# SPATIAL ARRANGEMENT AND NUTRIENT MANAGEMENT FOR MAIZE - FODDER COWPEA INTERCROPPING IN 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 for maize-fodder cowpea intercropping in rice fallows" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associate-ship, fellowship or other similar titile at any other University or Society.

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Vellayani,
15th April, 1989.

CERTIFICATE

Certified that this thesis entitled "Spatial arrangement and nutrient management for maize-fodder cowpea intercropping in rice fallows" is a record of research work done independently by Miss. Geethakumary, S. (86-11 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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# INTRODUCTION

# INTRODUCTION

The per capita landholding in Kerala, which has the highest density of population among the states in India, has been rapidly dwindling over the years. It is now approximately 0.12 ha. The agro-climatic endowments coupled with the enterprising nature of the people of Kerala have led to the emergence of diverse cropping patterns with a wide range of crops. Considering food crops, rice dominates the scene. Rice, being a crop which requires large quantities of water and suited to water-logged condition, cannot be grown throughout the year. The land is generally left fallow during summer. The low level of per capita land available to the farmer necessitates raising of an alternative crop capable of surviving moisture stress during this period.

Maize is a crop which occupies a unique position among food grains because of its adaptability to a wide range of soil and climatic conditions. 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). It is an important crop which not only meets the dietary needs of man but also has a wider range of uses than any other cereal. Recently there has been an increasing interest in the use of maize grains for the production of ethanol which acts as a substitute for the petroleum based fuels.

One of the major problems encountered in the integrated dairy development programmes of this state is the acute shortage of forage especially during summer. Feed and fodder account for nearly 70 to 80 per cent of the total cost of milk production. Due to the high cost of grains and oilcakes, it has become rather difficult for the dairy men to feed animals with concentrates alone. Therefore the only avenue left is to produce quality fodder throughout the year for economic livestock production. The scope for developing arable land exclusively for fodder production is very much limited in the State.

Cowpea is an excellent leguminous fodder crop of short duration, quick growth, high palatability and high protein content. Most of the fodder varieties of cowpea are tolerant to shade as well as drought. The average fodder yield under rainfed condition is 20-30 t/ha. Being a legume, cowpea is well suited as an intercrop with cereal maize. Thus the production potential of the rice fallows can be increased by including cowpea as an intercrop in maize during summer.

The practice of mixing crops together in the same space and at the same time, has been an agricultural practice for a long time. Yield levels of individual component crops in intercropping systems are generally low. Nevertheless, intercropping tends to be an inevitable practice to increase production per unit area per unit time.

New technological modifications in the pattern of planting of crops grown in association have made intercropping an economically viable and feasible practice. For maximum yield advantage there should be an element of complementarity among the crops used in the system in order to exploit the available resources.

There are two types of mixtures viz., replacement mixtures and additive or superimposed mixtures. In the replacement mixtures, a portion of one crop is replaced by another. In additive mixtures, the population of the base crop is kept constant and another crop is added to this, over and above the population of the base crop. In the present investigation, maize is considered as the base crop. It is tried in different spatial arrangements with varying populations of cowpea.

Adequate fertilizer application is an important factor for the better performance of this system. It is also essential to maintain soil fertility and to prevent soil deterioration due to greater exploitation by the system. The nutritional requirements of maize and legumes have been investigated separately in Kerala. But the nutrient requirements of these crops when grown in association need detailed investigation.

Maize and fodder cowpea have been studied extensively and found to grow successfully under Kerala conditions. But their production potential in mixtures, the possibility of reducing the doses of nutrients to maize + legume mixture and the additional income that can be generated by the system have not yet been investigated in detail. Hence, the present study has been undertaken with the following main objectives.

1. To assess the optimum population of fodder cowpea that can be accommodated as intercrop with grain maize in summer rice fallows.

2. To work out a suitable fertilizer dose for the grain maize + fodder cowpea intercropping system.

3. To study the nutrient uptake and the soil nutrient status in the maize + fodder cowpea intercropping system under different fertility levels.

4. To work out the economics of intercropping fodder cowpea with maize at different levels of nutrition.

# REVIEW OF LITERATURE

## 2. REVIEW OF LITERATURE

Intercropping is one of the most common systems of growing crops in the tropics especially in developing countries. This system used to be regarded as a primitive practice which would give way to solecropping as a consequence of agricultural development, but recent research suggests that when two or more crops are grown together, better use is made of resources than when they are grown separately and yield advantages are achieved without additional needs for costly inputs. 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 legumes capable of utilizing atmospheric nitrogen may play a supplementary role when intercropped with maize in fulfilling the nitrogen needs of the crop. The major works conducted in India and abroad on maize intercropped with cowpea and other legumes are reviewed here.

### 2.1. Interaction of maize and legume association

Two plant species with contrasting morphological and physiological characters will together be able to exploit their total environment more effectively than their sole cultures and will thereby give increased yield and net returns. It is therefore a general consideration to go for intercropping. The harmful or beneficial effect of a particular cropping system is the net result of different types of interactions between the component crops, viz. competition, complementary effect, supplementary effect, annidation, allelopathy etc.

Studies conducted by Bala *et al.* (1968) in Rumenia showed that polebeans (*Vigna sesquipedalis*) gave better fodder yield than cowpeas (*Vigna unguiculata*) when grown as intercrops in maize. In another experiment, Permeti (1969) observed that maize + cowpea mixture gave higher yield than maize + soybean mixture under identical conditions of soil and climate.

Haizel (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. Crude protein content in cowpea grown with maize was higher than that grown with sorghum (Anon., 1974).

When maize and soybean were grown together, Beets (1977) observed that the individual yields of both the crops of the association were reduced but their combined yield was higher than that of the highest yielding crop. Singh and

Relwani (1978) reported that the competitive effect was observed to be the highest when the seeds of maize and legumes were mixed together and sown in the same row.

The companion cropping of maize with cowpea produced significantly higher total dry matter yield compared to growing of maize alone or in association with cluster beans (Chauhan and Dungarwal, 1980). Arias and Munoz (1983) reported a higher seed yield from maize + legume mixture eventhough the pure crop yields exceeded that of the individual components of the mixture.

Chang and Shibles (1985a) reported that in a maize + cowpea mixture, the dry matter productivity was greater in mixture than in solecultures. Ofori and Stern (1986) reported that yields of maize and cowpea were significantly reduced by intercropping.

Morgado (1986) reported that the yields of the intercropped cowpea and maize were 30-53 per cent and 30 per cent lower than the respective solecrops.

Majority of the works carried out in this line show that the interactions in general are favourable for both crops of the system.

2.1.1. Effect of maize on legume

a. 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. The results of the 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 soleculture (Davis and Garcia, 1983).

b. Effect on yield and dry matter production

Syarifuddin <u>et al</u>. (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 those legumes. Thomas (1975) found that maize crop could be used to alter the competitive balance in favour of legumes when they were grown together.

According to Beets (1976) the situation might get so worse that the cereal could be considered to be the dominant species and the legume the subordinate or suppressed species. But Remison (1980) found 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) reported that yields of cowpea were drastically reduced by about 52 per cent in mixtures with maize. On the other hand, Chang and Shibles (1985a) observed that the greatest seed yields resulted when cowpea showed strong competition with little yield reduction per plant.

Ofori and Stern (1986) reported that yields of cowpea were significantly reduced by intercropping. Compared to solecrops, intercropping, on an average, reduced cowpea seed yields by about 45 per cent. Morgado (1986) noticed that intercropped cowpea, yield was 30 per cent lower than that of the solecropped cowpea.

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

2.1.2. Effect of legume on maize

a. 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. Cowpea and velvet bean trailed over maize for support and suppressed its growth by reducing photosynthetic activity.

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.

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 inter-cropped with mung bean or penut 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 an anchoring effect of the climbing beans.

b. 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.

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. Sharma and Singh (1972) reported that alternating one row of maize with one row of cowpea decreased the total dry matter yield in comparison with planting maize alone. The yield of sorghum was not affected by intercrops and among the intercrops cowpea gave the maximum yield (Morachan *et al.*, 1977).

Chand (1977) reported that intercropping of soybean in maize had no adverse effect on maize grain yields and gave additional seed yields, the highest being in soybean. Ahmed and Gunasena (1979) reported that as a general rule, maize yields were slightly depressed by intercropping, particularly at low nitrogen levels. However, intercrops offered, virtually no competition with the main crop, but legumes augmented maize production (Gangwar, 1980).

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 grain yield of maize by 17-22 per cent.

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) reported eight per cent reduction in maize yield when it was intercropped with cowpea. An analysis of competition between maize and cowpea was carried out by Chang and Shibles (1985a) and they observed that the maize yield was not depressed in the presence of cowpea. While conducting an experiment on production efficiency of maize + legume intercrop as influenced by crop combinations and planting arrangements, Uddin and Irabagen

(1986) found that, the ear diameter of maize intercropped with mung bean was wider than those with cowpea or soybean, where ear length and the number of kernels per ear were the same in all treatments. The 1000 seed weight was not affected by the legume intercrop. But maize intercropped with either mung bean or peanut had higher yield than those with cowpea.

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.

2.2. Effect of plant arrangement and density on maize + legume mixture

Willey and Osiru (1972) used a replacement series with beans and maize, and showed that at low density the replacement of maize by beans gave no advantages, but at higher total density yield advantage of 38 per cent was obtained.

Many studies have been conducted on the effects of component and total populations in cereal + legume intercrops, on mixture productivity and yield components (Osiru and Willey, 1972; Willey and Osiru, 1972; Kassam, 1976; Wahua and Miller, 1978). Most of these studies have indicated that yields of the cereals can be maintained over a wide range of spatial arrangements and that appreciable increases in yields of the associated legumes can be achieved. In these studies however, workers have paid more attention to the cereal populations than to the cropping densities of the associated legumes.

Freyman and Venkateswarlu (1977) showed that a high sorghum population could help to ensure a high sorghum yield, and that this could then allow an increase in the sown proportion and yield of pigeonpea. Francis (1978) reported that maize responded to increased plant densities upto $8 \times 10^4$ plants/ha in CIAT experiments. There was no reduction in maize yield caused by associated planting at the same density, when the bean densitiesvaried (Francis et al., 1978).

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 (De et al., 1978). This planting geometry might provide additional space for the intercrop component. It would thus augment the utilization of available space, time, nutritional factors and light to boost the production per unit area of natural and applied inputs (Singh, 1979).

Willey (1979) reported that relative yields of crops in most mixtures depended on the crop species or cultivars, on stand geometry and most significantly on the relative size of the component populations. This was in agreement with the earlier findings (Francis et al., 1976 and Trenbath, 1976). Willey (1979) also found that greater mixture populations were needed to maximise productivity when the intercrops differed greatly in their growth patterns and time of maturity.

In replacement experiments, whenever an LER-Summation of the relative yields of the component crops - greater than one was obtained, the intercrops did not compete for the same resources, and it was suggested that optimum population density could be greater in mixtures than in either sole crop (Spitters, 1980).

In a detailed study on the growth and resource use of a 2:1 row arrangement of sorghum and pigeonpea, Natarajan and Willey (1980) suggested that pigeonpea yields were limited by poor light interception after sorghum harvest. An increased pigeonpea population produced some improvement in light interception and yield, but it was considered that further response was restricted by the relatively wide distance between pigeonpea rows in the 2:1 pattern.

Venkateswarlu _et al._ (1981) summarised a number of experiments from the All India Co-ordinated Research Project for Dryland Agriculture and recommended a row arrangement of 2 sorghum : 1 pigeonpea with both crops at their approximate solecrop optimum populations.

Tarhalkar and Rao (1981) showed that sorghum yields could also be maintained in different paired row arrangements that allowed pigeonpea to be sown between pairs of sorghum rows. The seed yield of pigeonpea in a sorghum-pigeonpea intercropping system responded to plant populations above the solecrop optimum of 40000 plants/ha, but the response for the combined yield of both crops was less because of decreasing sorghum yield.

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 and cowpea yields increased approximately in a linear manner as the cowpea population increased in pure or mixed stands, but the rate of increase was much less in the mixture. The suggested optimum component populations were 20000 plants $ha^{-1}$ for maize and 33000 plants $ha^{-1}$ for cowpea.

Chang and Shibles (1985b) 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. They also noted that the yield of maize generally was a function of maize population density.

Ofori and Stern (1987a) reported that in a maize+cowpea mixture increasing the density of either crop resulted in increases in total yield.

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

## 2.3. Effect of fertilizer on maize + legume associations

Balanced application of fertilizer elements is essential for getting higher yields.

### 2.3.1. Nitrogen

#### a. 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. An increase in growth and growth characters of plants in a maize + legume intercropping system was observed by Chand (1977).

Applied nitrogen could reduce competition between intercrops and maize (Dalal, 1977). Bubpromma and Mobbayad (1978) found that in a mixed crop of sorghum and soybean increase in level of N fertilization resulted in increased leaf area index of sorghum, but decreased the leaf area index of soybean.

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).

b. Effect on yield and dry matter production

Olsen (1974) obtained lower yield of fodder legumes when N level was increased and he attributed this to increased competition and yield of grasses.

Whether intercropped or not, maize showed a positive response to N application and the yield of intercropped legume always showed a negative response (Ahmed and Gunasena, 1979). Singh and Chand (1980) observed a significant and consistent increase in stover yields of maize with increase in nitrogen level upto 120 kg/ha.

Searle et al. (1981) reported that fertilizer nitrogen had no effect on maize grain yield, but it increased maize total dry matter yield. There was no significant interaction between cropping pattern and fertilizer nitrogen. Moreover nitrogen applied to intercropped legumes appeared inhibitory to nitrogen fixation, both directly from increased soil nitrogen and indirectly by stimulation of maize growth and shading of intercropped legumes.

Ofori and Stern (1987b) reported that maize was more efficient than cowpea in the utilization of N to produce grain. With each increment of N, utilisation efficiency declined in maize but was almost constant in cowpea.

c. 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). Aggarwal et al. (1978) reported that the total N uptake was significantly related to the above ground biomass production.

Singh and Chand (1979) observed that the rate of N uptake in maize plant was minimum upto 30 days and maximum between 39 and 60 days after sowing. The intercropping treatments did not have any significant influence on the nitrogen uptake by maize crop at various stages of its growth but N levels affected the uptake of nitrogen significantly at each stage.

Nitrogen uptake in herbage was greater than applied N fertiliser with the exception of the highest rates of N applied without phosphorus (Nuttal, 1980). Waghmare and Singh (1984) reported that in a sorghum + legume mixture the nitrogen uptake by sorghum and by the total system was greater than in sole sorghum and N application increased the N uptake. Ofori and Stern (1986) reported that the N uptake in maize and cowpea were reduced by intercropping cowpea and maize, but the plant N concentration was not affected.

2.3.2. Phosphorus

a. Effect on growth and growth characters

Black (1968) stated that the best response of crops to P was obtained in the early stages of crop growth but decreased gradually with the approach to maturity. 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 88 kg N/ha (Agboola and Fayemi, 1970).

Garg *et al.* (1970) found increase in the number of leaves in cowpea with increase in P 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.

b. Effect on yield and dry matter production

Ram _et al_. (1970) reported that for the highest yield of fodder cowpea, application of 80 kg $P_2O_5$/ha was necessary. A significant increase in the dry matter yield of maize by P application was reported by Bhandari and Virmani (1972).

Average dry matter yield of cowpea was increased from 772 to 964 kg/ha by an increase in applied P 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 (1979) reported that sorghum did not respond to P fertilization while clusterbean and cowpea responded to P application.

Tripathi _et al_. (1984) reported that application of 60 kg $P_2O_5$/ha to cowpeas grown in rows of 25 and 75 cm apart for fodder and seed production respectively gave the highest yields.

c. 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 P uptake (6.3 to 18.9 kg P/ha) was less than applied P (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 system 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.

2.3.3. Potassium

a. Effect on growth and growth characters

In a three year field trial with soybean, Groneman (1974) observed that K fertilizers had little effect on growth. The vegetative growth of switch grass favoured by N fertilization but not by K (Smith, 1979). Annamma George (1980) obtained increase in height and number of leaves of blackgram with the application of potassium fertilizer upto 30 kg/ha.

b. Effect on yield and dry matter production

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

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. 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 (5.13 t/ha) with 120 kg $K_2O$ and irrigation at 25 per cent depletion of available soil moisture.

c. 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).

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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 potassium was minimum for light textured soils having comparatively lower amount of available potassium. Level of applied potassium 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.

### 2.3.4. 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 in three splits (Kuznetsov, 1970). Application of NPK fertilizers increased fodder yield and crude protein content both in maize and soybean (Cirenko and Livenskii, 1971). For the ref: the year is given as 1972

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, dry matter 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.

Accumulation curves for N, P, K and Ca were determined for intercropped maize and cowpeas given different fertilizer combinations (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-velvetbean mixture the crude protein yield was maximum at 160:80:80 kg N, $P_2O_5$ and $K_2O$/ha (Mercy George and Mohamed Kunju, 1984).

Kawamoto (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. Therefore yield of these nutrients were higher in the mixed cropping than those in pure cropping even if the dry matter yield of sorghum in the mixed cropping was a little less than that in pure sorghum cropping.

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. Maize + legume association and 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.

Phosphorus application of cowpea increased the residual N and P in the soil (Garg et al., 1970). Nihal Singh and Khatri (1972) recorded appreciable increase in the content of organic carbon, total nitrogen and available phosphorus in the soil with the increasing levels of P application to legumes.

Intercropping aims at improving the soil fertility and minimising the yield losses due to crop failures. Thus legumes invariably find a place in the cropping systems because of their enhanced nitrogen supply (Wetselaar et al., 1973).

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 N content of the soil due to intercropping of sorghum with legume was reported by Morachan et al. (1977).

Singh and Chand (1979) stated that the N fixed by legumes was used up for their own requirement and hence there was no significant improvement in the final soil N status. However, Singh (1980) observed that inclusion of legumes like cowpea, guar, urd, mung etc. in a cereal crop improved the soil fertility through N fixation.

Bhatia et al. (1980) reported that efficient soil moisture conservation was obtained by including legumes in a mixture. Improvement in the soil physical status, more particularly in the soil structure was noticed due to inclusion of legumes (Biswas, 1982).

2.6. Fertilizer economy due to intercropping

Datta and Prakash (1974) reported a mean return of

Rs.3.19 and Rs.2.62 per rupee invested in N and P respectively in a maize + legume mixture.

For hybrid maize variety Deccan, the economic optimum was 182 kg N/ha (Kumaraswamy et al., 1975). They also found that it was not economical to apply P and K fertilizers to the maize crop when the inherent availability of these nutrients in the soil was either low medium or high status.

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.

In all the five experiments conducted by Ahmed and Gunasena (1979) regardless of crop combinations used, the intercrop system provided higher returns than the solecrop system at corresponding N levels.

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).

Gangwar (1980) reported that by growing maize + legume varieties in association, the productivity could be increased considerably without proportionate increase in the use of nitrogenous fertilizers. This might be due to the fact that N fixation would have been inhibited by the application of higher levels of N.

# MATERIALS AND METHODS

# 3. MATERIALS AND METHODS

A field investigation was carried out during the summer season of 1987-88 to assess the optimum population of fodder cowpea that could be raised as an intercrop in summer rice fallows with grain maize and to work out a suitable fertilizer dose for grain maize + fodder cowpea intercropping system. The materials used and methods adopted are detailed below.

## 3.1. 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 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.

Table 1. Soil characteristics of the experimental area

A. Mechanical composition (%)

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

B. Chemical composition (kg/ha)

| | | |
|---|---|---|
| Available nitrogen | - 0.0292 per cent | (Alkaline permanganate method) |
| Available phosphorus | - 0.008 per cent | (Bray's method) |
| Available potassium | - 0.021 per cent | (Ammonium acetate method) |
| 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 received the normal package of practices recommendations.

3.1.4. Season

The experiment was conducted during the summer season of 1987-'88. The crops were sown on 24-3-1988. Cowpea was harvested on 11-5-'88 and maize, on 19-6-'88.

3.1.5. Weather conditions during the cropping period

The meteorological parameters recorded are rainfall, maximum and minimum temperature, relative humidity and 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 I and illustrated graphically in Figure 1.

