biswas et al. (1977) and Palaniappan (1985).

4.5.3. Available potassium

Available potassium in the soil after the experiment was affected by different crop arrangements and the interaction of crop arrangements with fertilizer levels while the effect of fertilizer levels was not significant.

S_1 recorded the highest value and was significantly superior to other crop arrangements.

The treatment combination S_1F_1 recorded the maximum available potassium while S_4F_3 recorded the lowest value.

The pure crop of cowpea showed the maximum value. In all other crop arrangements, where maize was also grown, uptake of potassium was higher (Table 8). This might have resulted in low available potassium in these crop arrangements and were on par.

The treatment combination involving the sole crop of cowpea and full dose of fertilizers recorded the highest potassium content in soil. Even though fertilizer levels were not significant, higher fertilizer levels together with the treatment sole cowpea where maize was excluded led to maximum available potassium in the soil.

There was not much variation in available potassium content of soil after the experiment compared to the initial value (121.5 kg/ha) except for the sole crop of cowpea. This might be because of the dynamic equilibrium existing among the various forms of soil potassium (Palaniappan, 1985).

4.6. Biological efficiency indices

4.6.1. Land equivalent ratio (LER) (Figure 9)

The data on LER were analysed and the mean values are presented in Table 12.

Table 12. LER, LEC and IER of cowpea + fodder maize intercropping

Treatments	LER	LEC	IER
Main factor(S)			
S_3	1.90	0.94	1.87
S_4	1.61	0.64	1.61
S_5	1.51	0.54	1.47
SE ±	0.059	0.028	0.052
CD (0.05)	0.204	0.099	0.180
Sub factor(F)			
F_1	1.75	0.85	1.72
F_2	1.72	0.71	1.72
F_3	1.55	0.57	1.51
SE ±	0.049	0.052	0.055
CD (0.05)	0.146	0.154	0.162
S x F			
S_3F_1	2.08	1.30	2.06
S_3F_2	1.97	0.86	1.94
S_3F_3	1.65	0.66	1.60
S_4F_1	1.58	0.62	1.60
S_4F_2	1.67	0.71	1.68
S_4F_3	1.58	0.59	1.56
S_5F_1	1.58	0.61	1.50
S_5F_2	1.52	0.56	1.53
S_5F_3	1.42	0.46	1.38
SE ±	0.085	0.089	0.095
CD (0.05)	0.253	0.266	0.281

The effects of different crop arrangements, fertilizer levels as well as their interactions were significant on LER.

Among the different crop arrangements, S_3 recorded the highest value and was significantly superior to other arrangements. S_4 and S_5 were on par.

Among the fertilizer levels, F_1 and F_2 were on par and were significantly superior to F_3.

S_3F_1 recorded the highest LER which was on par with S_3F_2. S_5F_3 recorded the lowest value for LER.

In the present investigation, the highest value for LER was recorded by the alternate row arrangement. The LER value for this arrangement was 1.9 meaning 90 per cent more land would be required as sole crops to produce the same yields as intercropping ie, it was 90 per cent more efficient than the respective sole crops. Even though triple row arrangement recorded the lowest LER value it was 50 per cent more efficient than its corresponding pure crops.

With the three fertilizer levels, 100 per cent dose recorded the maximum value (1.75) which was on par with 75 per cent dose (1.72). Intercropping with full dose of fertilizers was 75 per cent more efficient than their respective sole crops.

In combination involving triple row of cowpea + one row of maize with lowest level of fertilizers, the total yield was low due to severe competition that existed there. So this combination recorded the lowest value for LER.

Thus the study clearly reveals the vast potential of introducing a crop like fodder maize along with cowpea in the rice-rice-cowpea cropping system commonly followed in Kerala. The best arrangement is alternate rows of cowpea and fodder maize. Seventy five per cent of the recommended dose of fertilizers is as good as 100 per cent dose. Though the most biologically efficient combination is alternate rows of cowpea and fodder maize applied with full dose of fertilizers, it was on par with that applied with 75 per cent dose.

4.6.2. Land equivalent coefficient (LEC) (Figure 9)

The data on LEC were analysed and the mean values are presented in Table 12.

The effects due to different crop arrangements, fertiliser levels and their interactions were significant on LEC.

FIGURE 9.1
L.E.R,L.E.C AND I.E.R
Effect of Crop Arrangements

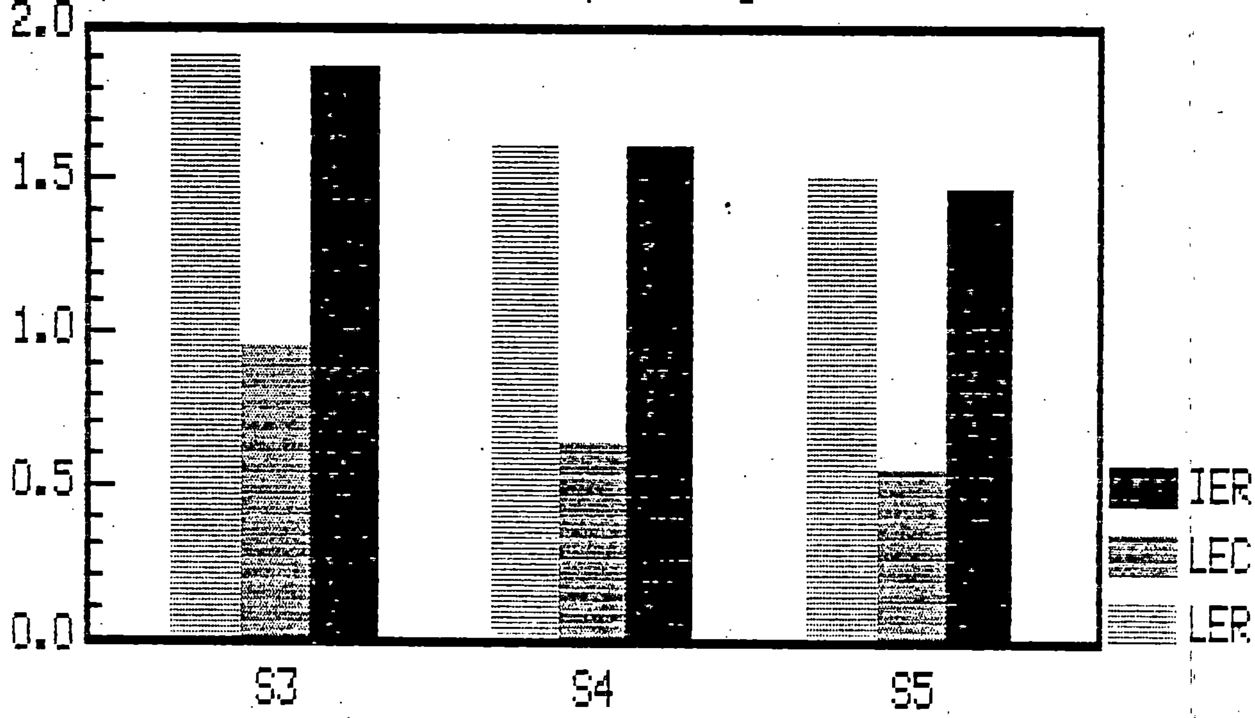


FIGURE 9.2
L.E.R,L.E.C AND I.E.R
Effect of Fertilizer Levels

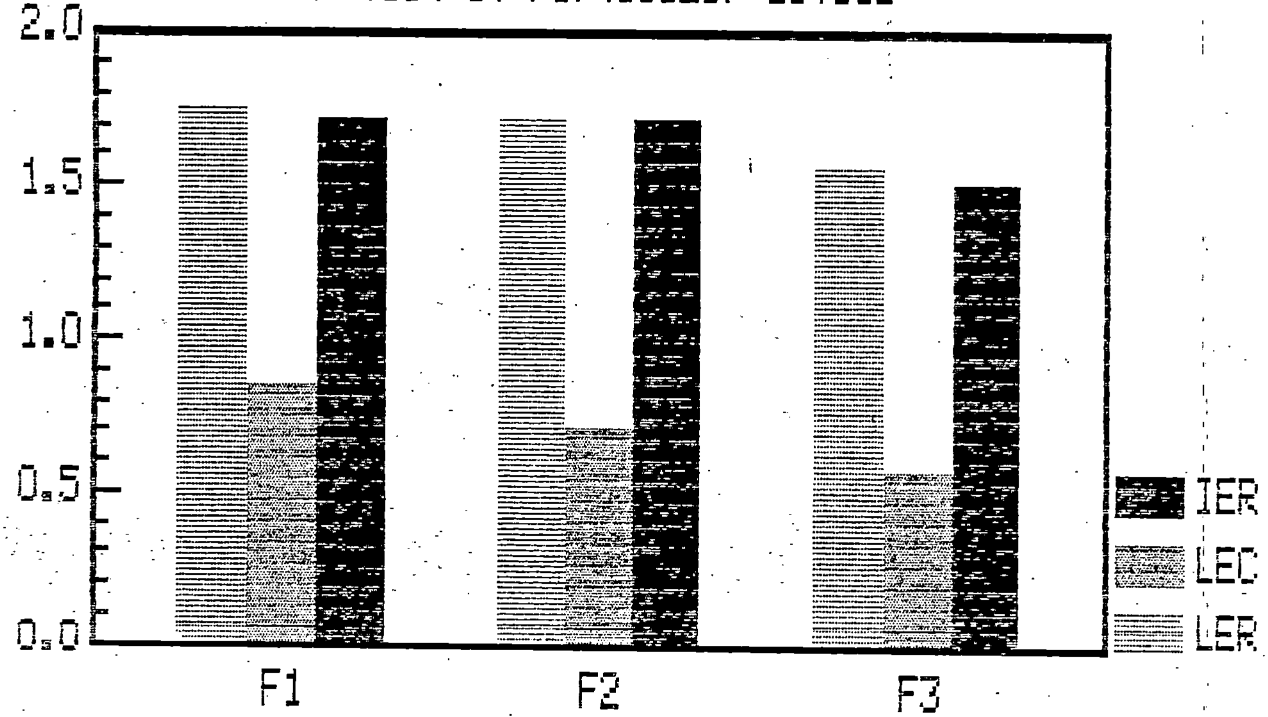
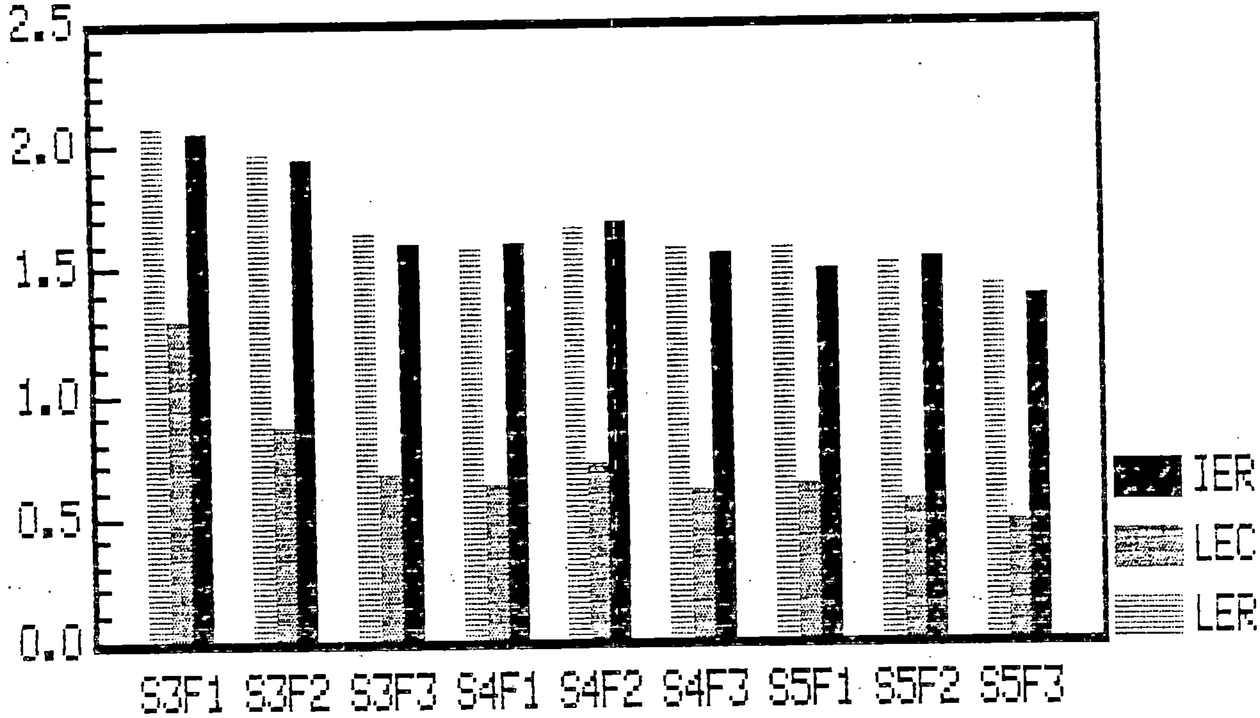