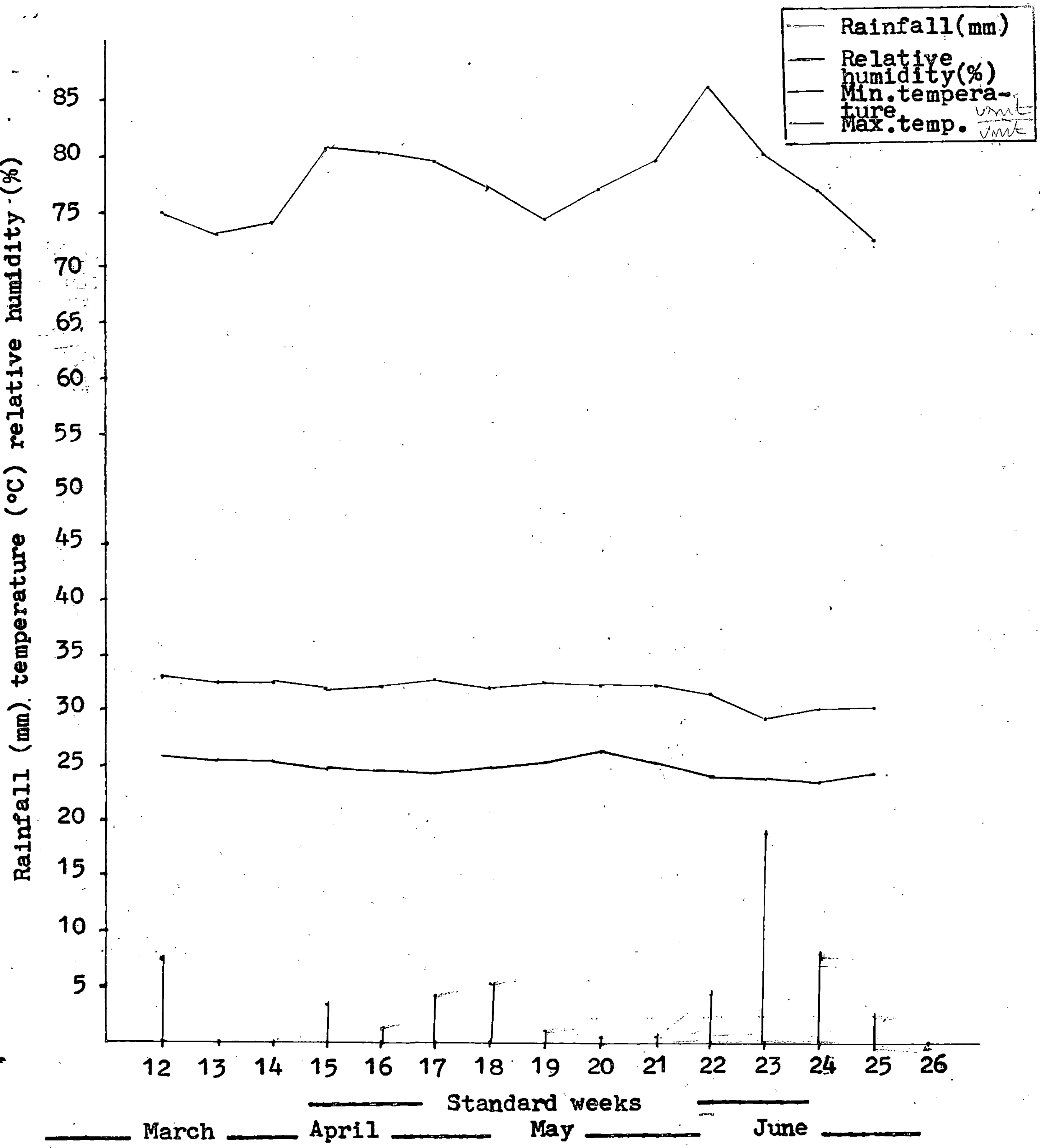



Fig. 1. Weather conditions during the crop season 18th March to 23rd June 1988

During the cropping period a mean maximum temperature of 32.21°C was observed, while the mean minimum temperature was 24.93°C. The average relative humidity recorded was 77.81 per cent. A total amount of 59.39 mm of rainfall was received during the experimental period, distributed over 17 rainy days. On an average the season was normal.

## 3.2. Materials

### 3.2.1. Varieties

Maize

The variety used was Co.1, a high yielding maize hybrid with a duration of 90 days.

Cowpea

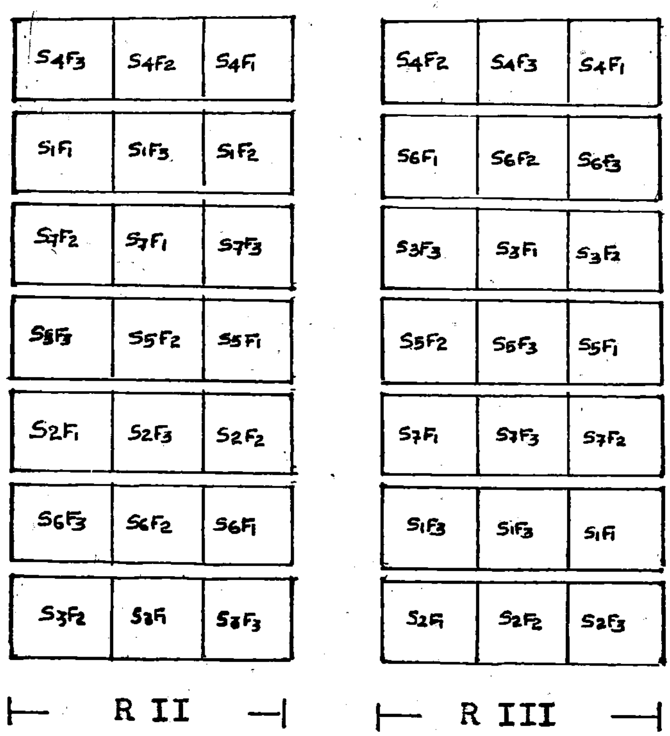
The variety used was C-152. It is a popular fodder variety. It gives 30-50 t/ha green fodder yield with 12-20 per cent crude protein content on dry weight basis.

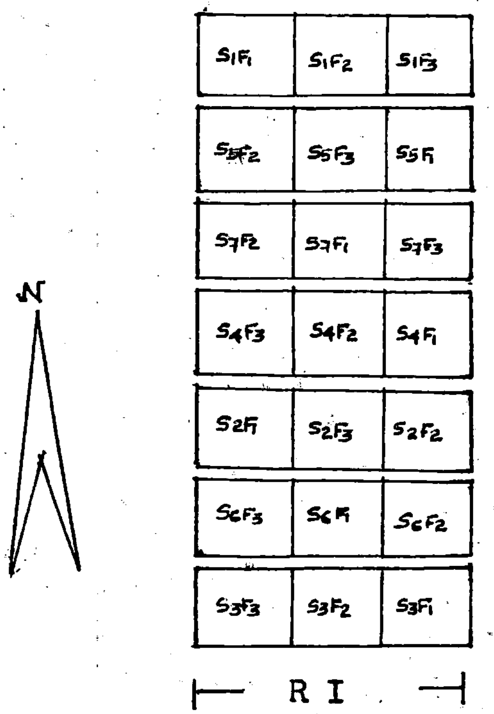
### 3.2.2. Seed materials

The seeds of maize and cowpea were obtained from Super Seeds, Coimbatore. The seeds were tested for viability and were found to give 99 to 100 per cent germination.

### 3.2.3. Fertilizers

Fertilizers analysing to the following nutrient contents were used.




TREATMENTS

MAJOR

S1 - Maize at 60x20cm spacing.

S2 - Maize at 60x20cm spacing + 1 row of cowpea in between the maize rows.

S3 - Maize at 60x20cm spacing + 2 rows of cowpea in between the maize rows.

S4 - Maize at 40/80x20cm paired rows.

S5 - Maize at 40/80x20 cm paired rows + 2 rows of cowpea in the interpair spaces.

S6 - Maize at 40/80x20cm paired rows + 3 rows of cowpea in the interpair spaces.

S7 - Cowpea at 20x10cm spacing.

MINOR

F1 - Total recommended doses of nutrients for maize, cowpea or maize + cowpea depending on crop arrangement and area occupied by each crop.

F2 - 75 per cent "

F3 - 50 per cent "

Fig. 2. Lay out - split plot design

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

## 3.3. Methods

### 3.3.1. Design and Layout

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

### 3.3.2. Treatments

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

Main plot treatments

Crop arrangements (Fig. 3)

1. Maize at 60 x 20 cm spacing ($S_1$)
2. Maize at 60 x 20 cm spacing + 1 row of cowpea in between the rows ($S_2$)
3. Maize at 60 x 20 cm spacing + 2 rows of cowpea in between the rows ($S_3$)
4. Maize at 40/80 x 20 cm paired rows ($S_4$)
5. Maize at 40/80 x 20 cm paired rows + 2 rows of cowpea in the interpair spaces ($S_5$)

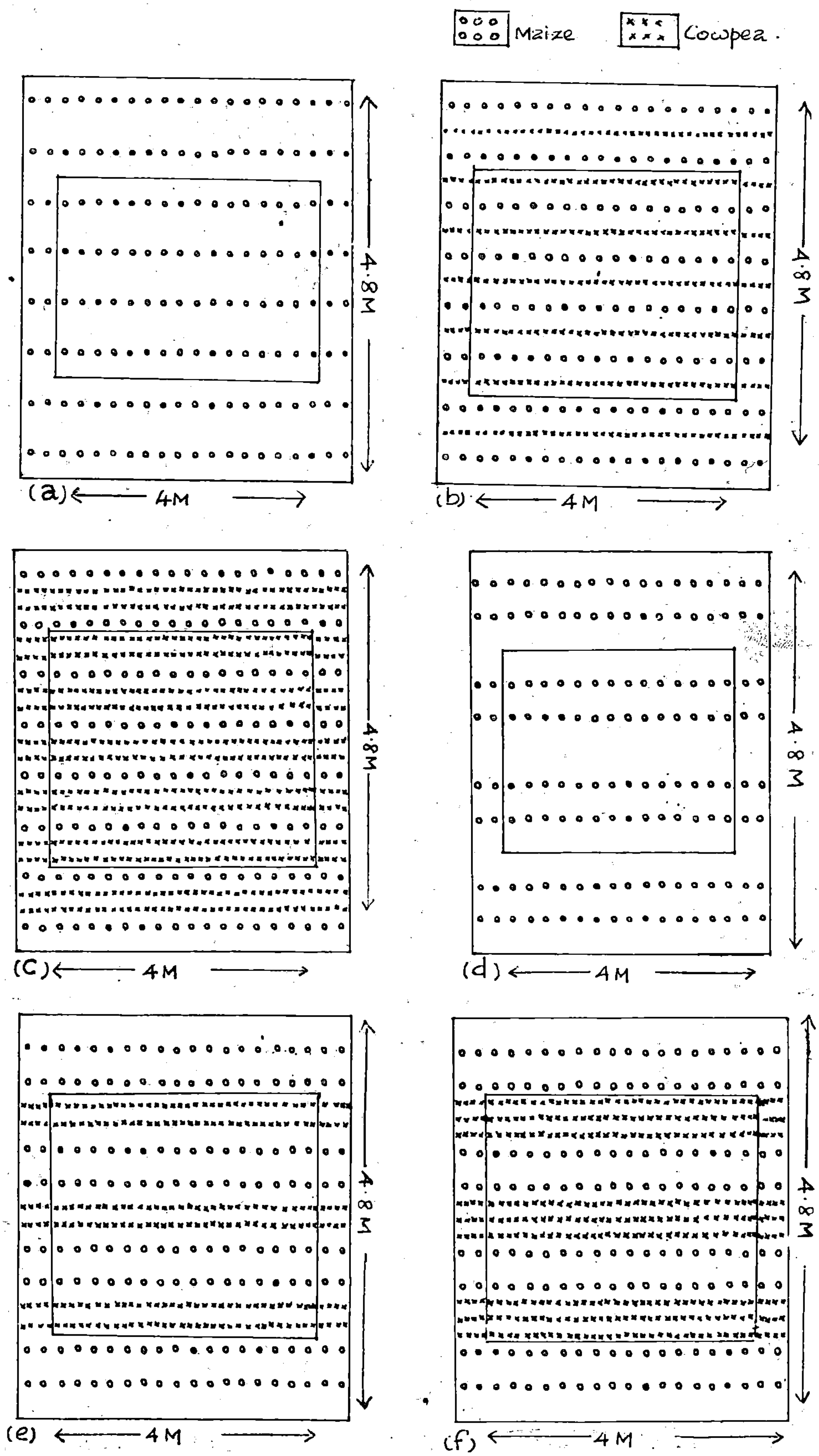



Fig. 3. Plan of crop arrangements. a. S1 (Maize at 60x20cm spacing), b. S2 (Maize at 60x20cm spacing + 1 row of cowpea between the maize rows), c. S3 (Maize at 60x20cm spacing + 2 rows of cowpea between the maize rows, d. S4 (Maize at 40/80x20cm paired rows, e. S5 (Maize at 40/80x20cm paired rows + 2 rows of cowpea in the interpair spaces, f. S6 (Maize at 40/80x20cm paired rows + 3 rows of cowpea in the interpair spaces.

6. Maize at 40/80 x 20 cm paired rows + 3 rows of cowpea in the interpair spaces ($S_6$)
7. Cowpea at 20 x 10 cm spacing ($S_7$)

Sub plot treatments

Fertility levels

1. Full recommended doses of nutrients for maize, cowpea or maize + cowpea, depending on crop arrangement and the area occupied by each crop ($F_1$)
2. 75 per cent " ($F_2$)
3. 50 per cent " ($F_3$)

The recommended dose of fertilizers as per the package of practices recommendations, KAU (1986) for maize is 135:65:15 kg N, $P_2O_5$ and $K_2O$/ha, while that for fodder cowpea is 25:60:30 kg N, $P_2O_5$ and $K_2O$/ha. The nutrients were supplied to each plot based on the crop arrangement. In the intercropped plots, additional nutrients were supplied based on the population of cowpea. The nutrient requirements in the different treatments are given in Table 2.

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. $S_5F_3$ |

Table 2. Nutrient requirements for 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 | $P_2O_5$ | $K_2O$ |
| $S_1$ | 135.00 | 65.00 | 15.00 | 101.25 | 48.75 | 11.25 | 67.50 | 32.50 | 7.50 |
| $S_2$ | 144.30 | 87.20 | 26.10 | 108.20 | 65.40 | 19.60 | 72.15 | 43.60 | 13.15 |
| $S_3$ | 152.90 | 107.80 | 36.40 | 114.65 | 80.85 | 27.30 | 76.45 | 53.90 | 18.20 |
| $S_4$ | 135.00 | 65.00 | 15.00 | 101.25 | 48.75 | 11.25 | 67.50 | 32.50 | 7.50 |
| $S_5$ | 145.40 | 89.80 | 27.40 | 109.00 | 67.35 | 20.50 | 72.50 | 44.90 | 13.70 |
| $S_6$ | 150.00 | 101.00 | 33.00 | 112.50 | 75.75 | 24.75 | 75.00 | 50.50 | 16.50 |
| $S_7$ | 25.00 | 60.00 | 30.00 | 18.75 | 45.00 | 22.50 | 12.00 | 30.00 | 15.00 |

| | |
|---|---|
| 16. $S_6F_1$ | 19. $S_7F_1$ |
| 17. $S_6F_2$ | 20. $S_7F_2$ |
| 18. $S_6F_3$ | 21. $S_7F_3$ |

Number of replication - 3

Total number of plots - 63

### 3.3.3. Plot size

The gross mainplot size was 14.4 x 4.0 m and the gross subplot size was 4.8 x 4.0 m. The net plot size was calculated, after leaving two rows of maize all around the plot, for all the arrangements except $S_7$, the pure crop of cowpea. In $S_7$, the net plot size was calculated after leaving two rows of cowpea 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 3.

Table 3. Net plot size for different treatments

| Crop arrangements | Net plot size sq. (m) | |
|---|---|---|
| | Main | Sub |
| $S_1$ | 7.2 x 3.2 | 2.4 x 3.2 |
| $S_2$ | 8.1 x 3.2 | 2.7 x 3.2 |
| $S_3$ | 8.4 x 3.2 | 2.8 x 3.2 |
| $S_4$ | 7.2 x 3.2 | 2.4 x 3.2 |
| $S_5$ | 8.7 x 3.2 | 2.9 x 3.2 |
| $S_6$ | 9.0 x 3.2 | 3.0 x 3.2 |
| $S_7$ | 12.0 x 3.6 | 4.0 x 3.6 |

Number of plants of maize and cowpea per subplot in different crop arrangements are given in Table 4.

Table 4. Number of plants of maize and cowpea in the subplots

| Crop arrangements | Number of plants | | | |
|---|---|---|---|---|
| | Maize | | Cowpea | |
| | Gross plot | Net plot | Gross plot | Net plot |
| $S_1$ | 160 | 64 | NIL | NIL |
| $S_2$ | " | " | 280 | 160 |
| $S_3$ | " | " | 560 | 320 |
| $S_4$ | " | " | NIL | NIL |
| $S_5$ | " | " | 240 | 192 |
| $S_6$ | " | " | 360 | 288 |
| $S_3$ | NIL | NIL | 960 | 836 |

3.3.4. Field culture

Preparation of the field

The experimental field was dug twice, stubbles removed, clods broken and laid out into three blocks. A composite soil sample was collected from each of the three blocks. The blocks were then subdivided into 21 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.

Manure and fertilizer application

Cowdung at the rate of 15 t/ha was applied at the time of preparation of land as per the recommendations in the package of practices, KAU (1986). The different doses of nitrogen, phosphorus and potassium were applied according to the treatment schedule.

One-third the quantity of nitrogen, half the quantity of potassium and the entire quantity of phosphorus were applied just before sowing as basal. One-third of nitrogen and half of potassium were applied at the knee high stage of maize (30 DAS) and the remaining one-third nitrogen at 60 DAS, after the harvest of cowpea.

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.

After cultivation

The soil was stirred lightly and the weeds were removed at the time of the first top dressing. A light earthing up was given to the maize after the harvest of cowpea at the time of second top dressing.

Plant protection

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

Harvest

Cowpea was harvested on 11-5-1988 at the 50 per cent flowering stage. Maize was harvested on 19-6-'88 when the crop was mature and the grains had ripened with moisture content of 20 per cent.

3.3.5. Observations recorded

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

3.3.5.1. Observations on growth characters

Five plants each of maize and cowpea were tagged at random as observational plants in each plot. The observations on the growth characters were taken at 20 days interval for maize and at 15 days interval for cowpea from these plants.

Height of plants

The height from the base of the plant to the tip of the growing point was measured in centimetres for the five plants. The mean height was then worked out and recorded in cm.

Number of leaves per plant

Total number of leaves in each of the five plants of maize and cowpea were recorded at different stages of growth, and mean number of leaves per plant was worked out. The observations were recorded at 20 days interval for maize and at 15 days interval for cowpea.

Days to silking

The period taken for silking of 50 per cent of the maize plants from seeding was observed and recorded.

Leaf/stem ratio

The samples plants collected were separated into leaves and stem, oven dried at 80 $\pm$ 5°C to a constant weight, weighed separately and the leaf stem ratios were worked out for cowpea and maize.

3.3.5.2. Observations on yield components

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

Number of cobs per plant

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

Length of cob

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

Girth of cob

Girth at the ends and middle of the sample cobs were measured in centimetre and the average was calculated.

Dry weight of grains per cob

Grains were separated from the cobs collected from sample plants, oven dried at 80 ± 5°C to a constant weight, and the mean weight was recorded in gram.

Number of grains per cob

Number of grains per cob from the sample plants was counted and the mean calculated.

1000 grain weight

Weight of 1000 grains from each treatment was recorded separately in gram.

3.3.5.3. Observations on yield

Fodder yield of cowpea

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

Grain yield of maize

The grains were separated from the cobs harvested from each net plot. They were then cleaned, sun-dried and the weight was recorded. The weight was then adjusted to 15.5 per cent moisture and expressed in t/ha.

Stover yield

The weight of sun-dried stover from the net plot was recorded and expressed in t/ha.

Harvest index

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

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.3.6. Chemical analysis

3.3.6.1. Plant analysis

Samples collected for chemical analysis were oven-dried at 80 ± 5°C and ground in a Wiley mill.

Nitrogen content

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

Phosphorus content

The phosphorus content was determined colorimetrically 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).

Potassium content

The potassium contents of the samples were determined by using the Atomic Absorption Spectrophotometer (PE.3030) available in the Central Instrumentation Laboratory of the NARP (SR).

3.3.6.2. Uptake studies

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

3.3.6.3. Quality characters

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

3.3.6.4. Soil analysis

Soil analysis for the mechanical composition and chemical chancteristics was carried out using the following procedures.

| | | |
|---|---|---|
| Mechanical composition | - | International pipette method |
| Available nitrogen | - | Alkaline permanganate method (Subbiah and Asija, 1956) |
| Available phosphorus | - | Brays method (Jackson, 1967) |
| Available potassium | - | Ammonium acetate method (Jackson, 1967) |
| pH | - | 1:2.5 soil - water ratio using pH meter |

3.3.7. Biological efficiency indices

Land Equivalent Ratio (LER)

It was worked out from the data on the yield of maize and cowpea 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

3.3.7.2. Land Equivalent Coefficient (LEC)

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

LEC = LM x LC where,

LM = LER of maize

LC = LER of cowpea

3.3.7.3. Area x Time Equivalency Ratio (ATER)

It was worked out from the data of the yields of maize and cowpea both in mixture and pure culture and also considering the duration of both crops in days. It was worked out for the mixture plots using the formula suggested by Hiebsch and McCollum (1987).

$$ATER = \sum_{i=1}^{n} (tiM/_{ti}) \; (Yi^{I}/Yi^{M}) \quad \text{where,}$$

tiM = growing period of crop 'i' in pure crop

ti = total growing period of the intercropping system

$Yi^{I}$ = yield of 'i' in intercropping

$Yi^{M}$ = yield of 'i' in pure cropping

n = total number of crops in the intercropping system

3.3.8. 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).