FIGURE 9.3
L.E.R, L.E.C AND I.E.R
Combined Effects



Of the different crop arrangements, S_3 recorded the highest value and S_5 the lowest.

Considering the fertilizer levels, F_1 recorded the highest value (0.85) and was on par with F_2. F_2 and F_3 were on par.

Among the treatment combinations S_3F_1 was significantly superior to all others and S_5F_3 recorded the lowest LEC.

The LEC value for crop arrangement S_3 was 0.94. When LEC for a two-crop mixture is greater than 0.25, but less than unity the neighbourhood effects involve competitive complementarity. In the present study all the intercropping arrangements fall in this category which indicates that they are in the same situation.

The fertilizer level F_1 and the treatment combination S_3F_1 recorded the maximum LEC values since their corresponding LER values were maximum.

4.7. Economic efficiency indices (Figure 10)

4.7.1. Net returns

The net returns from pure crops and intercrops were analysed and the mean values are presented in Table 13.

Table 13. Economics of cowpea + fodder maize intercropping system under different crop arrangements and fertility levels

Treatments	Net income (Rs.)	Benefit/ cost ratio	Return/rupee invested on Labour (Rs.)	Return/rupee invested on Fertilizer (Rs.)	Return/ cropping day (Rs.)
Main factor(S)					
S_1	5890.00	2.15	2.23	27.72	65.44
S_2	6713.30	2.02	2.23	9.83	110.78
S_3	12853.00	2.40	2.58	13.65	142.81
S_4	10035.30	2.07	2.20	18.31	108.73
S_5	8305.50	1.90	2.02	13.39	92.28
SE ±	1227.56	0.162	0.179	2.832	16.539
CD (0.05)	3782.81	NS	NS	8.727	50.966
Sub factor(F)					
F_1	9737.50	2.17	2.39	13.01	115.78
F_2	8401.50	2.08	2.17	14.67	97.81
F_3	8139.40	2.07	2.19	22.07	98.42
SE ±	446.86	0.063	0.065	0.943	5.656
CD (0.05)	1290.45	NS	0.187	2.724	16.334
S x F					
S_1F_1	6138.25	2.18	2.30	20.17	68.20
S_1F_2	5555.75	2.08	2.14	24.63	61.73
S_1F_3	5976.00	2.19	2.26	38.35	66.40
S_2F_1	6832.00	2.00	2.26	7.21	113.87
S_2F_2	6121.00	1.91	2.09	8.18	98.68
S_2F_3	7187.00	2.15	2.33	14.11	119.78
S_3F_1	15549.00	2.54	2.91	12.11	172.76
S_3F_2	12638.00	2.55	2.55	13.04	140.42
S_3F_3	10372.00	2.11	2.27	15.82	115.24
S_4F_1	10287.00	2.11	2.26	13.86	114.30
S_4F_2	10060.00	2.02	2.13	15.59	103.45
S_4F_3	9759.00	2.10	2.20	25.49	108.44
S_5F_1	9881.00	2.04	2.21	11.68	107.79
S_5F_2	7632.50	1.82	1.93	11.91	84.80
S_5F_3	7403.00	1.82	1.91	16.59	82.26
SE ±	999.21	0.139	0.144	2.109	12.648
CD (0.05)	2885.53	0.404	0.417	6.091	36.524

Price of cowpea grains Rs.8/kg   Price of green maize fodder Rs.40/kg

The effects due to crop arrangements, fertilizer levels and their interactions were significant on net returns. S_3 recorded the highest returns on par with S_4. S_4 and S_5 were on par while S_5 was in turn on par with the pure crop treatments which gave the minimum values.

Considering the fertilizer levels, F_1 recorded the highest net returns. F_2 and F_3 were on par.

The treatment combination S_3F_1 gave the highest net returns and S_1F_2 the lowest.

The treatment giving the highest net returns was considered to be the best. Here the crop arrangement S_3 and fertilizer level F_1 recorded the maximum value for net returns. The highest total yield from these might be the reason for such results. Mutanal (1987) also reported that net income was maximum when maize was grown with one row of cowpea. Similarly S_3F_1 recorded the highest value.

4.7.2. Benefit-cost ratio

The average benefit-cost ratios were worked out and the data are presented in Table 13.

Different crop arrangements and fertilizer levels were not significant on benefit-cost ratio, but their interactions were significant.

The treatment combination S_3F_2 showed the highest value for this ratio. The lowest value was recorded by S_5F_2 and S_5F_3 combinations.

This index provides an estimate of the benefit the farmer derives for the expenditure he incurred in adopting a particular cropping system. Among the different treatment combinations of the present investigation S_3F_2 recorded the maximum value for the benefit-cost ratio followed by S_3F_1 showing their superiority over other treatment combinations.

4.7.3. Return per rupee invested on labour

The average values were worked out and presented in Table 13. Different fertilizer levels and interaction of crop arrangements with fertilizer levels were significant on return per rupee invested on labour while the effects of crop arrangements were not significant.

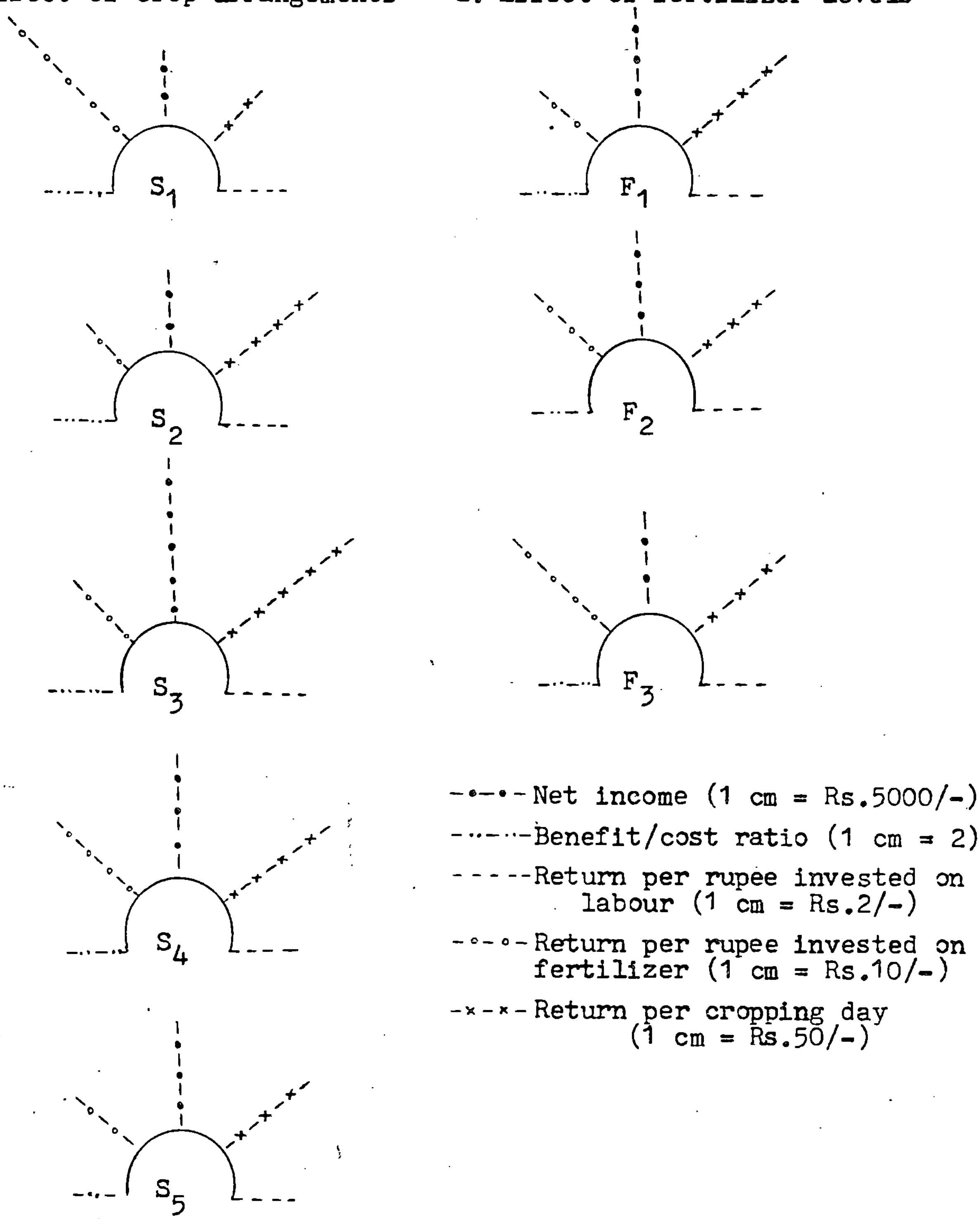
Among fertilizer levels, F_1 recorded the maximum and was superior over other two levels. F_2 and F_3 were on par.