3.3.8.1. Gross returns

The monetary value of the economic produce such as grains, stover and green fodder obtained from maize and cowpea under both intercropping and pure cropping were calculated based on the local market prices of the produces and expressed in Rs./hectare basis.

3.3.8.2. 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.

3.3.8.3. Net returns

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

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

This was calculated using the formula

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

3.3.8.5. Return per rupee invested on labour

This was calculated using the formula

Return per rupee invested on labour

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

3.3.8.6. Return per rupee invested on fertilizers

This was calculated using the formula

Return per rupee invested on fertilizers

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

3.3.8.7. Income Equivalent Ratio (IER)

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

3.3.8.8. Monetary advantage based on LER

This was calculated using the formula suggested by Willey (1979).

$$\text{Monetary advantage} = \text{Value of combined intercrop yield} \times \frac{\text{LER}-1}{\text{LER}}$$

3.3.8.9. Per day return

Per day return of the cropping system during cropping period

This was calculated using the formula $\frac{\text{Net returns}}{\text{Cropping period in days}}$

3.3.9. 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

# 4. RESULTS

An investigation was carried out during the summer season of 1987-88, in the College of Agriculture, Vellayani with the object of selecting the best crop arrangement under different fertility levels for a maize + fodder cowpea intercropping system. Observations were made on growth and yield characters and different biological and economic indices were worked out to determine the best system. The data recorded were analysed statistically and the results are given below. The mean values are given in Tables 5 to 12 and the analyses of variance in Appendices II to VIII.

## 4.1. Growth characters

### 4.1.1. Height of plants

The mean height of plants recorded at various growth stages are presented in Tables 5 and 6 and their respective analyses of variance in Appendices II and III.

a) Maize

The different crop arrangements and fertilizer levels produced significant differences in the height of maize plants at 20th day, while their interactions showed no marked influence on this character. The crop arrangement

$S_2$ (one row of cowpea in between the maize rows planted at normal row arrangement of 60 x 20 cm spacing) produced maximum plant height and was on par with all other crop arrangements except $S_4$ (pure crop of maize at 40/80 x 20 cm paired rows), $S_5$ (maize at 40/80 x 20 cm + two rows of cowpea in the interpair spaces) and $S_6$ (paired rows of maize + 3 rows of cowpea in the interpair spaces). $S_4$ resulted in the shortest plants. The crop arrangement $S_3$ (two rows of cowpea in between the maize rows, planted at normal row arrangement) produced maximum plant height at 40 DAS and it was on par with all other crop arrangements. At 60 DAS $S_2$ produced maximum plant height and it was on par with $S_1$ and was superior to all other treatments. The treatments $S_3$, $S_4$, $S_5$ and $S_6$ were also on par. At harvest also $S_2$ produced the maximum plant height and it was on par with $S_1$ (pure crop of maize at normal row arrangements) and superior to the remaining treatments.

Among the fertilizer levels $F_1$ (100 per cent of recommended doses of fertilizers) produced maximum height and was markedly superior to $F_2$ (75 per cent of the recommended doses) which in turn was superior to $F_3$. The fertilizer levels showed the same trend in all growth stages of the crop.

Considering the different interactions, eventhough the effects were not significant, $S_2F_1$ produced comparatively

Table 5. Height and number of leaves of maize at different stages of growth

| Treatments | Height | | | | Number of leaves | | | |
|---|---|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60 DAS | Harvest | 20 DAS | 40 DAS | 60 DAS | Harvest |
| Main factor (S) | | | | | | | | |
| $S_1$ | 73.11 | 175.53 | 208.02 | 248.80 | 7.38(2.71) | 14.44(3.79) | 18.89(4.35) | 19.11(4.37) |
| $S_2$ | 73.76 | 175.71 | 210.38 | 248.96 | 7.46(2.72) | 14.33(3.78) | 19.31(4.39) | 19.64(4.43) |
| $S_3$ | 71.91 | 176.49 | 204.22 | 241.98 | 7.07(2.66) | 14.18(3.75) | 18.60(4.33) | 18.98(4.35) |
| $S_4$ | 66.78 | 171.74 | 201.44 | 237.30 | 6.69(2.58) | 13.87(3.72) | 18.10(4.25) | 18.20(4.26) |
| $S_5$ | 70.31 | 174.46 | 204.13 | 241.22 | 6.76(2.59) | 13.22(3.63) | 17.53(4.19) | 17.87(4.23) |
| $S_6$ | 70.27 | 171.59 | 201.02 | 236.60 | 6.87(2.62) | 12.8(3.58) | 17.76(4.19) | 18.04(4.25) |
| SE± | 0.973 | 1.306 | 1.540 | 1.206 | 0.0136 | 0.019 | 0.018 | 0.017 |
| CD(0.05) | 3.067 | NS | 4.850 | 3.800 | 0.0430 | 0.060 | 0.057 | 0.054 |
| Sub factor (F) | | | | | | | | |
| $F_1$ | 76.82 | 183.33 | 214.73 | 258.52 | 7.30(2.70) | 14.18(3.85) | 19.36(4.40) | 19.60(4.43) |
| $F_2$ | 70.88 | 174.15 | 204.17 | 240.62 | 6.99(2.64) | 13.47(3.67) | 18.28(4.27) | 18.63(4.31) |
| $F_3$ | 65.37 | 165.28 | 195.71 | 228.29 | 6.78(2.6) | 13.08(3.62) | 17.53(4.19) | 17.78(4.21) |
| SE± | 0.670 | 0.807 | 1.650 | 1.202 | 0.0090 | 0.021 | 0.016 | 0.015 |
| CD(0.05) | 1.946 | 2.355 | 4.820 | 3.507 | 0.0260 | 0.062 | 0.046 | 0.045 |
| S x F | | | | | | | | |
| $S_1F_1$ | 77.73 | 181.00 | 214.60 | 262.27 | 7.86(2.80) | 15.70(3.96) | 19.73(4.44) | 20.00(4.47) |
| $S_1F_2$ | 73.47 | 178.67 | 210.60 | 253.00 | 7.26(2.70) | 13.90(3.74) | 18.59(4.31) | 18.79(4.34) |
| $S_1F_3$ | 68.13 | 166.93 | 198.87 | 231.13 | 7.00(2.65) | 13.66(3.70) | 18.33(4.28) | 18.53(4.31) |
| $S_2F_1$ | 81.07 | 186.80 | 227.60 | 273.80 | 7.60(2.76) | 15.66(3.96) | 20.27(4.5) | 20.47(4.52) |
| $S_2F_2$ | 75.33 | 175.20 | 206.53 | 241.20 | 7.53(2.74) | 13.86(3.72) | 19.33(4.4) | 19.60(4.43) |
| $S_2F_3$ | 64.87 | 165.13 | 197.00 | 231.87 | 7.10(2.66) | 13.47(3.67) | 18.33(4.28) | 18.86(4.34) |
| $S_3F_1$ | 78.27 | 189.93 | 209.60 | 254.80 | 7.60(2.76) | 15.26(3.91) | 20.33(4.51) | 20.53(4.53) |
| $S_3F_2$ | 72.33 | 174.40 | 205.87 | 241.13 | 7.00(2.65) | 13.67(3.70) | 18.20(4.27) | 18.40(4.29) |
| $S_3F_3$ | 65.13 | 165.13 | 197.20 | 230.00 | 6.60(2.57) | 13.20(3.63) | 17.80(4.22) | 18.00(4.24) |
| $S_4F_1$ | 71.33 | 179.61 | 210.27 | 249.23 | 7.12(2.67) | 14.73(3.84) | 19.00(4.36) | 19.26(4.39) |
| $S_4F_2$ | 65.47 | 172.17 | 200.53 | 237.20 | 6.70(2.59) | 13.66(3.70) | 17.93(4.23) | 18.13(4.26) |
| $S_4F_3$ | 63.53 | 163.47 | 193.53 | 225.47 | 6.20(2.49) | 13.20(3.63) | 17.26(4.11) | 17.20(4.15) |
| $S_5F_1$ | 76.87 | 185.33 | 217.53 | 260.67 | 6.70(2.58) | 14.13(3.76) | 18.13(4.26) | 18.46(4.30) |
| $S_5F_2$ | 69.60 | 172.13 | 200.27 | 237.53 | 6.67(2.58) | 12.87(3.59) | 17.6(4.19) | 18.00(4.24) |
| $S_5F_3$ | 64.47 | 165.90 | 194.60 | 225.47 | 6.93(2.63) | 12.67(3.56) | 16.86(4.11) | 17.13(4.14) |
| $S_6F_1$ | 75.67 | 177.33 | 208.80 | 250.33 | 6.93(2.63) | 13.40(3.66) | 18.65(4.32) | 18.85(4.34) |
| $S_6F_2$ | 69.07 | 172.33 | 201.20 | 233.67 | 6.73(2.64) | 12.71(3.57) | 17.98(4.24) | 18.45(4.30) |
| $S_6F_3$ | 66.07 | 165.10 | 193.67 | 225.80 | 6.93(2.6) | 12.27(3.50) | 16.59(4.07) | 16.79(4.10) |
| SE± | 1.630 | 1.976 | 4.04 | 2.94 | 0.0220 | 0.052 | 0.038 | 0.038 |
| CD(0.05) | NS | NS | NS | 8.59 | 0.0640 | NS | NS | NS |

S - Crop arrangements F - Fertility levels

Note:- Figures given in parenthesis are transformed values and the comparisons are made based on them taller plants at all stages of growth except at 40 DAS, where $S_3F_1$ resulted taller plants. Shorter plants were produced by $S_4F_3$ at all stages of growth.

b) Cowpea

The different crop arrangements and fertilizer levels produced marked differences in the height of cowpea at 15 DAS and at the time of harvest, while at 30 DAS the effect of crop arrangement on plant height was not significant. The interaction of crop arrangements with fertilizer levels had no marked influences on plant height.

At all stages of crop growth, $S_7$ (pure crop of cowpea at normal planting density) produced the highest plant height. At 15 DAS and at harvest $S_7$ was on par with $S_2$ (one row of cowpea in between maize rows) while at 30 DAS all crop arrangements appeared to be on par. At all growth stages $S_6$ (three rows of cowpea in the interpair spaces of 40/80 x 20 cm maize arrangement) resulted the minimum plant height.

$F_1$ (100 per cent of the recommended doses of nutrients) produced the tallest plants at all growth stages. However at harvest, $F_1$ was on par with $F_2$ in this character. $F_3$ resulted the shortest plants at all growth stages.

Eventhough the effects of S x F interactions were not significant in plant height of cowpea the treatment combinations $S_7F_1$ and $S_6F_3$ produced the tallest and shortest plants at all growth stages respectively.

4.1.2. Number of leaves per plant

The mean number of leaves per plant at different growth stages of the crops are presented in Tables 5 and 6 and the respective analyses of variance in Appendices II and III.

a) Maize

The different crop arrangements and fertilizer levels significantly influenced the number of leaves of maize at all growth stages, whereas their interactions had significant effect only at the 20th day after sowing.

The crop arrangement $S_2$ gave the highest number of leaves at all growth stages, except at 40 DAS at which the treatment $S_1$ recorded the highest value. The treatment $S_2$ was on par at all stages with $S_1$ except at the harvest stage, where, it was markedly different, and at this stage, $S_2$ recorded the maximum number.

$F_1$ produced maximum number of leaves at all growth stages and was significantly superior to $F_2$ and $F_3$. $F_2$ was also significantly superior to $F_3$.

The interaction of fertilizer levels with crop arrangement was significant only at 20 DAS. $S_1F_1$ produced significantly more number of leaves than all other treatment combinations.

b) Cowpea

At all the stages of growth the number of leaves produced by cowpea was found to be unaffected by different crop arrangements and interaction of crop arrangements with fertility levels. There was significant effect due to fertilizer levels.

The full recommended levels of fertilizers ($F_1$) produced the highest number of leaves at all growth stages and this was followed by $F_2$ (75 per cent of recommended level). $F_1$ and $F_2$ were significantly different at all stages except at the 30th DAS where they were on par. $F_3$ (50 per cent of recommended level) produced the minimum number of leaves.

4.1.3. Days to silking

Data on this observation was statistically analysed and the mean values are presented in Table 7 and its respective analysis of variance in Appendix IV.

The results revealed that the effects due to different crop arrangements, fertilizer levels and their interactio

Table 6. Height and number of leaves of cowpea at different stages of growth, fodder yield and leaf/ ratio of cowpea at the time of harvest

| Treatments | Height | | | Number of leaves | | | Fodder yield t/ha | Leaf/s ratio |
|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | Harvest | 15 DAS | 30 DAS | Harvest | | |
| Main factor (S) | | | | | | | | |
| $S_2$ | 41.24 | 82.60 | 112.67 | 6.22(2.49) | 14.67(3.83) | 19.27(4.39) | 9.84 | 1.40 |
| $S_3$ | 40.76 | 81.82 | 110.73 | 6.22(2.48) | 14.38(3.79) | 19.01(4.36) | 12.79 | 1.30 |
| $S_5$ | 40.68 | 82.38 | 111.78 | 6.24(2.49) | 14.58(3.81) | 18.32(4.28) | 6.60 | 1.35 |
| $S_6$ | 39.52 | 82.09 | 109.36 | 5.96(2.43) | 14.36(3.79) | 18.23(4.27) | 10.40 | 1.37 |
| $S_7$ | 42.38 | 85.10 | 114.83 | 6.42(2.53) | 14.82(3.85) | 19.27(4.39) | 20.54 | 1.30 |
| SE± | 0.396 | 0.750 | 0.840 | 0.0310 | 0.0220 | 0.029 | 0.600 | 0.06 |
| CD (0.05) | 1.290 | NS | 2.740 | NS | NS | NS | 1.950 | NS |
| Sub factor (F) | | | | | | | | |
| $F_1$ | 43.55 | 87.21 | 115.93 | 7.29(2.70) | 15.05(3.88) | 19.80(4.45) | 12.88 | 1.33 |
| $F_2$ | 40.93 | 83.02 | 113.59 | 6.10(2.47) | 14.75(3.84) | 18.66(4.32) | 11.74 | 1.30 |
| $F_3$ | 38.26 | 78.16 | 106.10 | 5.21(2.28) | 13.84(3.72) | 18.06(4.25) | 11.46 | 2.42 |
| SE± | 0.290 | 0.696 | 1.060 | 0.0290 | 0.0196 | 0.021 | 0.270 | 0.04 |
| CD (0.05) | 0.870 | 2.050 | 3.130 | 0.0852 | 0.0580 | 0.062 | 0.790 | NS |
| S x F | | | | | | | | |
| $S_2F_1$ | 43.67 | 85.20 | 114.07 | 7.30(2.70) | 14.73(3.84) | 20.80(4.56) | 9.90 | 1.30 |
| $S_2F_2$ | 41.00 | 84.47 | 115.00 | 6.24(2.50) | 15.10(3.88) | 18.90(4.34) | 9.72 | 1.37 |
| $S_2F_3$ | 39.07 | 78.13 | 108.93 | 5.12(2.26) | 14.20(3.77) | 18.30(4.28) | 9.90 | 1.51 |
| $S_3F_1$ | 42.13 | 83.93 | 111.53 | 7.50(2.73) | 14.60(3.83) | 20.50(4.53) | 13.89 | 1.36 |
| $S_3F_2$ | 41.33 | 83.20 | 114.60 | 6.30(2.50) | 14.50(3.81) | 18.80(4.34) | 11.98 | 1.37 |
| $S_3F_3$ | 38.80 | 78.33 | 106.07 | 4.90(2.22) | 13.90(3.72) | 17.90(4.23) | 12.50 | 1.26 |
| $S_5F_1$ | 44.63 | 87.73 | 116.53 | 7.30(2.70) | 15.50(3.93) | 18.60(4.31) | 7.12 | 1.34 |
| $S_5F_2$ | 40.00 | 81.87 | 113.87 | 6.30(2.51) | 14.50(3.81) | 18.70(4.32) | 7.29 | 1.32 |
| $S_5F_3$ | 37.40 | 77.53 | 104.93 | 5.10(2.26) | 13.70(3.70) | 17.80(4.22) | 5.38 | 1.40 |
| $S_6F_1$ | 41.87 | 88.87 | 117.07 | 6.90(2.63) | 15.00(3.87) | 18.90(4.35) | 10.77 | 1.32 |
| $S_6F_2$ | 40.33 | 81.20 | 108.47 | 5.70(2.40) | 14.70(3.83) | 18.30(4.27) | 10.07 | 1.20 |
| $S_6F_3$ | 36.37 | 76.20 | 102.53 | 5.10(2.26) | 13.40(3.66) | 17.60(4.19) | 10.25 | 1.58 |
| $S_7F_1$ | 45.47 | 90.33 | 120.47 | 7.50(2.74) | 15.50(3.93) | 20.40(4.52) | 22.75 | 1.34 |
| $S_7F_2$ | 42.00 | 84.37 | 116.00 | 6.00(2.45) | 14.80(3.85) | 18.90(4.35) | 19.62 | 1.21 |
| $S_7F_3$ | 39.67 | 80.60 | 108.03 | 5.70(2.39) | 14.20(3.77) | 18.50(4.30) | 19.27 | 1.36 |
| SE± | 0.600 | 1.560 | 2.380 | 0.0650 | 0.0440 | 0.047 | 0.600 | 0.10 |
| CD (0.05) | NS | NS | NS | NS | NS | NS | NS | NS |

S - Crop arrangements

F - Fertility levels

Note:- Figures given in parenthesis are transformed values and the comparisons are made based on them were not significant on the expression of this character.

4.1.4. Leaf/stem ratio

The mean values on the leaf/stem ratio are presented in Tables 6 and 7 and their respective analyses of variance in Appendices III and IV.

a) Maize

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 the interactions of crop arrangements with fertilizer levels were significant, eventhough the individual effect of fertilizer levels was not marked. The crop arrangement $S_4$ recorded the highest leaf/stem ratio and it was on par with $S_1$. $S_6$ gave the minimum value.

Among the different interactions $S_4F_1$ recorded the highest value for leaf/stem ratio and the minimum value was shown by $S_6F_1$.

b) Cowpea

The leaf/stem ratio of cowpea at the time of harvest was found to be unaffected by different crop arrangements, fertilizer levels and their interactions.