Of the different treatment combinations, S_3F_1 recorded the highest value on par with S_3F_2. S_5F_3 recorded the lowest value for this aspect.

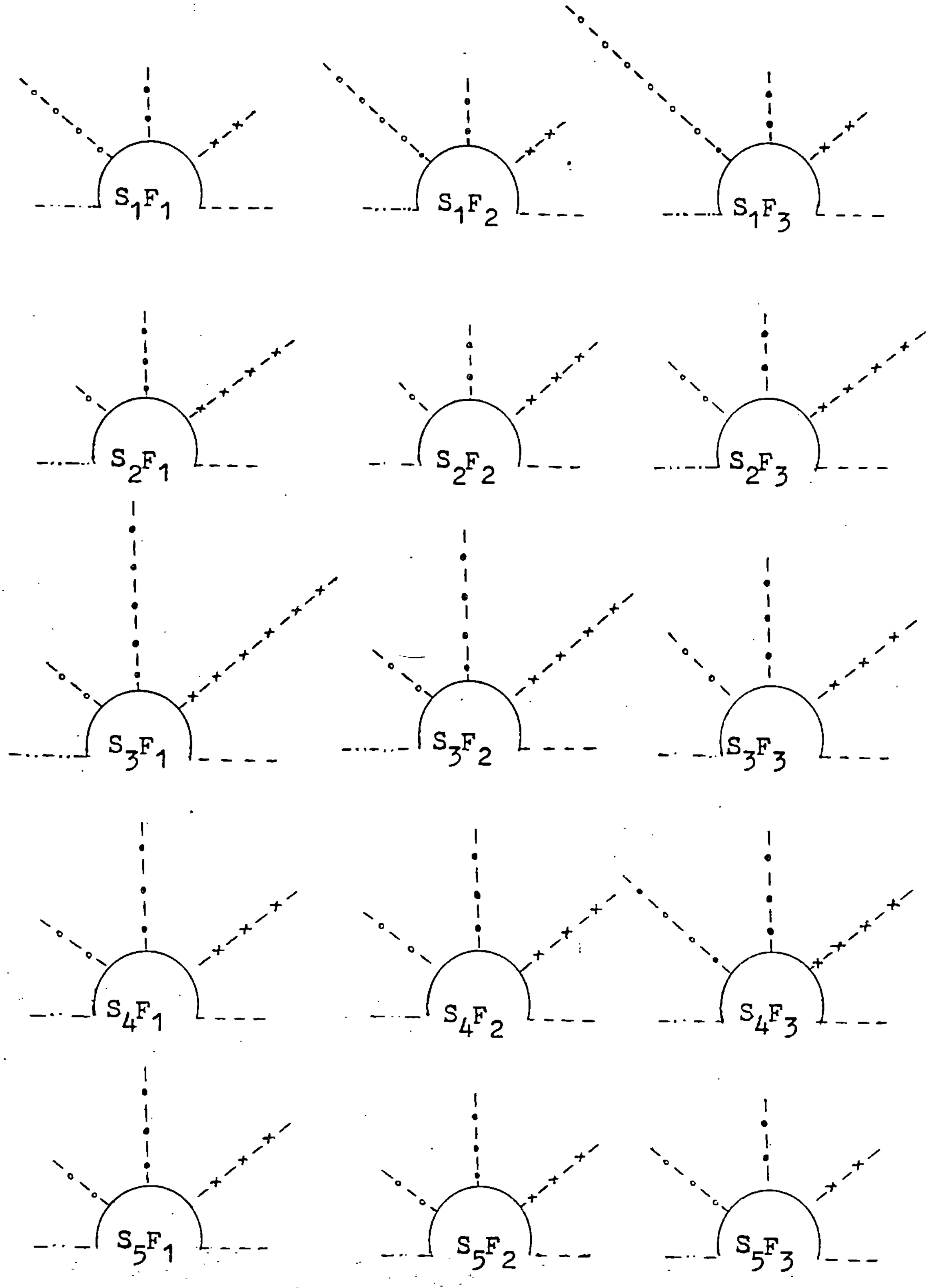
Figure 10.

Economics of cowpea + fodder maize intercropping

1. Effect of crop arrangements   2. Effect of fertilizer levels



3. Combined effect of crop arrangements and fertilizer levels



Return per rupee invested on labour will provide an estimate of the production efficiency of a particular treatment with regard to the amount spent on labour. The higher yields in plots given higher dose of fertilizers could have increased the returns and thus the return per rupee invested on labour as investment on labour did not perhaps increase markedly with increased application of fertilizers.

Cowpea and fodder maize planted in alternate rows with full dose of fertilizers recorded the maximum value. Similar result in a maize-fodder cowpea intercropping system was reported by Geethakumary (1989).

4.7.4. Return per rupee invested on fertilizers

The average values of return per rupee invested on fertilizers are presented in Table 13.

Different crop arrangements, fertilizer levels and their interactions influenced the return per rupee invested on fertilizers.

S_1 recorded the maximum value and was superior to other crop arrangements. All other crop arrangements were on par.

Of the three fertilizer levels, F_3 resulted in the maximum value while F_1 and F_2 were on par.

The highest value was recorded by S_1F_3 and the lowest by S_2F_1 which was on par with S_2F_2.

Return per rupee invested on fertilizer gives an estimate of the production per unit cost spent on fertilizers for different treatments. Among the crop arrangements, the sole crop of cowpea gave the highest value perhaps because the investment on fertilizers was minimum here. The same argument could be put forward for the higher values in F_3 where minimum expenditure occurred for fertilizors.

Again S_1F_3, the pure crop of cowpea with lowest fertilizer requirement and lowest level of fertilizer recorded the highest value for return per rupee invested on fertilizers.

4.7.5. Return per cropping day

The average values of return per cropping day were worked out and the same are presented in Table 13.

The effects due to crop arrangements, fertilizer doses and their interactions were significant in affecting the return per cropping day.

Irrespective of fertilizer levels per day return from all crop arrangements were on par except S_1 which gave the minimum value.

Among fertilizer levels, F_1 recorded the maximum and other two levels were on par.

Among the treatment combinations, the highest value was recorded by S_3F_1 which was on par with S_3F_2. The lowest value was recorded by S_1F_2.

Since the pure crop of cowpea occupied the field for the full cropping period of 90 days and since the returns from this treatment was not correspondingly higher, the low value for returns per cropping day in this treatment is understandable.

The higher returns in F_1 could have increased the returns per cropping day in this treatment. In treatment combinations also the results can be due to a reflection of the effect of net returns in these treatments.

4.7.6. Income Equivalent Ratio (IER) (Figure 9)

The data on IER were analysed statistically and the mean values are presented in Table 12.

The effects due to different crop arrangements, fertilizer levels and interaction of crop arrangements with fertilizer levels were significant on IER.

Among the different crop arrangements, S_3 showed the highest value and S_5 the lowest. The fertilizer doses

F_1 and F_2 were on par. F_3 recorded the lowest value.

The treatment combination S_3F_1 recorded the maximum IER on par with S_3F_2. S_5F_3 recorded the minimum value for IER.

IER was calculated by the same equation used for the calculation of LER. Here, instead of the quantity of produce the monetary value of the produce was taken into consideration. So the value of IER was expected to be almost similar to LER. In the present study also the crop arrangement S_3 recorded the highest value and S_5 the lowest. Similar variation in IER value due to crop arrangement was earlier reported by Geethakumary (1989).

Just like LER, IER was maximum for 100 per cent and 75 per cent dose of fertilizers.

The combinations involving S_3 and higher levels of fertilizers recorded higher IER values while S_5 along with the lowest dose of fertilizers recorded the lowest value.

From the above results and discussions on yield and biological and economic efficiency indices, it is clear that fodder maize is an ideal intercrop for cowpea in rice fallows. By planting fodder maize with cowpea in alternate rows, we get almost double the income compared to the pure crop of cowpea. In most of the results, full dose and 75 per cent dose of fertilizers were found to be on par. The soil nutrient status can also be improved by this inter-cropping. So the cropping system of cowpea and fodder maize in alternate rows with 75 per cent of the recommended dose of fertilizers is an ideal practice for the summer rice fallows.

SUMMARY

5. SUMMARY

An experiment was conducted in the summer rice fallows of the Instructional Farm attached to the College of Agriculture, Vellayani during 1988-'89 with the objective of selecting the best crop arrangement for a cowpea + fodder maize intercropping system under different fertility levels. The different crop arrangements tried were pure crop of cowpea at 25 x 15 cm spacing (S_1), pure crop of maize at 30 x 15 cm spacing (S_2), cowpea at 30 x 15 cm spacing with alternate rows of maize (S_3), paired row of cowpea at 45/15 x 15 cm spacing with one row of maize in between (S_4) and triple row of cowpea at 30/15 x 15 cm spacing with one row of maize in between (S_5). The sole crops were raised to compare the efficiency of different intercrop arrangements. The fertilizer levels tried were 100 per cent (F_1), 75 per cent (F_2) and 50 per cent (F_3) of the recommended doses of nutrients for cowpea, maize and cowpea + maize according to the crop arrangement and the area occupied by each crop. The experiment was laid out in split plot design with four replications. Observations were made on growth characters, yield, quality, uptake of nutrients and yield advantages. The results of the study are summarised below.

The crop arrangement S_3 produced the maximum plant height in cowpea at all stages of growth except at harvest where the crop arrangements did not influence this character. Full recommended doses of fertilizers were found to be the best. In the case of maize also the crop arrangement S_3 and full recommended dose of nutrients (F_1) produced the tallest plants.

Sole crop of cowpea (S_1) produced the maximum number of leaves at flowering (40 DAS) where as maize gave the maximum number of leaves in the crop arrangement S_3. The number of leaves of cowpea as well as maize increased with increasing levels of nutrients.

Pure crops of cowpea and maize recorded the maximum for their respective LAI values. Leaf area indices were maximum at higher levels of fertilizers.

The leaf : stem ratio of fodder maize was not affected by different crop arrangements or fertilizer levels. There were marked differences due to interaction effects and S_2F_1 recorded the highest value.

The drymatter yield of cowpea was not affected by the crop arrangements, while full dose of fertilizers registered the highest value. Drymatter yield of maize was maximum for S_2. The fertilizer levels did not influence the drymatter production of maize significantly.

Nitrogen uptake by cowpea was not affected by crop arrangements. The crop arrangement S_3 recorded the highest nitrogen uptake by maize. Considering the fertilizer levels, F_1 recorded the highest value. Among the different treatment combinations, S_5F_1 registered the highest value for cowpea and S_3F_1 registered the highest value for maize.

Phosphorus uptake by cowpea was not affected by crop arrangements. S_3 recorded the maximum phosphorus uptake by maize. Full dose of fertilizers resulted in the highest phosphorus uptake by cowpea. The treatment combination S_3F_1 recorded the maximum phosphorus uptake by maize.