Table 7. Days to 50% silking(in maize) leaf/stem ratio, number of cobs/plant, length of cob, girth o cob, number of grains/cob, 1000 grain weight, dry weight of grains/cob and Harvest Index of maize (at the time of harvest)

| Treatments | Days to 50% silking | Leaf/stem ratio | Number of cobs/plant | Length of cob (cm) | Girth of cob (cm) | Number of grains/ cob | 1000 grain weight (g) | Dry weight of grains/ cob (g) |
|---|---|---|---|---|---|---|---|---|
| Main factor (S) | | | | | | | | |
| $S_1$ | 57.76(7.6) | 0.61 | 1.12(1.06) | 20.14 | 14.81 | 514.43 | 201.14 | 111.48 |
| $S_2$ | 58.52(7.65) | 0.49 | 1.02(1.01) | 19.13 | 13.93 | 454.81 | 193.99 | 88.88 |
| $S_3$ | 59.44(7.71) | 0.48 | 1.00(1.00) | 18.66 | 13.94 | 434.66 | 192.69 | 82.90 |
| $S_4$ | 61.78(7.86) | 0.62 | 1.08(1.05) | 19.67 | 14.88 | 491.28 | 190.40 | 97.63 |
| $S_5$ | 60.68(7.79) | 0.45 | 1.04(1.02) | 18.47 | 14.02 | 439.31 | 194.33 | 82.73 |
| $S_6$ | 60.22(7.76) | 0.41 | 1.00(1.00) | 17.82 | 13.94 | 423.08 | 188.11 | 76.30 |
| SE$\pm$ | 0.120 | 0.012 | 0.012 | 0.240 | 0.290 | 10.260 | 4.880 | 2.540 |
| CD(0.05) | NS | 0.037 | 0.038 | 0.760 | NS | 32.300 | NS | 8.010 |
| Sub factor (F) | | | | | | | | |
| $F_1$ | 58.91(7.68) | 0.51 | 1.08(1.04) | 19.66 | 14.79 | 531.88 | 208.00 | 110.78 |
| $F_2$ | 59.91(7.74) | 0.52 | 1.06(1.03) | 19.06 | 14.26 | 490.17 | 193.45 | 96.19 |
| $F_3$ | 60.53(7.78) | 0.51 | 1.02(1.01) | 18.23 | 13.71 | 356.73 | 179.23 | 62.99 |
| SE$\pm$ | 0.073 | 0.007 | 0.0062 | 0.210 | 0.190 | 13.560 | 2.710 | 2.720 |
| CD(0.05) | NS | NS | 0.010 | 0.600 | 0.560 | 39.590 | 7.910 | 7.950 |
| S x F | | | | | | | | |
| $S_1F_1$ | 55.50(7.45) | 0.61 | 1.10(1.06) | 21.20 | 15.27 | 597.90 | 216.43 | 129.44 |
| $S_1F_2$ | 58.60(7.66) | 0.60 | 1.20(1.08) | 20.47 | 14.70 | 525.60 | 195.60 | 116.50 |
| $S_1F_3$ | 60.20(7.76) | 0.63 | 1.10(1.05) | 18.77 | 14.46 | 419.79 | 191.40 | 88.50 |
| $S_2F_1$ | 55.80(7.47) | 0.47 | 1.10(1.03) | 20.40 | 15.03 | 551.67 | 212.40 | 118.67 |
| $S_2F_2$ | 59.50(7.71) | 0.53 | 1.10(1.00) | 18.97 | 14.20 | 468.27 | 189.20 | 91.13 |
| $S_2F_3$ | 60.40(7.77) | 0.46 | 1.00(1.00) | 18.02 | 12.56 | 344.52 | 180.37 | 56.83 |
| $S_3F_1$ | 58.20(7.63) | 0.48 | 1.00(1.00) | 19.00 | 14.50 | 484.73 | 204.73 | 99.57 |
| $S_3F_2$ | 59.70(7.73) | 0.52 | 1.00(1.00) | 19.13 | 13.90 | 488.17 | 196.20 | 95.73 |
| $S_3F_3$ | 60.50(7.78) | 0.45 | 1.00(1.00) | 17.83 | 13.43 | 331.07 | 177.13 | 53.40 |
| $S_4F_1$ | 64.30(8.02) | 0.64 | 1.13(1.06) | 20.40 | 15.67 | 576.20 | 212.73 | 122.90 |
| $S_4F_2$ | 56.70(7.53) | 0.58 | 1.20(1.08) | 19.73 | 14.53 | 510.20 | 192.27 | 103.10 |
| $S_4F_3$ | 64.40(8.03) | 0.63 | 1.03(1.02) | 18.88 | 14.45 | 387.43 | 166.20 | 66.90 |
| $S_5F_1$ | 62.90(7.93) | 0.49 | 1.10(1.06) | 19.07 | 14.40 | 501.93 | 200.53 | 100.63 |
| $S_5F_2$ | 58.30(7.64) | 0.46 | 1.00(1.00) | 18.33 | 14.08 | 494.33 | 205.60 | 91.30 |
| $S_5F_3$ | 61.04(7.81) | 0.45 | 1.00(1.00) | 18.02 | 13.58 | 321.67 | 176.87 | 56.27 |
| $S_6F_1$ | 67.70(7.6) | 0.35 | 1.00(1.00) | 17.87 | 13.90 | 478.87 | 201.17 | 93.47 |
| $S_6F_2$ | 66.81(7.18) | 0.44 | 1.00(1.00) | 17.73 | 14.17 | 454.47 | 181.83 | 79.40 |
| $S_6F_3$ | 56.45(7.51) | 0.43 | 1.00(1.00) | 17.87 | 13.77 | 335.90 | 183.43 | 56.03 |
| SE$\pm$ | 0.180 | 0.017 | 0.015 | 0.500 | 0.470 | 33.220 | 6.640 | 6.570 |
| CD(0.05) | NS | 0.051 | NS | NS | NS | NS | NS | NS |

S - Crop arrangements F - Fertility levels

Note:- Figures given in parenthesis are transformed values and the comparisons are based on them

## 4.2. Yield attributes

### 4.2.1. Fodder yield (cowpea)

The data on fodder yield of cowpea were analysed statistically and the mean values are presented in Table 6 and analysis of variance in Appendix III.

The different crop arrangements and fertilizer levels were found to influence the fodder yield eventhough their interaction effect was not significant.

The crop arrangement $S_7$ produced the maximum fodder yield. Among the intercrop arrangements $S_3$ gave the highest yield and it was markedly superior to all other arrangements.

$F_1$ produced significantly higher fodder yield than $F_2$ and $F_3$ and the latter two were on par.

### 4.2.2. Number of cobs per plant

The mean values on number of cobs per maize plant are presented in Table 7 and the respective analysis of variance in Appendix IV.

There was significant difference in the number of cobs per plant due to different crop arrangements and fertilizer levels. But the effect of interaction of fertilizer levels with crop arrangements was not significant.

Among the different crop arrangements $S_1$ was found to be the best followed by $S_4$. $S_1$ and $S_4$ were on par. In the intercrop arrangements, $S_5$ was the best and this was on par with all other intercrop arrangements.

Considering the fertilizer levels, $F_1$ produced the maximum number of cobs per plant which was on par with $F_2$. and $F_2$ inturn was superior to $F_3$.

4.2.3. Length of cob

The values on the mean length of maize cobs are presented in Table 7 and the analysis of variance in Appendix IV.

The effect of different crop arrangements and fertilizer levels on cob length were significant eventhough their interactions were not significant. As in the case of number of cobs per plant, here also the crop arrangement $S_1$ (pure crop of maize at normal row arrangement) produced the longest cobs followed by $S_4$.

Among the crop mixtures $S_2$ produced the maximum length and it was on par with $S_3$ and $S_5$. $S_6$ produced the shortest cobs.

The cob length increased significantly as fertilizer levels were increased from $F_3$ to $F_2$. But $F_2$ and $F_1$ were on par.

4.2.4. Girth of cob

Data on this observation were analysed statistically and the mean values are presented in Table 7 and analysis of variance in Appendix IV.

The effects of different crop arrangements and the interaction of crop arrangements with fertilizer levels were not significant on girth of cob while the effects of fertilizer levels was significant.

The fertilizer level $F_1$ produced the maximum girth of cob followed by $F_2$. The treatments $F_1$ and $F_2$ were on par. $F_3$ produced the lowest girth of cob and it was on par with $F_2$.

4.2.5. Number of grains per cob

The mean values of number of grains per cob obtained after statistical analysis are presented in Table 7 and analysis of variance in Appendix IV.

Different crop arrangements and fertilizer levels were found to influence this character significantly.

Considering the various crop arrangements $S_1$ produced the maximum number of grains per cob and it was on par with $S_4$. $S_6$ produced the minimum number of grains per cob and it was on par with all other crop arrangements except $S_1$ and $S_4$. Among the various intercrop arrangements $S_2$ produced the maximum number of grains per cob.

Of the three fertilizer levels, the effect of $F_1$ was found to be the best and it was significantly superior to $F_2$ and $F_3$. $F_3$ produced the minimum number of grains per cob, and it was significantly inferior to $F_2$.

The interaction effects of crop arrangements with fertilizer levels were not found to be significant in the number of grains per cob.

4.2.6. Thousand grain weight

The data on 1000 grain weight of maize were analysed statistically and the mean values are presented in Table 7 and the analysis of variance in Appendix IV.

The effects of different crop arrangements and the interactions of crop arrangements with fertilizer levels were not significant in influencing this character. But the effect of different fertilizer levels was significant. As in the case of other yield attributes, $F_1$ gave the highest values of 1000 grain weight followed by $F_2$ while $F_3$ gave the lowest value.

4.2.7. Dry weight of grains per cob

The data on dry weight of grains per cob were analysed statistically and the results are presented in Table 7 and the analysis of variance in Appendix IV.

The effects of different crop arrangements and fertilizer levels were significant while their interactions was not significant.

Considering the crop arrangements $S_1$ produced the maximum dry weight of grains per cob and it was significantly superior to all other crop arrangements. $S_6$ produced the minimum dry weight of grains per cob and was on par with $S_5$ and $S_3$. Among the intercrop arrangements $S_2$ produced the maximum dry weight of grains per cob and it was superior to all other intercrop arrangements.

The different fertilizer levels produced significant variations in the dry weight of grains. $F_1$ gave the maximum dry weight and was superior to the other two fertilizer treatments. $F_2$ gave the next higher dryweight and $F_3$ gave the minimum dry weight of grain per cob.

4.2.8. Harvest Index

The data on Harvest Index were analysed statistically and the mean values are presented in Table 7 and the analysis of variance in Appendix IV.

Different crop arrangements and fertilizer levels produced marked difference in Harvest Index eventhough their interaction was not significant. The highest value for HI was obtained for crop arrangements $S_5$ and $S_6$. Crop arrangements $S_2$, $S_3$, $S_5$ and $S_6$ were found to be on par. $S_1$ recorded the lowest value of HI. $S_1$ was on par with $S_4$.

With the three fertilizer levels $F_1$ produced the maximum HI followed by $F_2$ while $F_3$ gave the minimum values.

4.2.9. Grain yield of maize

The data on grain yield of maize was statistically analysed and the mean values are presented in Table 8 and the analysis of variance in Appendix V.

The effects of different crop arrangements and fertilizer levels on maize yield were significant while their interactions were not significant.

Among the different crop arrangements $S_1$ (pure crop of maize at normal row arrangement) produced the maximum yield of 5.34 t/ha followed by $S_4$ (pure crop of maize in paired rows) with an yield of 5.31 t/ha. In the intercrop arrangements $S_2$ produced the maximum yield (5.28 t/ha) and was superior to all other intercrop arrangements. $S_2$ was followed by the treatments $S_3$ and $S_5$ which were on par. The treatment $S_6$ resulted in the minimum grain yield (5.21 t/ha).

Of the three fertilizer levels, $F_1$ (full dose of fertilizers) gave the maximum grain yield of 5.81 t/ha and

Table 8. Grain yield, stover yield, N, P and K content in grain and stover, uptake of N, P and K by the maize crop at the time of harvest and protein content in maize grain

| Treatments | Grain yield (t/ha) | Stover yield (t/ha) | N, P and K content in maize stover (%) | | | N, P and K content in grain (%) | | | Uptake of N, P and K kg/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | N | P | K | N | P | K |
| Main factor (S) | | | | | | | | | | | |
| $S_1$ | 5.34 | 7.83 | 1.10 | 0.40 | 1.010 | 1.40 | 0.35 | 1.04 | 162.6 | 50.84 | 135.62 |
| $S_2$ | 5.28 | 7.63 | 1.20 | 0.36 | 0.995 | 1.59 | 0.33 | 0.98 | 178.3 | 45.16 | 128.93 |
| $S_3$ | 5.25 | 7.61 | 1.15 | 0.32 | 1.010 | 1.56 | 0.30 | 0.97 | 171.21 | 41.17 | 128.79 |
| $S_4$ | 5.31 | 7.78 | 1.01 | 0.40 | 0.990 | 1.42 | 0.34 | 0.99 | 155.88 | 50.16 | 130.16 |
| $S_5$ | 5.25 | 7.43 | 1.23 | 0.32 | 0.960 | 1.52 | 0.30 | 0.92 | 173.80 | 40.21 | 120.02 |
| $S_6$ | 5.21 | 7.37 | 1.26 | 0.29 | 0.960 | 1.50 | 0.28 | 0.91 | 174.00 | 36.44 | 118.52 |
| SE± | 0.005 | 0.061 | 0.021 | 0.005 | 0.009 | 0.045 | 0.004 | 0.024 | 2.800 | 0.600 | 1.100 |
| CD (0.05) | 0.016 | 0.190 | 0.067 | 0.017 | 0.029 | NS | 0.013 | 0.075 | 8.900 | 1.880 | 3.500 |
| Sub factor (F) | | | | | | | | | | | |
| $F_1$ | 5.81 | 8.10 | 1.37 | 0.41 | 1.080 | 1.74 | 0.36 | 1.02 | 212.06 | 53.71 | 147.10 |
| $F_2$ | 5.40 | 7.67 | 1.17 | 0.36 | 0.970 | 1.51 | 0.31 | 0.96 | 172.77 | 44.81 | 126.41 |
| $F_3$ | 4.60 | 7.05 | 0.93 | 0.29 | 0.920 | 1.24 | 0.28 | 0.93 | 123.05 | 33.48 | 107.51 |
| SE± | 0.016 | 0.067 | 0.020 | 0.005 | 0.006 | 0.032 | 0.003 | 0.018 | 2.690 | 0.430 | 1.450 |
| CD (0.05) | 0.045 | 0.200 | 0.059 | 0.014 | 0.017 | 0.093 | 0.021 | 0.051 | 7.850 | 1.240 | 4.240 |
| S x F interaction | | | | | | | | | | | |
| $S_1F_1$ | 5.91 | 8.25 | 1.21 | 0.46 | 1.13 | 1.59 | 0.39 | 1.17 | 193.86 | 61.20 | 162.07 |
| $S_1F_2$ | 5.45 | 7.97 | 1.17 | 0.41 | 1.02 | 1.40 | 0.32 | 1.00 | 169.28 | 50.16 | 134.71 |
| $S_1F_3$ | 5.65 | 7.28 | 0.93 | 0.36 | 0.90 | 1.21 | 0.33 | 0.96 | 124.65 | 41.17 | 110.09 |
| $S_2F_1$ | 5.83 | 8.12 | 1.49 | 0.41 | 1.10 | 1.96 | 0.37 | 1.07 | 235.46 | 55.33 | 152.24 |
| $S_2F_2$ | 5.39 | 7.62 | 1.21 | 0.36 | 0.98 | 1.49 | 0.30 | 0.97 | 175.47 | 43.88 | 126.79 |
| $S_2F_3$ | 4.61 | 7.17 | 0.89 | 0.31 | 0.90 | 1.31 | 0.31 | 0.91 | 123.95 | 36.27 | 107.76 |
| $S_3F_1$ | 5.77 | 8.14 | 1.26 | 0.39 | 1.11 | 1.87 | 0.35 | 1.07 | 210.30 | 52.94 | 151.80 |
| $S_3F_2$ | 5.38 | 7.58 | 1.17 | 0.33 | 0.98 | 1.68 | 0.29 | 0.94 | 178.70 | 40.72 | 125.00 |
| $S_3F_3$ | 4.60 | 7.10 | 1.03 | 0.25 | 0.96 | 1.12 | 0.27 | 0.90 | 124.62 | 29.84 | 109.57 |
| $S_4F_1$ | 5.87 | 8.28 | 1.31 | 0.45 | 1.07 | 1.59 | 0.38 | 1.00 | 201.60 | 59.60 | 147.42 |
| $S_4F_2$ | 5.45 | 7.89 | 0.93 | 0.42 | 0.97 | 1.31 | 0.35 | 0.99 | 144.81 | 51.81 | 131.01 |
| $S_4F_3$ | 4.60 | 7.15 | 0.80 | 0.35 | 0.94 | 1.37 | 0.30 | 0.98 | 121.24 | 39.08 | 112.07 |
| $S_5F_1$ | 5.77 | 8.01 | 1.45 | 0.36 | 1.05 | 1.77 | 0.32 | 0.90 | 218.40 | 47.58 | 136.02 |
| $S_5F_2$ | 5.40 | 7.59 | 1.26 | 0.34 | 0.96 | 1.68 | 0.31 | 0.93 | 186.34 | 43.48 | 123.30 |
| $S_5F_3$ | 4.57 | 6.68 | 0.98 | 0.26 | 0.88 | 1.12 | 0.27 | 0.92 | 116.68 | 29.57 | 100.73 |
| $S_6F_1$ | 5.72 | 7.82 | 1.49 | 0.36 | 1.04 | 1.68 | 0.31 | 0.91 | 212.80 | 45.60 | 133.05 |
| $S_6F_2$ | 5.37 | 7.38 | 1.31 | 0.31 | 0.93 | 1.49 | 0.30 | 0.91 | 182.01 | 38.77 | 117.65 |
| $S_6F_3$ | 4.55 | 6.92 | 0.98 | 0.21 | 0.92 | 1.31 | 0.23 | 0.91 | 127.16 | 24.95 | 104.86 |
| SE± | 0.038 | 0.160 | 0.050 | 0.012 | 0.015 | 0.078 | 0.007 | 0.043 | 6.590 | 1.040 | 3.560 |
| CD(0.05) | NS | NS | 0.145 | NS | 0.043 | 0.230 | 0.021 | NS | 19.230 | 3.050 | NS |

was significantly superior to $F_2$ and $F_3$. $F_3$ (50 per cent of the recommended dose of fertilizers) gave the minimum yield of 4.60 t/ha.

4.2.10. Stover yield

The data on stover yield of maize at the time of harvest were analysed statistically and the mean values are presented in Table 8 and the analysis of variance in Appendix V.

The effects due to different crop arrangements and fertilizer levels were significant in affecting the stover yield of maize but the interactions of the above factors were not significant.

$S_1$ produced the highest yield followed by $S_4$. Both of them were on par ($S_1$ and $S_4$ were pure stands of maize at normal and paired rows respectively). Among the intercrops $S_2$ recorded the maximum stover yield and it was on par with $S_3$.

Of the three fertilizer levels $F_1$ produced the maximum stover yield and it was significantly superior to $F_2$ and $F_3$.

4.3. Chemical composition

4.3.1. Nitrogen content

The data on nitrogen content of maize and cowpea at harvest were analysed and the mean values are presented in Tables 8 and 9 and the respective analysis of variance in Appendices V and VI.

a) Maize

There was significant difference in the nitrogen content of maize stover due to different fertilizer levels, crop arrangements and their interactions.

Of the different crop arrangements, $S_6$ recorded the highest nitrogen percentage and was on par with $S_5$ and $S_2$. The $S_4$ arrangement recorded the lowest nitrogen percentage.

Among the three fertilizer levels $F_1$ recorded the highest value for nitrogen content, and it was superior to $F_2$ which inturn was superior to $F_3$.

Among the various treatment combinations, $S_2F_1$ and $S_6F_1$ registered the highest nitrogen content and they were on par with $S_5F_1$. $S_4F_3$ recorded the lowest value for nitrogen content of stover.

The nitrogen content of maize grain was affected by different fertilizer levels and the interaction of fertilizer levels with crop arrangements eventhough the crop arrangements had no significant effect.

Of the different fertilizer levels, $F_1$ gave the highest value and it was significantly superior to $F_2$ which in turn was superior to $F_3$.

Among the different treatment combinations $S_2F_1$ recorded the highest value. It was on par with $S_3F_1$ and $S_5F_1$ and significantly superior to all others. $S_3F_1$, $S_5F_1$, $S_5F_2$, $S_6F_1$ and $S_3F_2$ were on par. The combinations $S_5F_3$ and $S_3F_3$ recorded the lowest value of nitrogen in grain.

b) Cowpea

The nitrogen content of fodder cowpea at the time of harvest was influenced by different crop arrangements and fertilizer levels. But the effect due to their interaction was not significant.

Of the different crop arrangements $S_3$ recorded the maximum nitrogen content. $S_3$ was on par with $S_2$, $S_5$ and $S_6$. $S_7$ recorded the lowest value of nitrogen content.

Considering the three fertilizer levels $F_1$ recorded the maximum value and was superior to $F_2$ which in turn was superior to $F_3$.