Potassium uptake was the highest in the pure crops. Among the fertilizer levels, F_1 registered the highest values of potassium uptake by both cowpea and maize. The treatment combination S_5F_1 recorded the highest value for cowpea while S_2F_3 recorded the highest value for maize.

Considering the total uptake of nitrogen, crop arrangement S_3 and fertilizer level F_1 recorded the maximum. The treatment combination S_3F_1 was superior over others.

S_3 recorded the maximum total uptake of phosphorus while the fertilizer levels did not differ significantly.

The treatment combination S_3F_1 recorded the highest value.

For the total uptake of potassium also S_3 recorded the highest value. Total potassium uptake was maximum for highest level of fertilizers. The treatment combination S_5F_1 registered the highest value.

There were no marked differences in the number of pods per plant, length of pods, number of seeds per pod and hundred grain weight (test weight) of cowpea due to crop arrangements, fertilizer levels or their interaction effects.

As in the case of yield attributes, pod yield and grain yield of cowpea were also not affected by the crop arrangements or fertiliser levels.

The bhusa yield of cowpea was not affected by different crop arrangements. The full recommended dose of nutrients (F_1) and treatment combination S_1F_2 produced the highest bhusa yield.

The harvest index of cowpea was not affected by the crop arrangements. Fifty per cent dose of fertilisers (F_3) recorded the maximum value.

The crop arrangement S_2 produced the maximum fodder yield of maize. Among the intercrop arrangements, S_3

recorded the highest value. Fodder yield was also found to be increased with increasing levels of nutrients. The treatment combination S_3F_1 was the best.

The crop arrangement S_3 resulted in the highest protein content of cowpea grains. Protein content was not influenced by fertilizer levels. The treatment combination S_3F_3 recorded the greatest protein content of cowpea grains.

The crude protein content of fodder maize was not influenced by different crop arrangements. Seventy five per cent dose of fertilizers (F_2) resulted in the maximum protein content of fodder maize. The treatment combination S_3F_1 registered the highest value.

Among the different crop arrangements, S_1 recorded the highest value for available nitrogen in the soil after the experiment. In the case of fertilizer levels, F_2 registered the highest value.

Available phosphorus content in the soil after the experiment was affected by crop arrangements, fertilizer levels and their interactions. The crop arrangement S_2, fertilizer level F_1 and treatment combination S_2F_1 recorded the highest values for residual available phosphorus.

Among the crop arrangements, S_1 recorded the highest value for available potassium in the soil. Fertilizer levels did not significantly influence the available potassium content in the soil after the experiment. S_1F_1 resulted in the highest value for residual available potassium.

The crop arrangement S_3 recorded the highest land equivalent ratio (LER), land equivalent coefficient (LEC) and income equivalent ratio (IER). Among the different fertilizer levels, F_1 and F_2 were on par and recorded the maximum values.

Maximum net returns were obtained from the crop arrangement S_3, fertilizer level F_1 and treatment combinations S_3F_1 and S_3F_2.

Among the different treatment combinations, S_3F_1 and S_3F_2 showed higher values for benefit/cost ratio, return per rupee invested on labour and return per cropping day while S_1F_3 recorded the highest value for return per rupee invested on fertilizers.

It is thus concluded that S_3F_1 and S_3F_2 are the best treatment combinations for getting maximum benefit to the farmer from the grain cowpea + fodder maize intercropping system.

Future line of work

Experiments should be conducted including the two crops of rice and the summer fallow crops of cowpea and fodder maize in a total system and the mutual effects on all the component crops should be assessed.