4.3.2. Phosphorus content

The data on phosphorus content of maize and fodder cowpea at the time of harvest were analysed statistically and the mean values are presented in Table 8 and 9 and the

Table 9. N, P and K and crude protein content of cowpea and the uptake of N, P and K by cowpea

| Treatments | N, P and K content % | | | Protein % | Uptake (kg/ha) | | |
|---|---|---|---|---|---|---|---|
| | N | P | K | | N | P | K |
| Main factor (S) | | | | | | | |
| $S_2$ | 2.49 | 0.44 | 2.28 | 15.56 | 70.55 | 12.53 | 61.10 |
| $S_3$ | 2.50 | 0.43 | 1.71 | 15.63 | 89.18 | 15.30 | 64.41 |
| $S_5$ | 2.44 | 0.40 | 2.15 | 15.25 | 46.90 | 7.79 | 41.27 |
| $S_6$ | 2.41 | 0.41 | 1.86 | 15.06 | 72.20 | 12.10 | 55.60 |
| $S_7$ | 2.32 | 0.40 | 1.42 | 14.50 | 138.30 | 23.79 | 84.72 |
| SE± | 0.037 | 0.0069 | 0.068 | 0.230 | 4.590 | 0.98 | 4.680 |
| CD(0.05) | 0.120 | 0.023 | 0.220 | 0.750 | 14.960 | 3.18 | 15.260 |
| Sub factor (F) | | | | | | | |
| $F_1$ | 2.74 | 0.48 | 2.03 | 17.13 | 98.35 | 17.19 | 69.35 |
| $F_2$ | 2.50 | 0.41 | 1.90 | 15.63 | 84.52 | 13.91 | 62.86 |
| $F_3$ | 2.06 | 0.36 | 1.65 | 12.88 | 67.40 | 11.82 | 52.06 |
| SE± | 0.035 | 0.0055 | 0.040 | 0.220 | 2.770 | 0.41 | 1.990 |
| CD(0.05) | 0.100 | 0.016 | 0.120 | 0.630 | 8.160 | 1.22 | 5.880 |
| S x F interactions | | | | | | | |
| $S_2F_1$ | 2.80 | 0.54 | 2.63 | 17.50 | 79.80 | 15.27 | 74.91 |
| $S_2F_2$ | 2.52 | 0.41 | 2.32 | 15.75 | 70.66 | 11.52 | 64.69 |
| $S_2F_3$ | 2.15 | 0.38 | 1.89 | 13.44 | 61.18 | 10.82 | 53.64 |
| $S_3F_1$ | 2.75 | 0.49 | 1.66 | 17.19 | 100.24 | 17.99 | 60.60 |
| $S_3F_2$ | 2.66 | 0.43 | 1.93 | 16.63 | 91.42 | 14.98 | 66.31 |
| $S_3F_3$ | 2.10 | 0.36 | 1.56 | 13.13 | 75.88 | 12.88 | 56.43 |
| $S_5F_1$ | 2.80 | 0.46 | 2.32 | 17.50 | 57.40 | 9.47 | 47.74 |
| $S_5F_2$ | 2.38 | 0.40 | 2.38 | 14.88 | 49.84 | 8.53 | 48.53 |
| $S_5F_3$ | 2.15 | 0.34 | 1.78 | 13.44 | 33.32 | 5.36 | 27.54 |
| $S_6F_1$ | 2.75 | 0.47 | 1.94 | 17.19 | 85.50 | 14.42 | 59.93 |
| $S_6F_2$ | 2.52 | 0.41 | 1.91 | 15.75 | 73.10 | 11.90 | 53.36 |
| $S_6F_3$ | 1.96 | 0.34 | 1.73 | 12.25 | 57.96 | 10.05 | 51.51 |
| $S_7F_1$ | 2.57 | 0.44 | 1.58 | 16.06 | 163.84 | 28.8 | 103.55 |
| $S_7F_2$ | 2.43 | 0.40 | 1.40 | 15.19 | 137.62 | 22.61 | 79.42 |
| $S_7F_3$ | 2.96 | 0.36 | 1.28 | 18.50 | 108.43 | 19.97 | 71.20 |
| SE± | 0.078 | 0.122 | 0.090 | 0.490 | 6.190 | 0.930 | 4.450 |
| CD(0.05) | NS | NS | NS | NS | NS | NS | NS |

analysis of variance in Appendices V and VI.

a) Maize

The phosphorus content of maize plant at the time of harvest was affected by different crop arrangements and fertilizer levels while their interactions had no effect. The treatments $S_1$ and $S_4$ recorded the highest phosphorus percentage and $S_6$ the lowest.

With the three fertilizer levels, $F_1$ recorded significantly higher phosphorus content than $F_2$. $F_3$ registered the lowest percentage of phosphorus.

The phosphorus content of maize grain was affected by different crop arrangements, fertilizer levels and their interactions.

The crop arrangement $S_1$ recorded the highest value and it was on par with $S_4$. $S_6$ recorded the lowest value and it was significantly different from all others. Considering the intercrop arrangements $S_2$ recorded the highest value.

With the three fertilizer levels, $F_1$ recorded the highest value and it was significantly superior to $F_2$ which in turn was significantly superior to $F_3$.

Among the different treatment combinations $S_1F_1$ recorded the highest value and it was on par with $S_2F_1$ but significantly superior to all others. The combination $S_6F_3$ recorded the lowest value and it was significantly inferior to all other treatment combinations.

b) Cowpea

The phosphorus content of cowpea at the time of harvest was significantly affected by varying crop arrangements and fertilizer levels, while their interaction was not significant.

The crop arrangement $S_2$ recorded the highest phosphorus content followed by $S_3$. while $S_2$ and $S_3$ were on par. The arrangements $S_5$ and $S_7$ recorded the lowest values and $S_5$, $S_6$ and $S_7$ were found to be on par.

There were significant variations in phosphorus content at different levels of fertilizer applications. $F_1$ recorded the maximum phosphorus content in fodder cowpea and $F_3$ the minimum.

4.3.3. Potassium content

The data on potassium content of maize and cowpea are analysed statistically and the mean values are presented in Tables 8 and 9 and their analyses of variance in Appendices V and VI.

a. Maize

The potassium content of maize stover at the time of harvest was affected by different crop arrangements, fertilizer levels and their interactions.

With regard to the different crop arrangements $S_1$ and $S_3$ gave highest content of potassium and they were on par with $S_2$ and $S_4$. $S_5$ and $S_6$ recorded the lowest value.

Among the three fertilizer levels, $F_1$ recorded the highest value which was significantly superior to $F_2$ and $F_3$. The treatment $F_3$ recorded the lowest value.

Of the different treatment combinations $S_1F_1$ recorded the highest value and it was on par with $S_2F_1$ and $S_3F_1$. $S_5F_3$ recorded the lowest value and it was on par with $S_1F_3$, $S_2F_3$ and $S_6F_3$.

The potassium content of maize grain was affected by different crop arrangements and fertilizer levels but their interactions had no effect. $S_1$ recorded the highest value and was on par with $S_2$, $S_3$ and $S_4$. The treatment $S_6$ recorded the lowest value and was on par with $S_5$. $S_5$ and $S_6$ were significantly lower to others.

Of the three fertilizer levels $F_1$ recorded the highest value and it was significantly superior to $F_2$ and $F_3$ where $F_2$ and $F_3$ were on par.

b. Cowpea

The potassium content of cowpea was affected by different crop arrangements and fertilizer levels while their interactions produced no effect.

Of the five crop arrangements $S_2$ recorded the highest value for potassium content and it was on par with $S_5$. $S_7$ recorded the lowest value of potassium percentage and was significantly less than that of all others.

Among the three fertilizer levels $F_1$ recorded the highest value and it was significantly superior to $F_2$ which in turn was superior to $F_3$.

4.4. Quality aspects

4.4.1. Crude protein content

The data on crude protein content expressed as percentage, of maize grain and cowpea were analysed statistically and the results are presented in Tables 8 and 9 and their analyses of variance in Appendices V and VI.

a) Maize

The protein content of maize grain was affected by different fertility levels and by the interactions of fertility levels with crop arrangements. Crop arrangements alone did not show any significant effect.

Of the three fertilizer levels $F_1$ recorded the highest value, significantly superior to $F_2$ which in turn was superior to $F_3$.

Considering the different treatment combinations $S_2F_1$ recorded the highest value followed by $S_3F_1$ and $S_5F_1$ and was significantly superior to all others. The combinations $S_5F_3$ and $S_3F_3$ recorded the lowest value for protein content.

b) Cowpea

The crude protein content of cowpea was affected by different crop arrangements and fertilizer levels, but their interactions had no significant effect.

Of the different crop arrangements $S_3$ recorded the highest values which was on par with $S_2$, $S_5$ and $S_6$. $S_7$ recorded the lowest value for protein percentage.

With the three fertilizer levels $F_1$ recorded the highest protein percentage followed by $F_2$ which was superior to $F_3$.

4.5. Uptake studies

The data on the uptake of nitrogen, phosphorus and potassium by maize and cowpea at the time of harvest were analysed and the mean values are presented in Tables 8 and 9 and their analyses of variance in Appendices V and VI.

4.5.1. Nitrogen uptake

a) Maize

The uptake of nitrogen by maize was affected by different crop arrangements fertilizer levels and their interactions.

In the crop arrangements, $S_2$ gave the maximum nitrogen uptake values and $S_4$ the lowest. $S_2$, $S_3$, $S_5$ and $S_6$ were on par, and significantly superior to $S_4$. The treatments $S_4$ and $S_1$ were on par.

The effects due to different fertilizer levels were significant. $F_1$ recorded the highest uptake of nitrogen which was significantly superior to $F_2$ which in turn was superior to $F_3$.

Of the different treatment combinations, $S_2F_1$ recorded the highest value and it was on par with $S_5F_1$. The combination $S_5F_1$ was also on par with $S_6F_1$, $S_3F_1$ and $S_4F_1$. But $S_2F_1$ was significantly superior to $S_6F_1$, $S_3F_1$ and $S_4F_1$. The lowest value was recorded by $S_5F_3$ and it was on par with $S_1F_3$, $S_2F_3$, $S_3F_3$, $S_4F_3$ and $S_6F_3$.

b) Cowpea

The effects due to different crop arrangements and fertilizer levels were significant on nitrogen uptake of cowpea eventhough their interaction effects were not significant.

The treatment $S_7$ recorded the highest value for nitrogen uptake and was significantly superior to all other crop arrangements. Among the intercrop arrangements $S_3$ recorded the highest value and $S_5$ recorded the lowest value.

Considering the different fertilizer levels, $F_1$ recorded the highest value and was significantly superior to $F_2$ which in turn was superior to $F_3$ which gave the lowest value.

4.5.2. Phosphorus uptake

a. Maize

The effects due to different crop arrangements fertilizer levels and their interactions were significant on this character.

The crop arrangement $S_1$ resulted in the maximum value for phosphorus uptake and $S_6$ the lowest.

In the case of fertilizer levels, $F_1$ recorded the maximum value for phosphorus uptake followed by $F_2$ while $F_3$ registered the lowest phosphorus uptake. The different levels were significantly different from each other.

Among the various treatment combinations $S_1F_1$ recorded the highest value for phosphorus uptake and was superior to other combinations except $S_4F_1$. The lowest value was given by the treatment combination $S_6F_3$.

b) Cowpea

Phosphorus uptake of cowpea showed pronounced variations due to different crop arrangements and fertilizer levels. But the effect due to their interactions were not significant.

Of the five crop arrangements including cowpea, $S_7$ recorded significantly higher values for this character than others. With regard to the intercrop arrangements, $S_3$ recorded the highest value and $S_5$ the lowest.

The fertilizer level $F_1$ was significantly superior to the other two levels in phosphorus uptake. $F_2$ was significantly superior to $F_3$ which recorded the lowest P uptake.

4.5.3. Potassium uptake

a) Maize

Potassium uptake was influenced by different crop arrangements and fertilizer levels, while their interactions showed no marked effect.

$S_1$ (pure crop of maize at normal row arrangement) recorded the maximum value for potassium uptake and $S_1$ (three rows of cowpea in the interpair spaces of paired row arrangement) showed the minimum value.

Among the fertilizer levels $F_1$ recorded the highest value for potassium uptake followed by $F_2$, and $F_3$ resulted the lowest value.

b) Cowpea

Different crop arrangements and fertilizer levels had a pronounced effect in this parameter, while their interaction had no effect.

The crop arrangement $S_7$ recorded the maximum value and $S_5$ the minimum value. Among the intercrop arrangements $S_3$ recorded the highest value.

Potassium uptake increased significantly by increased dose of fertilizer application. The $F_1$ level recorded the higher K uptake while the $F_3$ resulted in the lowest.

4.6. 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 maize, cowpea and maize + cowpea arrangements and fertilizer levels are presented in Table 10 and the analysis of variance in Appendix VII.

Table 10. Available N, P and K in the soil after the experiment and net income from the Maize + Fodder Cowpea intercropping system

| Treatments | Available N (kg/ha) | Available P (kg/ha) | Available K (kg/ha) | Net income Rs. |
|---|---|---|---|---|
| Main factor (S) | | | | |
| $S_1$ | 454.22 | 18.20 | 382.78 | 5603.65 |
| $S_2$ | 448.00 | 18.10 | 350.56 | 7344.39 |
| $S_3$ | 485.33 | 17.24 | 294.89 | 7504.50 |
| $S_4$ | 441.78 | 19.16 | 403.00 | 5571.20 |
| $S_5$ | 441.78 | 17.93 | 357.78 | 6160.17 |
| $S_6$ | 497.78 | 17.45 | 314.34 | 7130.20 |
| $S_7$ | 429.33 | 17.51 | 278.89 | 2579.36 |
| SE± | 7.08 | 0.29 | 2.19 | 280.16 |
| CD(0.05) | 21.75 | 0.88 | 6.70 | 863.00 |
| Sub factor (F) | | | | |
| $F_1$ | 498.67 | 19.92 | 356.95 | 6753.95 |
| $F_2$ | 461.33 | 17.50 | 350.71 | 6357.17 |
| $F_3$ | 410.67 | 16.41 | 313.29 | 4821.80 |
| SE± | 2.89 | 0.18 | 1.04 | 125.95 |
| CD(0.05) | 8.34 | 0.52 | 8.10 | 364.80 |
| S x F | | | | |
| $S_1F_1$ | 485.33 | 18.80 | 393.33 | 6709.92 |
| $S_1F_2$ | 466.67 | 18.80 | 406.67 | 5890.36 |
| $S_1F_3$ | 410.67 | 17.07 | 348.33 | 4210.67 |
| $S_2F_1$ | 504.00 | 19.87 | 386.67 | 8240.33 |
| $S_2F_2$ | 448.00 | 17.33 | 348.67 | 7477.50 |
| $S_2F_3$ | 392.00 | 17.07 | 348.33 | 6315.33 |
| $S_3F_1$ | 543.30 | 19.33 | 306.67 | 7678.50 |
| $S_3F_2$ | 485.33 | 16.13 | 296.67 | 8033.50 |
| $S_3F_3$ | 429.33 | 16.27 | 281.33 | 6801.50 |
| $S_4F_1$ | 466.67 | 21.20 | 419.00 | 6646.58 |
| $S_4F_2$ | 448.00 | 18.93 | 410.00 | 5867.02 |
| $S_4F_3$ | 410.67 | 17.33 | 380.00 | 4050.00 |
| $S_5F_1$ | 485.33 | 20.00 | 353.33 | 7232.17 |
| $S_5F_2$ | 448.00 | 17.60 | 383.33 | 6762.17 |
| $S_5F_3$ | 392.00 | 16.20 | 336.67 | 4486.17 |
| $S_6F_1$ | 541.33 | 20.13 | 344.67 | 8069.67 |
| $S_6F_2$ | 504.00 | 16.73 | 336.67 | 7371.83 |
| $S_6F_3$ | 448.00 | 15.47 | 261.67 | 5949.17 |
| $S_7F_1$ | 466.67 | 20.13 | 295.00 | 2700.50 |
| $S_7F_2$ | 429.33 | 16.93 | 273.33 | 3097.83 |
| $S_7F_3$ | 392.00 | 15.47 | 268.33 | 1939.75 |
| SE± | 7.62 | 0.47 | 2.70 | 333.00 |
| CD(0.05) | NS | 1.40 | 8.00 | NS |

Maize grain @ Rs.2/- per kg
Maize stover @ Rs. 50 per kg
Cowpea fodder @ Rs 75 per kg

4.6.1. Available nitrogen in the soil

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

Among the different crop arrangements $S_6$ recorded the highest value for available nitrogen in the soil after the experiment and $S_7$ recorded the lowest value.

Available soil nitrogen contents increased significantly as fertilizer levels were raised from $F_3$ to $F_2$ and again from $F_2$ to $F_1$.

4.6.2. Available phosphorus in the soil

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

Among the different crop arrangements $S_4$ recorded the highest value for available phosphorus and $S_3$ the lowest.

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

In the case of different treatment combinations $S_4F_1$ recorded the highest value and $S_6F_3$ and $S_7F_3$ the lowest values.

#### 4.6.3. Available potassium in the soil

Available potassium in the soil after the experiment was affected by different crop arrangements, fertilizer levels and their interaction.

The treatment $S_4$ recorded the highest value for available potassium in the soil and $S_7$ gave the lowest value.

Considering the fertilizer levels, $F_1$ recorded the highest value and it was followed by $F_2$ while $F_3$ gave the lowest available potassium in the soil after the experiment.

Among the treatment combinations, the maximum value was given by $S_4F_1$ and the minimum by $S_6F_3$.

### 4.7. Biological efficiency indices

#### 4.7.1. Land equivalent ratio (LER)

The data on LER were analysed statistically and the mean values are presented in Table 11 and the analysis of variance in Appendix VIII.

The effect of different crop arrangements was significant on LER while those of fertility levels and interactions were not significant.

Among the different crop arrangements $S_3$ recorded the highest LER value of 1.58 and $S_5$ the lowest (1.29). $S_3$ was on par with $S_2$ and $S_6$.

4.7.2. Land Equivalent Coefficient (LEC)

The data on LEC were analysed statistically and the mean values are presented in Table 11 and the analysis of variance in Appendix VIII.

The effects due to different crop arrangements and fertilizer levels were significant on LEC while their interaction effects was not marked.

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

Considering the fertilizer levels $F_2$ recorded the highest value and it was on par with $F_3$. $F_1$ recorded the lowest LEC.

4.7.3. Area x Time Equivalency Ratio (ATER)

The data on ATER were analysed statistically and the mean values are presented in Table 11 and the analysis of variance in Appendix VIII.

The effects due to different crop arrangements, fertilizer levels and their interaction were significant on ATER.

Table 11. Advantages of intercropping - different indices - LER, LEC, ATER, Monetary Advantage based on LER and IER

| Treatments | LER | LEC | ATER | Monetary Advantage | IER |
|---|---|---|---|---|---|
| Main factor | | | | | |
| $S_2$ | 1.47 | 0.476 | 1.276 | 5485.20 | 1.470 |
| $S_3$ | 1.58 | 0.590 | 1.310 | 6466.49 | 1.610 |
| $S_5$ | 1.29 | 0.311 | 1.154 | 3644.64 | 1.295 |
| $S_6$ | 1.47 | 0.491 | 1.264 | 5412.44 | 1.482 |
| SE± | 0.035 | 0.035 | 0.019 | 363.87 | 0.030 |
| CD (0.05) | 0.12 | 0.12 | 0.067 | 1259.20 | 0.105 |
| Sub | | | | | |
| $F_1$ | 1.42 | 0.430 | 1.230 | 5371.51 | 1.430 |
| $F_2$ | 1.47 | 0.490 | 1.270 | 5467.91 | 1.480 |
| $F_3$ | 1.47 | 0.480 | 1.260 | 4917.16 | 1.480 |
| SE± | 0.017 | 0.015 | 0.012 | 161.10 | 0.017 |
| CD (0.05) | NS | 0.046 | 0.035 | NS | NS |
| S x F interactions | | | | | |
| $S_2F_1$ | 1.42 | 0.430 | 1.240 | 5503.50 | 1.420 |
| $S_2F_2$ | 1.48 | 0.490 | 1.320 | 5651.70 | 1.480 |
| $S_2F_3$ | 1.51 | 0.510 | 1.280 | 5320.41 | 1.520 |
| $S_3F_1$ | 1.54 | 0.550 | 1.300 | 6589.63 | 1.590 |
| $S_3F_2$ | 1.58 | 0.590 | 1.270 | 6627.36 | 1.590 |
| $S_3F_3$ | 1.63 | 0.640 | 1.360 | 6382.57 | 1.640 |
| $S_5F_1$ | 1.29 | 0.300 | 1.150 | 3935.22 | 1.270 |
| $S_5F_2$ | 1.34 | 0.360 | 1.200 | 4298.87 | 1.350 |
| $S_5F_3$ | 1.24 | 0.270 | 1.120 | 2699.83 | 1.260 |
| $S_6F_1$ | 1.43 | 0.450 | 1.220 | 5657.79 | 1.440 |
| $S_6F_2$ | 1.47 | 0.500 | 1.290 | 53130.70 | 1.490 |
| $S_6F_3$ | 1.51 | 0.520 | 1.280 | 5265.82 | 1.520 |
| SE± | 0.034 | 0.081 | 0.024 | 322.20 | 0.033 |
| CD (0.05) | NS | NS | 0.071 | NS | NS |

Considering the crop arrangements, $S_3$ recorded the highest value and $S_5$ the lowest. The crop arrangements $S_3$, $S_6$ and $S_2$ were on par.

Among the three fertilizer levels $F_2$ recorded the highest value of ATER and $F_1$ the lowest. $F_2$ and $F_3$ were on par. $F_3$ was on par with $F_1$ as well.

Considering the different treatment combinations, $S_3F_3$ recorded the highest value and $S_5F_3$ the lowest ATER.

4.8. Economic efficiency indices

4.8.1. Monetary advantage based on LER

The data on monetary advantage based on LER were analysed statistically and the mean values are presented in Table 11 and the analysis of variance in Appendix VIII.

The effects due to different crop arrangements was significant on the monetary advantage while that of fertilizer levels and the interaction of fertilizer levels with crop arrangements were not significant.

Among the crop arrangements, $S_3$ recorded the highest value and $S_5$ the lowest monetary advantage. $S_2$ was found to be advantageous over $S_6$.

4.8.2. Income Equivalent Ratio (IER)

The data on IER were analysed statistically and the mean values are presented in Table 11 and analysis of variance in Appendix VIII.