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* Originals not seen

Plate 1. Sole crop of cowpea

Plate 2. Sole crop of maize

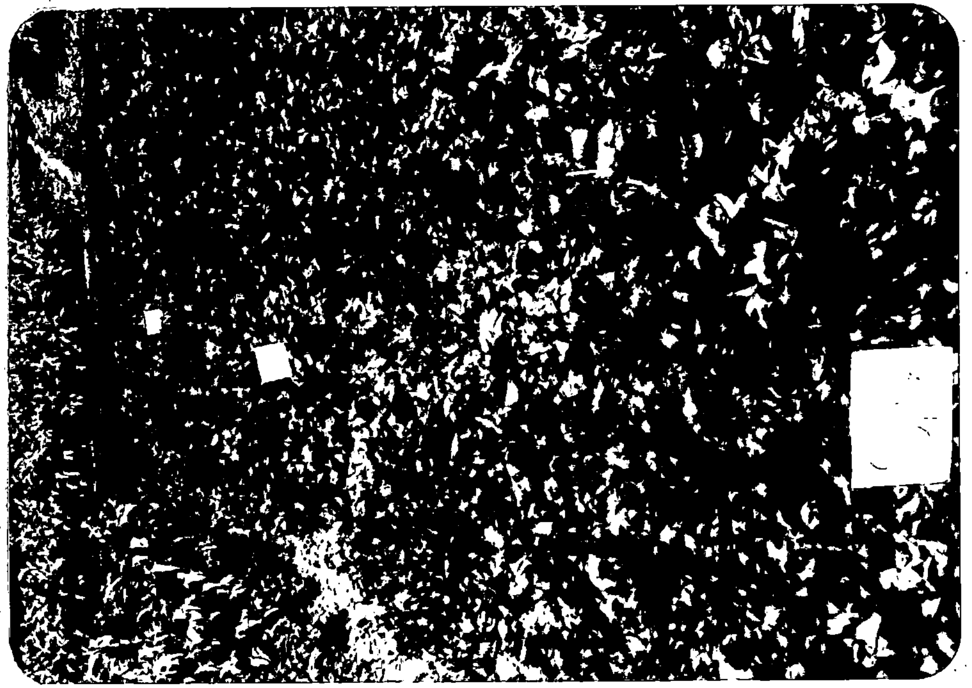

Plate 3. Overall view of the experimental plot

Plate 4. Cowpea and maize in alternate rows - ideal crop arrangement

APPENDICES

APPENDIX

Weather data during the crop period and their variations from the normal values

andard eks	Period	Rainfall (mm)		Temperature (°C) Maximum		Temperature (°C) Minimum		Relative humidity (%)		Number of rainy days	
		1989	Variation	1989	Variation	1989	Variation	1989	Variation	1989	Variation
9	Feb. 26-March 4	-	-0.78	32.36	-0.22	22.5	-0.28	75.75	+3.06	-	-1
10	5-11	5.61	+3.75	32.62	-0.21	22.56	-0.69	71.50	-1.93	3	+2
11	12-18	0.57	-0.63	32.74	-0.20	22.75	+0.12	68.64	-1.07	1	-1
12	19-25	-	-5.74	32.61	-0.89	23.66	-2.06	68.57	-9.04	-	-2
13	26-April 1	-	-1.12	33.59	+0.11	24.23	-1.42	70.07	-5.42	-	-1
14	2-8	-	-0.93	33.53	+0.04	25.06	-0.85	71.21	-5.06	-	-1
15	9-15	-	-2.74	33.74	+0.55	25.39	+0.06	75.64	-3.43	-	-1
16	16-22	5.94	+3.12	32.84	-0.18	24.57	-0.17	77.79	-1.27	3	+2
17	23-29	9.74	+6.85	32.81	+0.34	24.46	-0.55	77.43	-4.33	4	+3
18	30-May 6	6.71	+2.35	32.33	-0.07	24.18	-1.22	75.71	-3.88	1	-1
19	7-13	0.49	-0.39	32.29	-0.45	27.49	+1.71	74.07	-3.02	1	-
20	14-20	0.20	-0.18	32.67	-0.02	27.11	+0.81	74.93	+0.12	1	-
21	21-27	9.34	+8.58	30.28	-2.26	24.49	-0.85	80.71	+1.49	6	+5
22	28-June 3	2.83	-1.47	30.06	-1.14	24.78	+0.72	74.00	-9.52	3	+1

Positive sign (+) shows increase over the normal values and
Negative sing (-) shows the decrease from the normal values

SPATIAL ARRANGEMENT AND NUTRIENT MANAGEMENT OF GRAIN COWPEA-FODDER MAIZE INTERCROPPING IN SUMMER RICE FALLOWS

BY

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ABSTRACT OF A THESIS
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ABSTRACT

An investigation was carried out during the summer season of 1988-'89 in the Instructional Farm attached to the College of Agriculture, Vellayani to determine the best crop arrangement for a grain cowpea + fodder maize intercropping system in summer rice fallows under different fertility levels. The different crop arrangements tried were pure crop of cowpea at normal row arrangement, pure crop of maize at normal row arrangement, cowpea and maize in alternate rows, paired row of cowpea with one row of maize in between and triple row of cowpea with one row of maize in between. The fertilizer levels tried were 100, 75 and 50 per cent of the recommended doses of nutrients of cowpea, maize and cowpea + maize, depending on the crop arrangement and the area occupied by each crop. The experiment was laid out in split plot design with four replications. The crop arrangements were allotted to main plots and the fertility levels to the subplots.

Plant height of cowpea was maximum in the crop arrangement where cowpea was alternated with one row of maize where as the pure crop of cowpea produced the maximum number of leaves. In the case of maize, plant height and number of leaves were maximum when cowpea and maize were

grown in alternate rows. Pure crops of cowpea and maize recorded the highest for their respective LAI values at flowering. Plant height, number of leaves and LAI of both cowpea and maize were affected by different fertility levels. Higher doses of fertilizers were found to be the best.

The crop arrangements did not show pronounced variation in the uptake of nutrients by cowpea except potassium. Potassium uptake by cowpea and maize were maximum for their respective sole crops. For maize, nitrogen and phosphorus uptake were maximum when grown in alternate rows with cowpea plants. Full dose of fertilizers recorded the highest uptake values.

Number of pods per plant, length of pods, number of seeds per pod, hundred grain weight, pod yield as well as grain yield of cowpea were not affected by different crop arrangements or fertilizer levels.

The fodder yield of maize was affected by different crop arrangements and the pure crop of maize was on par with the crop arrangement where cowpea and maize were alternately grown. Hundred per cent recommended dose of fertilizers recorded the highest value for fodder yield of maize.

The treatment where cowpea and maize were grown in alternate rows resulted in the greatest protein content of cowpea grains. Seventy five per cent dose of fertilizers resulted in the highest crude protein content of maize fodder.

The various indices like LER, LEC, IER, net profit, benefit/cost ratio, return per rupee invested on labour and return per cropping day were found to be superior in the crop arrangement where cowpea and maize were grown in alternate rows and at full dose of fertilizers. Hundred per cent and seventy five per cent dose of fertilizers were on par with regard to LER, LEC, IER, net profit and benefit/cost ratio.

From a detailed analysis it is seen that cowpea alternated with one row of fodder maize under 75 per cent of the recommended level of nutrients, is the best in providing higher profit to the farmer.