The effect due to different crop arrangements was significant on IER while that of fertilizer levels and the interaction of fertilizer levels with crop arrangements were not significant.

Among the different crop arrangements, $S_3$ showed the highest value and $S_5$ the lowest.

4.8.3. Net returns

The net returns from pure crops and mixed crops were analysed statistically and the mean values are presented in Table 10 and the analysis of variance in Appendix VII.

The effects due to different crop arrangements and fertilizer levels were significant on net returns while that of their interaction was not significant. $S_3$ recorded the highest returns and $S_7$ the lowest. All intercrop arrangements were found to be better than pure crop arrangements.

Considering the fertilizer levels, $F_1$ recorded the highest returns and $F_3$ the lowest. The different levels were significantly different from each other.

4.8.4. Benefit/cost ratio

The average benefit/cost ratio from the three

Table 12. Economics of maize + fodder cowpea intercropping system under different fertility levels and crop arrangements

| Treatments | Benefit/ cost ratio | Return/ rupee invested on labour (Rs.) | Return/ rupee invested on fertilizer (Rs.) | Return/ cropping day (Rs.) |
|---|---|---|---|---|
| $S_1F_1$ | 1.730 | 1.839 | 7.567 | 74.56 |
| $S_1F_2$ | 1.660 | 1.736 | 8.687 | 65.45 |
| $S_1F_3$ | 1.480 | 1.526 | 9.240 | 46.79 |
| $S_2F_1$ | 1.790 | 1.969 | 6.056 | 91.56 |
| $S_2F_2$ | 1.750 | 1.880 | 7.047 | 83.08 |
| $S_2F_3$ | 1.660 | 1.745 | 8.660 | 70.17 |
| $S_3F_1$ | 1.730 | 1.900 | 5.655 | 85.32 |
| $S_3F_2$ | 1.790 | 1.945 | 7.497 | 89.26 |
| $S_3F_3$ | 1.700 | 1.800 | 9.249 | 75.57 |
| $S_4F_1$ | 1.720 | 1.831 | 7.505 | 74.96 |
| $S_4F_2$ | 1.650 | 1.733 | 8.656 | 65.19 |
| $S_4F_3$ | 1.460 | 1.506 | 7.753 | 45.01 |
| $S_5F_1$ | 1.690 | 1.852 | 5.323 | 80.51 |
| $S_5F_2$ | 1.670 | 1.796 | 6.471 | 75.17 |
| $S_5F_3$ | 1.470 | 1.528 | 6.441 | 49.85 |
| $S_6F_1$ | 1.770 | 1.949 | 5.892 | 89.66 |
| $S_6F_2$ | 1.750 | 1.867 | 6.962 | 81.91 |
| $S_6F_3$ | 1.610 | 1.700 | 8.215 | 66.10 |
| $S_7F_1$ | 1.650 | 1.900 | 5.790 | 57.46 |
| $S_7F_2$ | 1.480 | 1.635 | 5.523 | 40.50 |
| $S_7F_3$ | 1.500 | 1.647 | 7.897 | 41.27 |

replications were worked out and the data are presented in Table 12.

The treatment combination $S_2F_1$ and $S_3F_2$ showed the highest value (1.79) for this ratio. The lowest value was recorded by $S_4F_3$ combination.

4.8.5. Return per rupee invested on labour

The average value for this was worked out from the three replications and the data are presented in Table 12.

Of the different treatment combinations, $S_2F_1$ recorded the highest value and $S_4F_3$ the lowest value for this aspect.

4.8.6. Return per rupee invested on fertilizers

The average values of return per rupee invested on fertilizers was worked out from the three replications and the same is presented in Table 12.

The highest value was recorded by $S_3F_3$ and the lowest by $S_7F_2$.

4.8.7. Return per cropping day

The average values of return per cropping day were worked out from the three replications and the same is presented in Table 12.

The highest value was recorded by $S_2F_1$ and the lowest by $S_7F_2$.

# DISCUSSION

# 5. DISCUSSION

The present investigation is an attempt to select the best crop arrangement and fertilizer level for a grain maize + fodder cowpea intercropping system in summer rice fallows. The data collected on various growth characters, yield, quality and yield advantages were analysed statistically and the results are discussed in this chapter.

## 5.1. Growth characters

### 5.1.1. Height of plants

a) Maize (Table 5 and Appendix II)

The results revealed significant differences in the height of the plants due to different crop arrangements and fertility levels at all the stages of growth, except at 40 DAS, where the effect due to crop arrangement was not significant. But the interaction of crop arrangements with fertilizer levels was not significant at the different stages of growth. The crop arrangement $S_2$ where maize at normal row arrangement was alternated with one row of cowpea showed maximum height of maize and it was on par with all other intercrop arrangements and pure crop of maize at normal row arrangement, except paired row planting of maize. The lower value for plant height of maize in paired row arrangement might be due to the increased intraspecific competition persisting there. The arrangement at 40/80 x 20 cm paired row caused an uneven sharing of space between different maize plants. Within the paired row the maize plants were close enough to have intraspecific competition resulting in decreased plant height. This was in agreement with the earlier results of Cordero and McCollum (1979) who reported similar poor performance of maize plants in paired rows compared to normal rows.

The increased height of maize in intercrop treatments might be due to the increased supply of nutrients to the crop, where cowpea population was not enough to produce any adverse effect. Eventhough $S_5$ was prone to the same situation, the existence of intraspecific competition masked the favourable effects.

At 40 DAS the effect of different crop arrangements on the height of maize plant was not significant. At this time most of the maize plants were in their peak tasselling stage. Haizel (1974) and Mercy George (1981) observed that when maize was intercropped with legumes, upto the time of tasselling, the maize was more competitive than legumes, but this has been changed in favour of legumes from tasselling to maturity of the maize crop.

Again at 60 DAS and at the time of harvest $S_2$ produced the maximum plant height and $S_4$ and $S_6$ the minimum. The harvest of cowpea at 45 DAS favoured the maize plants by the residual effect of nitrogen in the case of intercrop arrangements. One more top dressing of nitrogen was given to the maize plants after the harvest of cowpea. These conditions favoured the maize plants in intercrop treatments to increase their plant height at these stages.

The maximum height was produced by the highest fertilizer level and it was markedly different from the other two levels. Height being a character dependent on nutrition, increased application of fertilizers would have encouraged the root growth which inturn resulted in higher rate of nutrient absorption which was manifested in 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.

b) Cowpea (Table 6 and Appendix III)

Results on plant height of cowpea showed that at all the stages the different plant arrangements had significant influence on this character. The pure crop of cowpea ($S_7$) exhibited the maximum height at all stages of growth. Better harvesting of sunlight by cowpea when grown as pure crop might be the reason for this. Further, there was no shading effect of maize on the pure crop of cowpea. Agboola and Fayemi (1971) and Dalal (1974) stated that maize was more competitive and considered to be the dominant species when intercropped with cowpea. The results obtained in the present investigation are in agreement with the findings of the above workers.

The highest level of fertilization produced the tallest plants and the lowest level the shortest. Upto 30 DAS the highest level was significantly different from the second level, while at the time of harvest, both of them were on par. In the early stages leguminous plants might have responded well to the added fertilizers and that might have increased their height differently according to the levels of fertilization.

5.1.2. Number of leaves per plant

a) Maize (Table 5 and Appendix II)

From the results it could be seen that there were significant differences in the number of leaves of maize due to different crop arrangements and fertilizer levels at all stages of growth.

The crop arrangement $S_2$ produced the maximum number of leaves and it was on par with $S_1$. In other crop arrangements the increased interspecific and intraspecific competitions might be the reason for reduced number of leaves. Presence of one row of cowpea in between the normally arranged maize rows 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. Guljaev and Ronsal (1962) reported that growth of maize was stimulated by secretions from the roots of legumes in the intercropping system.

The relationship between fertilizer levels and leaf number was found to be linear. 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.

b) Cowpea (Table 6 and Appendix III)

At all the stages of growth, the number of leaves in cowpea was found to be unaffected by different crop arrangements eventhough pure crop of cowpea gave a comparatively higher number of leaves. 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 was found to produce the maximum number of leaves in cowpea at all stages of growth. The increased doses of fertilizers, especially nitrogen and phosphorus, 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. Moreover, increased leaf number due to phosphorus application was 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.

5.1.3. Days to silking (Table 7 and Appendix IV)

Results showed that different crop arrangements, fertilizer levels and their interactions had no significant influence on the days to silking indicating that this is mainly a genetically influenced character.

5.1.4. Leaf/stem ratio

a) Maize (Table 7 and Appendix IV)

The different crop arrangements and the interaction of crop arrangements with fertilizer levels produced significant effect, while the different fertilizer levels individually had no significant influence on the leaf/stem ratio of maize. The treatment $S_4$ produced highest values for this ratio followed by $S_1$ and these were on par. In these crop arrangements, maize plants might have been supplied with sufficient space to produce longer and broader leaves compared to others. This might be the reason for the increased ratio. The treatment $S_6$ recorded the minimum leaf/stem ratio. The unavailability of sufficient space and the strong competition for nutrients resulted in the low leaf/stem ratio.

The interaction $S_4F_1$ recorded the maximum value for leaf/stem ratio. It was noticed that the crop arrangement, $S_4$ produced significantly higher ratio while the effect of fertilizer levels were not significant. In general for intercrop arrangements the combination with fertilizer level $F_2$ was found to be the best.

b) Cowpea

The leaf/stem ratio of cowpea was found to be not affected by different crop arrangements, fertilizer levels and their interactions.

5.2. Yield attributes

5.2.1. Fodder yield of cowpea (Table 6, Appendix III and Fig. 4)

Crop arrangements and fertilizer levels showed marked influence on fodder yield of cowpea eventhough their interaction effects were not significant. The pure crop of cowpea recorded the maximum yield of 20.54 t/ha. 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. Growth characters like plant height and number of leaves were maximum in this treatment. The cumulative effect of these characters resulted in increased fodder yield.

Among the intercrop treatments, $S_3$ recorded the highest fodder yield. Here the plant population of cowpea was high compared to other intercropping arrangements. $S_6$ produced the second highest yield, which had the second highest plant population in the system. The relationship between plant population and yield was found to be linear and positive. Similar increases in the fodder yield of pigeon pea when grown as intercrop in sorghum have been recorded by earlier workers like Freyman and Venkateswarlu (1977).

It was also seen that the highest yield was produced by the highest level of fertilizer. The yield attributing characters, like height of the plant and number of leaves per plant, were maximum under the highest level of fertilizer application. From the uptake studies (Table 9) it was clear that the uptake of major nutrients was also maximum in the fertilizer level $F_1$. The increased uptake of major nutrients might have had positive effect on yield attributing characters resulting in increased fodder yield.

5.2.2. Number of cobs per plant (Table 7 and Appendix IV)

There was significant difference in the number of cobs per plant due to different crop arrangements and fertilizer levels. The effects due to the interaction of crop arrangements with fertilizer levels on this character was not significant. Among the crop arrangements $S_1$ was found to be significantly superior to others except $S_4$ and these two treatments were on par. Both these were pure crops of maize and hence there was no competition from the intercrops. This situation facilitated the maize crop to utilise the environment and to produce higher number of cobs per plant in the sole cropping system. Increased competition from intercrops might be the reason for reduced number of cobs per plant in maize grown in the intercropping system.

From the results it was noticed that the highest fertilizer level contributed to the maximum number of cobs per plant. This finding is in conformity with the results obtained by Sharma (1973), Rathore _et al_. (1976), Brar & Khehra (1977), Short _et al_. (1982), Karim _et al_. (1983) and Adetiloye _et al_. (1984).

5.2.3. Length of cob (Table 7 and Appendix IV)

The results revealed significant difference in cob length due to crop arrangements and fertilizer levels. Here also the sole crop arrangements produced longer cobs than the intercropped ones. The lack of competition for space and nutrients by intercrops in pure crop system might have contributed to the production of longer cobs in sole cropped plots.

Among the two sole crop arrangements, paired row arrangement ($S_4$) recorded slight reduction in the length of cobs. This is because of the competition among the plants within the paired rows. The highest level of nutrients also produced longer cobs underlying the fact that adequate fertilization is essential to exploit the full productive capacity of crops. Increase in length of cob with increasing levels of nitrogen was reported by Subramonian et al. (1982), Adetiloye et al. (1984) and Jaleesa (1987).

5.2.4. Girth of cob (Table 7 and Appendix IV)

The effects of different crop arrangements and the interaction of crop arrangements with fertilizer levels were not significant in determining the cob girth, while the different fertilizer levels showed significant effect.

To produce thicker cobs adequate fertilization is a must and similar results were also reported by Lincy Xavier (1986) and Jaleesa (1987) by increasing nitrogen levels in grain maize.

5.2.5. Number of grains per cob (Table 7 and Appendix IV)

The results revealed that the different crop arrangements and fertilizer levels had significant influence on the number of grains per cob while their interactions was not significant.

Of the different crop arrangements the pure crop of maize produced the highest number of grains per cob. This was in agreement with the findings of Ofori and Stern (1986).

Level of fertilizers also significantly influenced the number of grains per cob. Number of grains increased linearly with increase in fertilizer levels. Similar result was also reported by Rathore et al. (1976).

5.26. Thousand grain weight (Table 7 and Appendix IV)

The results revealed that the 1000 grain weight was not influenced by different crop arrangements and interaction of crop arrangements with fertilizer levels. But the different fertilizer levels showed a significant influence in 1000 grain weight. Like all other yield attributes, this character was also positively influenced by adequate fertilization. Higher nutrient levels increased the size of seed by proper grain filling and contributed to a higher 1000 grain weight. Rathore et al. (1976) and Kharkar (1980) also reported similar findings.

5.2.7. Dry weight of grains per cob (Table 7 and Appendix IV)

The results revealed that different crop arrangements and fertilizer levels were significant in increasing the dry weight of grains per cob, while their interaction was not significant.

The pure crop of maize under normal spacing (60 x 20 cm) recorded the highest dry weight of grains per cob. The increased grain number per cob and the highest 1000 grain weight might have contributed to the maximum dry weight of grains in the pure crop system. Among the intercrop arrangements, $S_2$ produced maximum dry weight of grains per cob. In this crop arrangement the population of cowpea was minimum and hence the competition for light and nutrition would have been less. The number of grains per cob was also higher for $S_2$.

The full recommended dose of fertilizers produced the highest grain number per cob and maximum thousand grain weight and these together might have contributed to the maximum dry weight of grains per cob in $F_1$ treatment.

5.2.8. Grain yield (Table 8, Appendix V and Fig. 4)

The pure crop of maize recorded a significant increase in grain yield over the intercropped ones. The better growth environment in sole cropping contributed increased cob number per plant, number of grains per cob and 1000 grain weight which together would have increased the grain yield. Similar yield reduction in intercropped maize was reported by Remison (1980) and Davis and Garcia (1983).

Between the pure crops of maize, single row planting (60 x 20 cm spacing) recorded a significantly higher grain yield over the paired row planting (40/80 x 20 cm). The closer row to row spacing within the paired rows could have enhanced the competition between the plants and this in turn contributed to a decrease in grain number per cob and 1000 grain weight which in turn might have resulted in decreased grain yield. This was in agreement with the results obtained by Cordero and McCollum (1979) and Umrani et al. (1982).

Among the intercropping system $S_2$ recorded a significantly higher grain yield over other crop arrangements. The minimum intercrop population in $S_2$ could have reduced the competition and this in turn helped to increase the number of grains per cob, 1000 grain weight and finally the grain yield.

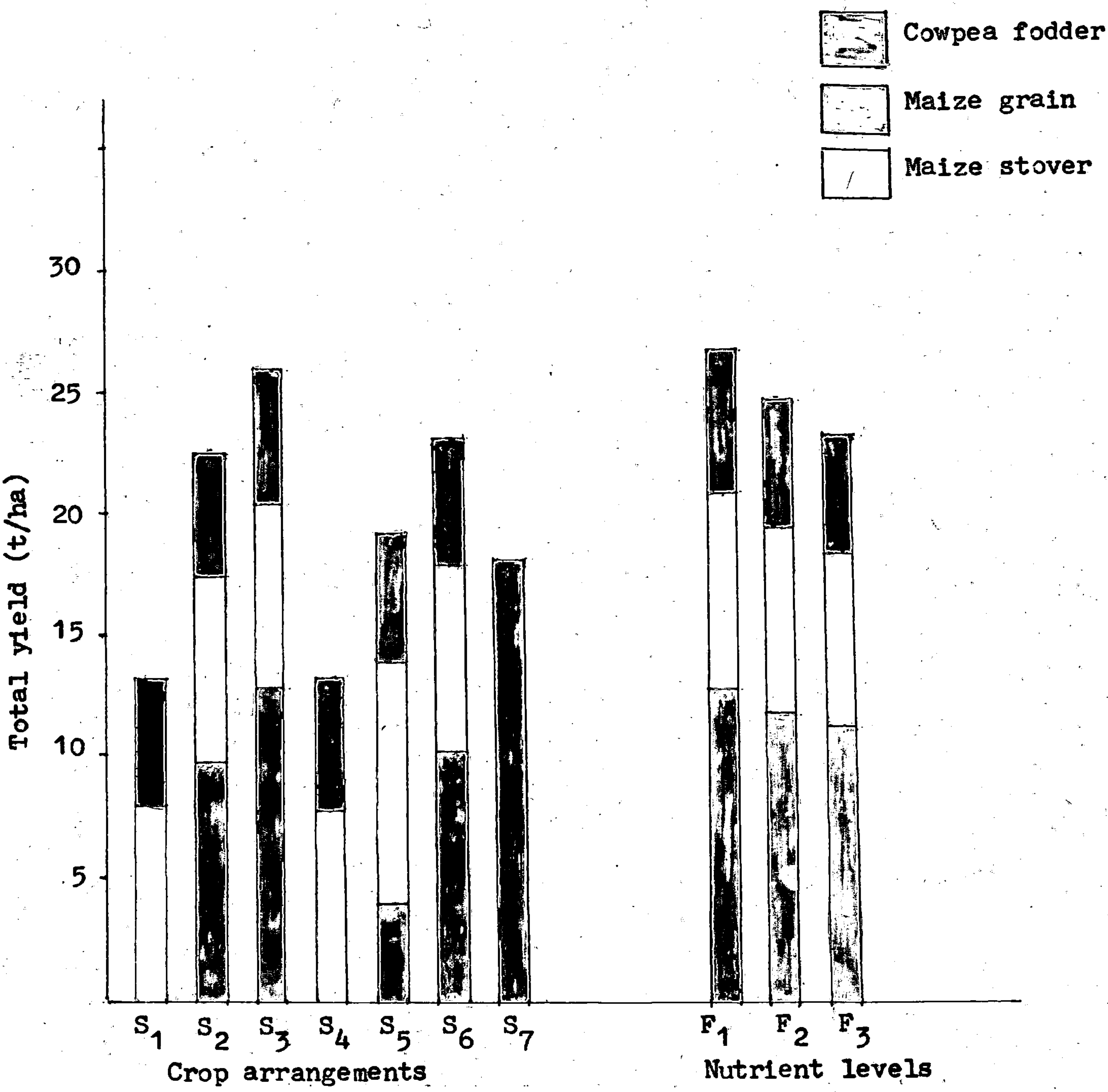



Fig.4 Total yield from maize + fodder cowpea intercropping system as affected by different crop arrangements and nutrient levels

Grain yield was increased due to increasing doses of fertilizer application. Higher doses of fertilizers favoured the growth of plants and helped to increase the various yield components like number of grains per cob, length of cob, girth of cob and 1000 grain weight. All these together could have resulted in the increased grain yield. These results were in agreement with the findings reported by Pushpangadan and George (1965), Sasidhar and Sadanandan (1972), Meenakshi et al. (1975), Khan and Singh (1976), Satyanarayana et al. (1978) and Kumar et al. (1984).

5.2.9. Stover yield (Table 8, Appendix V and Fig. 4)

From the results it was revealed that the pure crops of maize recorded significantly higher stover yield than the intercropped ones. Due to lack of competition, luxuriant plant growth was noticed in the sole crop arrangement. It was also seen that the total dry matter production was high in the above treatments. These effects together might have resulted in an enhanced stover yield per plot in the sole crop systems.

Among the fertilizer levels tried the highest level of nutrients significantly increased the stover yield. The vegetative characters like height of plants, number of leaves per plant etc. increased with increasing levels of nutrients and hence increased the stover yield. This is in conformity with the findings of Santos and Olsen (1977) and Singh et al. (1982).

Harvest Index (Table 7 and Appendix IV)

Harvest index was significantly influenced by different crop arrangements and fertilizer levels, but their interaction effect was not significant. The maximum value for harvest index was obtained for $S_5$ and $S_6$. All the intercrop arrangements were found to be on par and significantly superior to pure crop maize. The reduction in stover yield of intercropped maize compared to grain yield might have contributed to a higher harvest index for the intercropped maize.

Considering the fertilizer levels the highest fertilizer dose recorded the maximum harvest index which was on par with its immediate lower level (ie. 75 per cent of recommended level) indicating the lower dose is sufficient to obtain higher harvest index.

A relatively higher harvest index at higher levels of fertilizers is a clear indication that the variety tried responds well to the application of fertilizers.

5.3. Chemical composition

5.3.1. Nitrogen content

a) Maize (Table 8 and Appendix V)

The nitrogen content of maize stover as well as grain was influenced by different crop arrangements fertilizer levels and their interaction.

The results indicated that the presence of cowpea influenced the nitrogen content of maize. The intercrop treatments recorded higher nitrogen content than pure crop of maize. The release of nitrogen from the nodules of legume would have helped in increasing the nitrogen content of the maize plants.

The nitrogen content of maize was also found to be increased with increasing levels of nitrogen. Eventhough the applied nitrogen in intercropped treatments was high, that was shared by the component crops of the system, and the root nodules of the intercrop released the fixed nitrogen which might have contributed to the increase in nitrogen content of maize crop. Similar results were reported by Tiwana et al. (1978) and Fisher (1979).

b) Cowpea (Table 9 and Appendix VI)

The nitrogen content of cowpea at the time of harvest was influenced by crop arrangements and fertilizer levels. The crop arrangement $S_3$ recorded the maximum nitrogen content. Among the different fertilizer levels tried, the highest level produced a significant increase in nitrogen content of cowpea. Increased nitrogen application might have increased the uptake of nitrogen by the plant and hence increased the nitrogen content (Tisdale et al., 1985).

5.3.2. Phosphorus content

a) Maize (Table 8 and Appendix V)

The phosphorus content of maize was also significantly influenced by different crop arrangements, fertilizer levels and their interactions. The pure crops of maize recorded significantly higher phosphorus content than the intercropped ones. In intercropped plots, the intercrop being a legume some quantity of phosphorus might have been utilized for the root growth and activation of nitrogen fixing bacteria (Tisdale et al., 1985) resulting in a reduction in the phosphorus content of maize in maize legume intercropped plots.

The highest level of nutrition significantly increased the phosphorus content of maize. Increased nitrogen level due to increased dose of fertilizers might have resulted in the increased absorption of phosphorus, which in turn increased the phosphorus content (Tisdale et al., 1985).

b) Cowpea (Table 9 and Appendix VI)

The phosphorus content of cowpea was significantly influenced by crop arrangement and fertilizer levels while their interaction was not significant. The crop arrangement $S_2$ recorded the highest phosphorus content. The highest level of nutrients significantly increased the phosphorus content of cowpea. Increased nitrogen level due to increased doses of fertilizers might have resulted in the increased absorption of phosphorus which in turn would have increased the phosphorus content.

5.3.3. Potassium content

a) Maize (Table 8 and Appendix V)

The results indicated that $S_1$ and $S_3$ gave the highest content of potassium in the maize stover and they were on par with $S_2$ and $S_4$. As per the treatment schedule, $S_3$ received the highest amount of potassium which encouraged the maize plants to absorb more with luxury consumption. Of the different fertilizer levels $F_1$ recorded the highest potassium percentage. The high amount of potassium application might be the reason for the increased potassium content in maize grain as well as in stover.

In the case of different treatment combinations $S_1F_1$ recorded the highest value and it was on par with $S_3F_1$. The increased potassium percentage due to individual effect of $S_1$, $S_3$ and $F_1$ might have reflected in their combinations also.

b) Cowpea (Table 9 and Appendix VI)

In the case of cowpea the highest percentage of potassium was recorded by the crop arrangement $S_2$ which was on par with $S_5$. In $S_2$ and $S_5$ the population of cowpea was less when compared to $S_3$, $S_6$ and $S_7$. The lowest yields of cowpea fodder were also obtained from these treatments. The low population of cowpea coupled with the lower fodder yield could have resulted in a higher content of potassium in the plant. The absorbed potassium might not have been utilised for further production purpose and hence accumulated in plant parts.

The highest fertilizer level was found to be giving the maximum potassium percentage. Higher levels of fertilizers would have stimulated luxury consumption which inturn could have helped to increase the potassium content in the plant (Tisdale _et al._, 1985). Further, the potassium content in the soil was high enabling the plant to exhibit the phenomenon of luxury consumption.

5.4. Quality aspects

5.4.1. Protein content of maize (Table 8 and Appendix V)

The protein content of maize was not affected by the different crop arrangements. Similar results were also reported earlier by Mercy George (1981). But the fertilizer levels had a significant influence on the protein percentage of maize grain. As the fertility level was increased, there was a proportionate increase in the protein content of grain. The relationship between nitrogen fertilization and protein percentage was well established by several workers (Tripathi, 1971; Singh, 1976; Gangro, 1978 and Jaleesa, 1987).

The treatment combination $S_2F_1$ recorded the highest value for protein percentage, which was on par with $S_3F_1$ and $S_5$. $F_1$ showing that at higher levels of nitrogen the protein content would be high.

b) Crude protein content of cowpea (Table 9 and Appendix VI)

The results revealed that all intercrop arrangements gave high protein percentage than the sole crop of cowpea. This might be due to high nutrient utilization from the increased fertilizer application. The fodder production from these treatments were also significantly inferior to that from cowpea grown as pure crop and thus the high fertilizer dose with the low fodder yield might have resulted in an increased protein content in intercropped cowpea.

5.5. Uptake studies

5.5.1. Nitrogen uptake

a) Maize (Table 8 and Appendix V)

The crop arrangement $S_2$ gave the maximum nitrogen uptake value which was on par with all other intercrop arrangements. In intercropping, the increased competitive ability of maize plants would have resulted in higher uptake of nitrogen. The maize could have been able to compete easily with legumes in the uptake of nitrogen because of its shallow root system. Similar result was also reported by Waghmare and Singh (1984) in sorghum + legume intercropping system.

The fertilizer levels had a marked influence on the nitrogen uptake of maize. The nitrogen uptake increased significantly at higher levels of nitrogen. This was in agreement with the results earlier reported by Relwani & Kumar (1971), Shanmugasundaram et al. (1974), Mercy George (1981) and Waghmare & Singh (1984).

The treatment combination $S_2F_1$ recorded the highest value for nitrogen uptake. The significant individual effects of $S_2$ and $F_1$ together might have resulted in a significantly higher value for the $S_2F_1$ combination.

b) Cowpea (Table 9 and Appendix VI)

The crop arrangement $S_7$ (pure crop of cowpea) recorded significantly higher nitrogen uptake, than other intercropping systems. The treatment $S_7$, recorded the highest fodder yield and this might be the reason for the increased uptake of nitrogen in $S_7$. This was in agreement with the earlier finding of Aggarwal et al. (1978) who reported that the total nitrogen uptake was significantly related to the above ground biomass production.

The nitrogen uptake of cowpea showed an increase due to increased doses of applied fertilizers. Similar results were earlier reported by Bains (1969) and Rajesh Chandran (1987).

5.5.2. Phosphorus uptake

Maize (Table 8 and Appendix V)

The results revealed that different crop arrangements significantly influenced the phosphorus uptake of maize. The crop arrangement $S_1$ recorded the maximum value. The soil test values (Table 1) revealed that the soil was medium in available phosphorus. So more phosphorus was available to maize in sole as well as intercrop arrangements. This could have resulted in the production of extensive root system in maize in the sole crop arrangements. It was seen from the earlier findings that under high status of available phosphorus, sole crops tended to take up more phosphorus (Waghmare and Singh, 1984). Phosphorus being an immobile nutrient in soil, it is absorbed when growing roots come in contact with organic and inorganic materials containing available forms of the element. If maize roots were more extensive than the cowpeas, they could have foraged for phosphorus more effectively and even penetrated the cowpea rhizospheres. This may explain why maize exhibited such irregular behaviour in the mixture.

The relationship between fertilization and phosphorus uptake was found to be linear upto the highest level tried in the present investigation. Higher uptake of phosphorus was associated with higher levels of phosphorus application (Maloth and Prasad, 1976). The results obtained in the present investigation also agreed with this finding.

b) Cowpea (Table 9 and Appendix VI)

The crop arrangement $S_7$ recorded significantly higher phosphorus uptake. The higher fodder yield of cowpea from $S_7$ coupled with the absence of maize to cause competition could have favoured the high phosphorus uptake by cowpea.

The maximum phosphorus uptake was recorded by the higher levels of fertilizers and it was in line with the findings of Faroda and Tomer (1975) and Maloth and Prasad (1976).

5.5.3. Potassium uptake

a) Maize (Table 8 and Appendix V)

The pure crop of maize at normal row arrangement ($S_1$)

recorded the highest value for potassium uptake. The higher dry matter production might have contributed to this increased potassium uptake in the pure crop of maize.

Higher levels of fertilizers significantly increased the potassium uptake by maize. Tiwana et al. (1978) and Mercy George (1981) reported similar increase in potassium uptake with increased application of nitrogen phosphorus and potassium.

b) Cowpea (Table 9 and Appendix VI)

The crop arrangement $S_7$ (pure crop of cowpea) recorded the highest value for potassium uptake. The high production of biomass in that arrangement where there was no maize crop might be a possible reason for this increased uptake of potassium.

The application of higher fertilizer doses increased the potassium uptake. Similar results were reported by Groneman (1974).

5.6. Nutrient status of the soil after the experiment

5.6.1. Available nitrogen content (Table 10 and Appendix VII)

From the results it was seen that the available nitrogen content of the soil was affected by different crop arrangements and fertilizer levels eventhough their interactions had no significant effect. Of the different crop arrangements, $S_6$ recorded the highest level of available nitrogen in the soil which was on par with $S_3$. The highest dose of fertilizers was applied in $S_3$, followed by $S_6$. There was also high availability of native nitrogen in the soil as evident from the initial soil analysis. Thus the high uptakes of nitrogen would not have reduced the available nitrogen in the soil in these two treatments, resulting in higher values under $S_3$ and $S_6$. The treatment $S_7$ received the lowest amount of fertilizers and hence the residual available nitrogen in the soil was also low. Similar results were reported by Chand (1977). Among the fertilizer levels, the highest dose of fertilizers ($F_1$) recorded the highest value of available nitrogen in the soil after the experiment.

5.6.2. Available residual phosphorus and residual potassium (Table 10 and Appendix VII)

There was significant difference in the available phosphorus and available potassium in the soil after the experiment due to crop arrangement, fertilizer levels and their interaction. The paired row of maize recorded the highest values. As the dose of applied fertilizer increased, there was a corresponding increase in the residual nutrients in the soil. When higher levels of nutrients were applied, a small fraction of the nutrients would have been left unutilised by the standing crops giving an increase in residual nutrient contents in the soil.

5.7. Biological efficiency indices (Table 11 and Appendix VIII

5.7.1. Land Equivalent Ratio (LER) Fig. 5

The results revealed that there were significant differences in the LER values due to different crop arrangements eventhough effects due to fertilizer levels and the interactions of fertilizer levels with crop arrangements were not significant.

Willey (1979) concluded that the most generally useful single index for expressing the yield advantage is LER, defined as the relative land area required as sole crops to produce the same yield as intercropping. The LER represents the increased biological efficiency achieved by growing two crops together in the particular environment used. The term LER is usually applied to combined intercrop yields but can be applied to the intercrop yield of each crop also.

In the present investigation the highest value for LER was recorded by $S_3$. The LER value for this arrangement was 1.58 meaning 58 per cent more land would be required as sole crops to produce the same yields as intercropping, ie.it was 58 per cent more efficient than the respective sole crops. Eventhough $S_5$ recorded the lowest LER value it was 29 per cent efficient than its corresponding pure

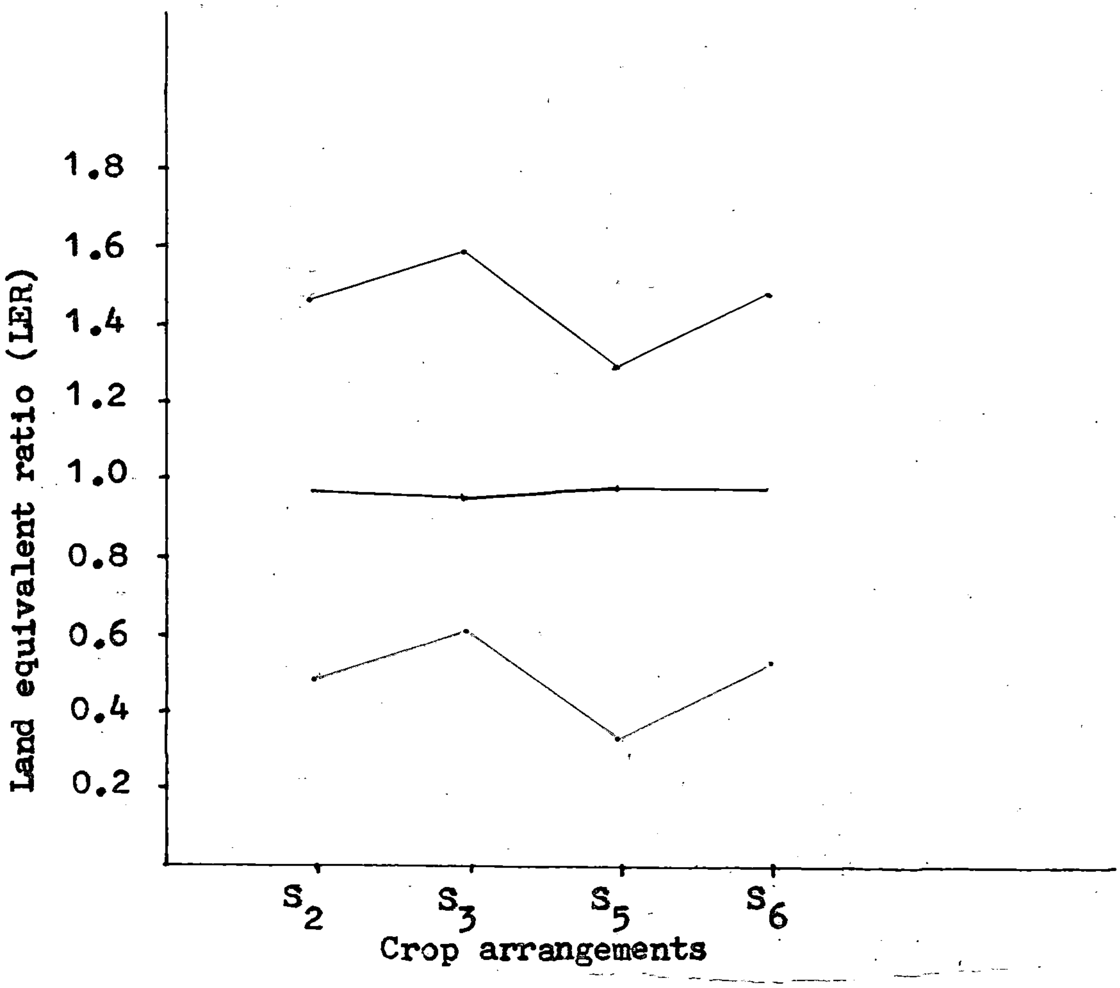
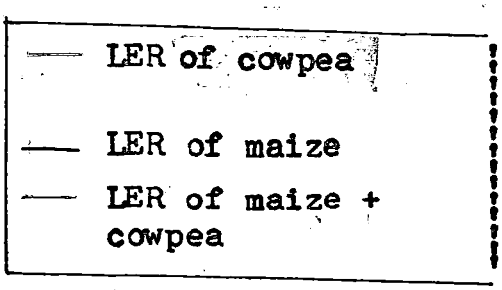



Fig. 5 Land equivalent ratios of maize, cowpea and maize + cowpea as affected by different crop arrangements



crops. All the intercropping arrangements were more efficient than the pure cropping systems. Since LER was calculated based on the yields of component crops LER increased with increasing yields of the system. Here the highest total yield was produced by $S_3$. So $S_3$ recorded the highest value for LER. LER was also increased with increasing populations of component crops upto a certain limit, where there was no yield reduction. Similar results were reported by Chang and Shibles (1985b).

5.7.2. Land Equivalent Coefficient (LEC) Fig. 6

It was seen that the land equivalent coefficient values were affected by different crop arrangements and nutrient levels whereas their interaction effect was not significant.

Eventhough LER is generally considered to be the most efficient index for measuring the biological efficiency of intercropping, there are certain discrepancies which arise from the use of LER in general. The mixture LER value obscures the extent to which the yield of one component crop has been modified by the presence of the other component crop or the reciprocal effects of component crops on one another. Also the mixture LER value fails to indicate the minimum level of reasonable contribution in terms of yield that is expected from the least productive crop

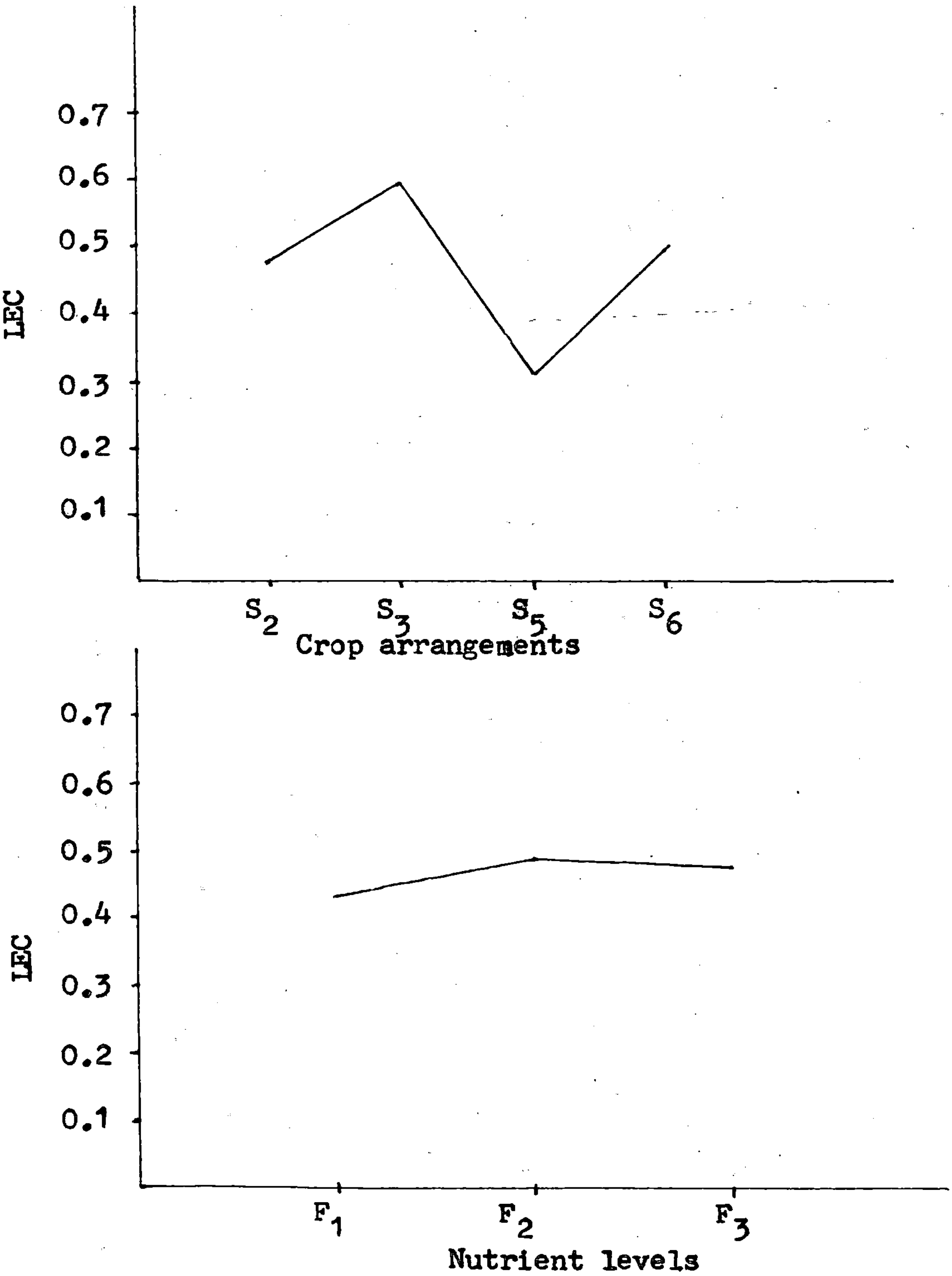



Fig. 6 Land equivalent coefficient (LEC) as affected by different crop arrangements and nutrient levels

component within a given mixture. LER concept fails to differentiate between the productivities of mixtures with different competitive relationships; because the same LER value can be obtained for different intercropping situation.

In this context the use of LEC is advantageous. The LEC has been found to be very effective in deciding the mixture yields as well as the intercrop proportion that give agronomic advantage. For two crop mixtures the LEC values are compared over the standard value of 0.25 obtained from the theoretical 50:50 yield where interspecific competition equalled intraspecific competition. In this present study the crop arrangement $S_3$ recorded the highest value and $S_5$ the lowest. The LEC value for crop arrangement $S_3$ was 0.590. When LEC for a two crop mixture is greater than 0.25 but less than unity (1.00 LEC 0.25) the neighbourhood effects involves competitive complementarity. In the present study all the intercropping arrangements fall in this category which indicate that they are in the same situation.

Of the different fertilizer levels $F_2$ recorded the highest LEC value which was on par with $F_3$. $F_1$ recorded the lowest value. Ahmed and Rao (1982) found that LER values of a maize-soybean intercrop were greater than 1.0

at all nitrogen levels and at all locations although the relative yield advantage declined at higher nitrogen levels. Ofori and Stern (1987) also reported similar results.

5.7.3. Area x Time Equivalency Ratio (ATER) Fig. 7

ATER was found to be influenced by different crop arrangements, fertilizer levels and their interaction.

In the calculation of LER time is not included. Duration of land occupancy by an intercrop is often longer than production cycle duration of one or more of the interplanted species. So Hiebsch and McCollum (1987) proposed an 'area x time equivalency ratio (ATER)' with a view to correct the conceptual inadequacy in LER by including duration of land occupancy in the intercrop vs monoculture comparisons. When published intercrop data were reevaluated via the ATER concept large land use advantages ascribed to growing food crops in mixture disappeared. They concluded that most crop mixtures utilized land area and time at about the same efficiency as pure stands of the mixture components.

In the present investigation also, the production cycle duration of the two crops were different. The duration of cowpea was almost half of that of maize. So while calculating the yield advantage the land occupancy period

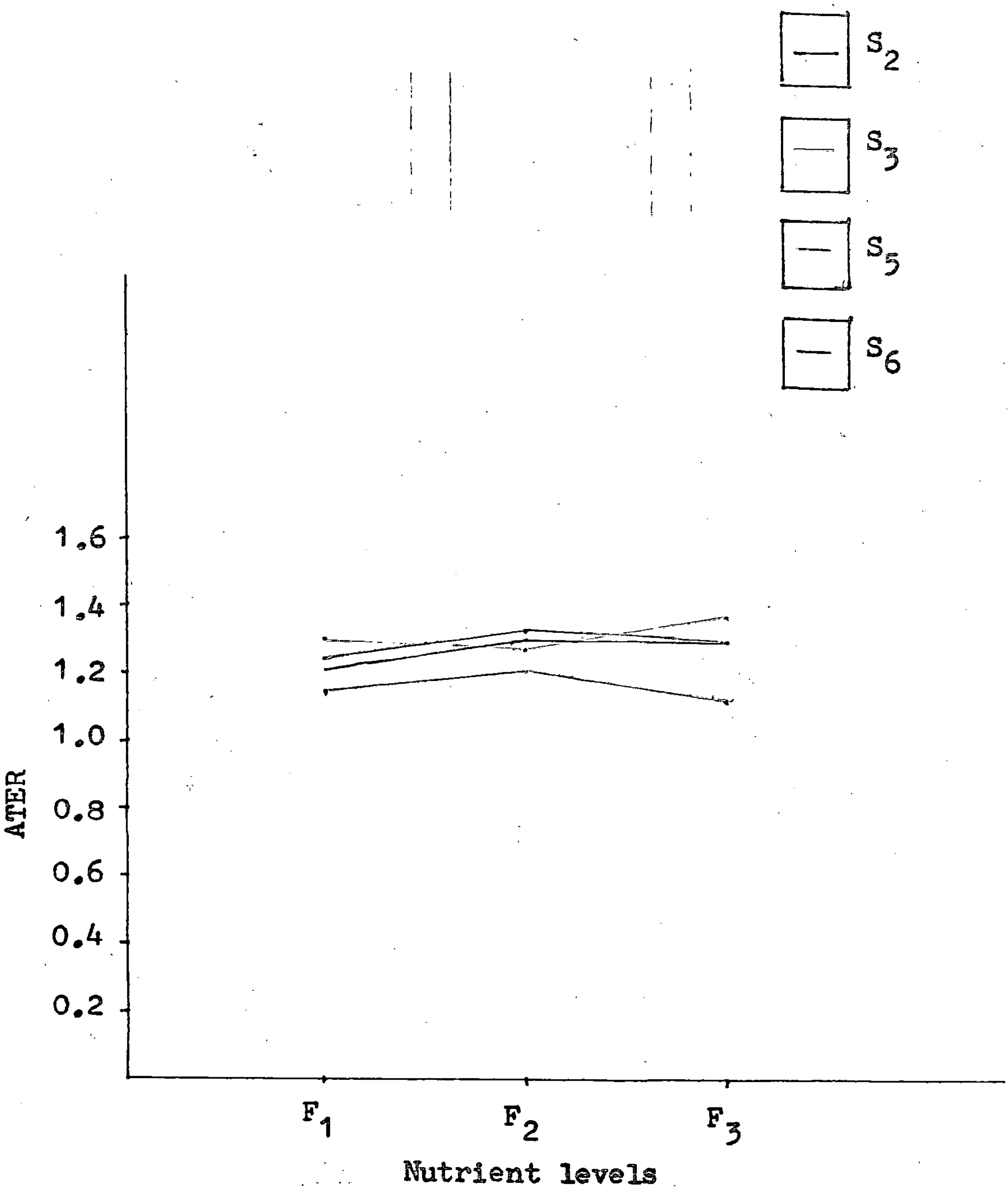



Fig. 7 Area x time equivalency ratio (ATER) as affected by different crop arrangements and nutrient levels

of the crops was also taken into consideration and an assessment by ATER was made. Here also $S_3$ recorded the highest value for ATER, which indicates the highest production from that arrangement. $S_5$ was found to be the poorest arrangement among these four intercrop treatments. Of the different fertilizer levels $F_2$ recorded the highest value and it was on par with $F_3$. This means that the yield advantages from intercropping decreases with increasing levels of nutrients.

Considering the different treatment combinations, $S_3F_3$ recorded the highest value and this was due to the better performance of $S_3$ and $F_3$ when considered separately.

5.8. Economic efficiency indices

5.8.1. Monetary advantage based on LER (table 11 and Appendix VIII)

The results revealed that the monetary advantage based on LER remained unaffected by different fertilizer levels and the interaction of crop arrangements with fertilizer levels. But it was affected by different crop arrangements.

The calculation of monetary advantage based on LER assumes that the appropriate economic assessment of intercropping should be in terms of increased value per unit area of land.

Among the different crop arrangements, $S_3$ showed the highest value for monetary advantage and $S_5$ the lowest. $S_3$ recorded the highest value for LER. This might be the reason for the high monetary advantage from this arrangement.

5.8.2. Income Equivalent Ratio (IER) (Table 11 and Appendix VIII)

From the results it was seen that the IER was affected by different crop arrangements and not affected by fertilizer levels and the interaction of fertilizer levels with crop arrangements.

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.

5.8.3. Net returns (Table 10 and Appendix VII)

The results revealed that the net returns was affected by different crop arrangements and fertilizer levels eventhough their interaction had no effect. The treatment giving the highest net returns was considered to be the best.

Of the different crop arrangements $S_3$ recorded the highest net returns and $S_7$ the lowest. The highest total yield from $S_3$ might be the reason for such results.

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

5.8.4. Benefit/cost ratio (Table 12)

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 $S_2F_1$ and $S_3F_2$ recorded the highest values for the benefit/cost ratio showing their superiority over other treatment combinations.

5.8.5. Return per rupee invested on labour (Table 12)

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. In the present investigation, the treatment combination $S_2F_1$ recorded the highest value.

5.8.6. Return per rupee invested on fertilizer (Table 12)

Return per rupee invested on fertilizer gives an estimate of the production per unit cost spent on fertilizers for different treatments. Here the treatment combination $S_3F_3$ gave the highest value.

5.8.7. Return per cropping day (Table 12)

The results revealed that the treatment combination $S_2F_1$ gave the highest return per cropping day.

From the above discussions it appears that the treatment combinations $S_3F_2$ and $S_2F_1$ are the best combinations for maximum profit to the farmer.

# SUMMARY

# 6. SUMMARY

An experiment was conducted in the summer rice fallows of the Instructional Farm attached to the College of Agriculture, Vellayani during 1987-88 with the object of selecting the best crop arrangement for a maize + fodder cowpea intercropping system under different fertility levels. The different crop arrangements tried were pure crop of maize at normal row arrangement of 60 x 20 cm spacing ($S_1$), maize at 60 x 20 cm spacing + one row of cowpea in between the maize rows ($S_2$), maize at 60 x 20 cm spacing + two rows of cowpea in between the maize rows ($S_3$), pure crop of maize at 40/80 x 20 cm paired rows ($S_4$), maize at 40/80 x 20 cm paired rows + two rows of cowpea in the interpair spaces ($S_5$), maize 40/80 x 20 cm + three rows of cowpea in the interpair spaces ($S_6$) and pure crop of cowpea at 20 x 10 cm spacing ($S_7$). The sole crops are raised to compare the efficiency of different crop arrangements. The fertilizer levels tried were full ($F_1$), three fourth ($F_2$), and half of the recommended doses of nutrients ($F_3$) for maize, cowpea and maize + cowpea according to the crop arrangement and the area occupied by each crop. The experiment was laid out in split plot design with three 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 $S_2$ produced the maximum plant height in maize. Full recommended doses of fertilizers were found to be the best. In the case of cowpea the pure crop ($S_7$) and full recommended doses of nutrients ($F_1$) produced the tallest plants.

Maize in the crop arrangement $S_2$ produced the maximum number of leaves. The number of leaves of maize as well as cowpea increased with increasing levels of nutrients. The number of leaves of cowpea was not influenced by different crop arrangements.

Days to 50 per cent silking in maize was not affected by different crop arrangements or fertilizer levels.

In the case of leaf/stem ratio the pure crop of maize at paired rows recorded the highest value which was on par with pure crop of maize at normal row arrangement. There were also marked differences in the leaf/stem ratio due to interaction effects and the treatment combination $S_4F_1$ recorded the highest value.

The crop arrangement $S_7$ produced the maximum fodder yield of cowpea. Fodder yield was also found to be increased with increasing levels of nutrients. Among the intercrop arrangements $S_3$ recorded the highest value for fodder yield.

More number of cobs per plant was found in pure crop arrangements of maize. Maize at normal row arrangement produced higher number of cobs and it was on par with $S_4$. Among the intercrop arrangements $S_5$ recorded the highest number of cobs per plant followed by $S_2$. The full recommended levels of nutrients produced the maximum number of cobs per plant.

Longest cobs were produced by pure crop of maize at normal row arrangement. When the fertilizer level was increased from $F_3$ to $F_2$ the cob length was increased significantly but $F_2$ and $F_1$ were on par. Among the intercrop arrangements, $S_2$ produced the longest cobs followed by $S_3$.

The girth of cob was affected by different fertilizer levels and $F_1$ produced the best results.

The maximum number of grains per cob was produced by $S_1$ which was on par with $S_4$. The highest fertilizer level was also significantly superior to other levels in this character. Among the different intercrop arrangements $S_2$ produced the maximum number of grains per cob followed by $S_5$.

The thousand grain weight was not affected by different crop arrangements and the interaction of crop arrangements with fertilizer levels. But the effect of fertilizer levels had a positive influence on this character.

The pure crop maize at normal row arrangement ($S_1$) produced the highest dry weight of grains per cob. Considering the intercrop arrangements $S_2$ was found to be the best followed by $S_3$. The dry weight of grains per cob increased with increasing levels of nutrients.

The harvest index of maize was affected by different crop arrangements and fertilizer levels. The highest value for HI was produced by the crop arrangements $S_5$ and $S_6$ and the full recommended doses of nutrients.

The grain yield of maize was affected by crop arrangements and fertilizer levels. The interaction had no effect. $S_1$ produced the maximum grain yield followed by $S_4$. Among the intercrop arrangements $S_2$ produced the maximum grain yield followed by $S_3$ and $S_5$ while 56 produced the minimum. The full recommended doses of nutrients ($F_1$) produced the highest grain yield.

The highest stover yield of maize was produced by the crop arrangement $S_1$ which was on par with $S_4$. Of the different intercrop arrangements $S_2$ was found to be the best followed by $S_3$.

The crop arrangement $S_6$ recorded the maximum nitrogen percentage in maize stover. Of the different treatment combinations, $S_2F_1$ and $S_6F_1$ registered the highest nitrogen percentage. In both maize grain and stover the highest nitrogen content was recorded by the 100 per cent recommended level of nutrients. In the case of maize grain the treatment combination $S_2F_1$ recorded the highest value for nitrogen percentage. In cowpea the crop arrangement $S_3$ recorded the highest nitrogen percentage. The fertilizer level $F_1$ resulted in the maximum values of nitrogen content.

The highest phosphorus percentage in maize grain and stover was recorded by the pure crop arrangements. For cowpea it was in the arrangement $S_2$. The fertilizer level $F_1$ recorded the highest phosphorus percentage for maize grain, maize stover and cowpea fodder.

The crop arrangement $S_1$ gave the highest potassium percentage for maize grain and stover. For maize stover $S_3$ also recorded the same value as $S_1$. In the case of cowpea $S_2$ recorded the highest value for potassium percentage. Of the three fertilizer levels, $F_1$ registered the highest potassium percentage for maize grain, stover and cowpea fodder. Among the different treatment combinations, $S_2F_1$ recorded the highest protein percentage in maize grain. In cowpea fodder, $S_3$ recorded the highest value for protein percentage. Considering the fertilizer levels $F_1$ registered the highest values for protein percentage in both maize grain and fodder cowpea.

The crop arrangement $S_2$ recorded the highest nitrogen uptake by maize. For cowpea $S_7$ recorded the highest value. Among the different treatment combinations $S_2F_1$ recorded the highest value of nitrogen uptake by maize. Considering the fertilizer levels $F_1$ produced the highest value for both maize and cowpea.

Pure crops of maize and cowpea recorded the highest uptake of phosphorus. The treatment combination $S_1F_1$ recorded the maximum value for phosphorus uptake in maize. In both crops $F_1$ gave highest phosphorus uptake.

The potassium uptake was the highest in the pure crops. Among the fertilizer levels, $F_1$ registered the highest values of potassium uptake by both maize and cowpea.

Among the different crop arrangements $S_6$ recorded the highest value for available nitrogen in the soil after the experiment. In the case of different fertilizer levels $F_1$ registered the highest value for available nitrogen in the soil. Available phosphorus content in the soil after the experiment was affected by different crop arrangements fertilizer levels and their interaction. The treatment $S_4$ recorded the highest value for residual available phosphorus. In the case of different fertilizer levels, $F_1$ registered the highest value. Considering the treatment combinations $S_4F_1$ was the best.

Among the different crop arrangements $S_4$ recorded the highest value for available potassium in the soil. Of the different fertilizer levels $F_1$ recorded the highest value. $S_4F_1$ recorded the highest value for residual available potassium in the soil.

The crop arrangement $S_3$ recorded the highest land equivalent ratio (LER), land equivalent coefficient (LEC) area x time equivalency ratio (ATER), monetary advantage based on LER and income equivalent ratio (IER). Among the different fertilizer levels $F_2$ recorded the highest value for LEC and ATER and was on par with $F_1$. The treatment combination $S_3F_3$ recorded the highest value for ATER.

The highest net returns were obtained from $S_2F_1$ and $S_3F_2$.

Considering the different treatment combinations, $S_2F_1$ and $S_3F_2$ showed the highest value for benefit/cost ratio, return per rupee invested on labour and return per cropping day while $S_3F_3$ recorded the highest value for return per rupee invested on fertilizers.

It is thus concluded that $S_2F_1$ and $S_3F_2$ are the best treatment combinations for getting maximum benefit to the farmer from the grain maize + fodder cowpea intercropping system.

# REFERENCE

## REFERENCES


Adetiloye, P.O., Ezedinma, F.O.C. and Okigbo, B.N. (1983). A Land Equivalent Coefficient concept for the evaluation of competitive and productive interaction in simple to complex crop mixtures. Ecol. Modelling, 19: 27-39.

Adetiloye, P.O., Okigbo, B.N. and Ezedinma, F.O.C. (1984). Response of maize plants and ear-shoot characters to growth factors in Southern Nigeria. Field Crops Res., 9: 265-267.

Agboola, A.A. and Fayemi, A.A. (1970). Intercropping maize with legumes 2. Effect of phosphorus and intercropping of tropical legumes on the yield of maize. W. Afr. J. Biol. Appl. Chem., 13: 31-38.

Agboola, A.A. and Fayemi, A.A. (1971). Preliminary trials on the intercropping of maize with different tropical legumes in Western Nigeria. J. Agric. Sci. Camb., 77: 219-225.

Aggarwal, R.K., Saxena, S.K. and Kaul, P. (1978). Herbage production and nutrient composition of grasses in arid grass land as related to season and rainfall 11. Cenchrus ciliaris and Cenchrus setigerus grass species. Forage Res., 4: 149-157.

Ahlawat, M.R., Saini, S.S. and Jindia, J.R. (1964). Effect of nitrogen on the yields of some early Kharif fodders grown alone or mixed with legumes. J. Res. Punjab Agric. Univ., 1: 106-110.

Ahmed, S. and Gunasena, H.P.M. (1979). Nitrogen utilization and economics of some intercropped systems in tropical Countries. Trop. Agric., 56: 115-125.

Ahmed, S. and Rao, M.R. (1982). Performance of maize-soybean intercrop combination in the tropics results of multi-location study. Field Crops Res., 5: 147-161.

Annamma George (1980). Nutritional requirement of blackgram (Vigna mungo (L). Hepper). M.Sc.(Ag.) thesis, Kerala Agricultural University.

Anonymous (1974). Annual Report of All India Co-ordinated Project for Research on Forage Crops. Tamil Nadu Agricultural University, Coimbatore. pp. 30-31.

*Arias, M., I.A., and Munoz, H.M. (1983). Evaluation of monoculture and intercropping systems of maize and legumes in the North East Guarico. Agronomia Tropical, 33: 143-154.

Bains, K.S. (1969). Relationship between applied nutrients plant composition and yield of beans (Phaseolus vulgaris (L). Indian J. Agron., 14: 80-82.

Bala, G.H., Georgescu, Doina and Georgescu, D. (1968). The use of pole beans and common cowpeas (Vigna sinensis) in improving the protein value of the feed of dairy cows and fattening cattle. Cowpeas (Vigna unguiculata (L). Walp). Abstr. World Lit., (1950-1973). 1: 756.

Balakumaran, K.N. (1981). Response of cowpea (Vigna unguiculata (L). Walp) to water management practices and phosphorus nutrition. M.Sc.(Ag.) thesis, Kerala Agricultural University.

*Barrato, A.C. and Serpa, J.E.S. (1986). Performance of maize and beans (Phaseolus vulgaris L) in separated or associated cropping system under the influence of phosphate fertilization. Comunicado Tecnico Centro Nacional de pesquisa de coco EMBRAPA, Brazil. 9.

*Beets, W.C. (1976). Some notes on multiple cropping practices and research in this field. Paper presented at the Department of Agriculture, University of Rhodesia, 55 pp.

Beets, W.C. (1977). Multiple cropping of maize and soybeans under a high level of crop management. Neth. J. Agric. Sci., 25: 95-102.

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

Bhatia, K.S., Srivasthava, K.K. and Lal, B. (1980). Moisture conservation efficiency of some legumes and their effect on the yield of Rai (Brassica juncia Coss.). under rainfed condition. Annals of Arid zone 19: 114-118.

Biswas, T.D. (1982). Management of soil physical condition for soil productivity. J. Indian Soc. Soil Sci., 30: 427-440.

Black, C.A. (1968). Soil Plant Relationships. John Wiley and Sons. Inc. New York, 2nd Ed. 792 pp.

Brar, H.S. and Khehra, A.S. (1977). Effect of the rate and time of applying nitrogen to maize. J. Res. Punjab Agric. Univ., 14: 1-4.

Bunpromma, K. and Mobbayad, B.B. (1978). Effects of plant population density and nitrogen fertilizer application on sorghum-soybean intercrop. Philipp. J. Crop Sci., 3: 221-227.

*Chand, P. (1977). Studies on the effect of intercropping of maize with grain legumes and its impact on nitrogen economy and yield in Kulu Valley. Thesis Abstr., 4: 178.

*Chang, I.C. and Liang, T.Y. (1981). Effect of potassium fertilization in rice and cotton in South East China. Agrokhimiya, 3: 12-17.

Chang, J.F. and Shibles, R.M. (1985a). An analysis of competition between intercropped cowpea and maize. 1. Soil 'N' and 'P' levels and their relationships with dry matter and seed productivity. Field Crops Res., 12: 133-143.

Chang, J.F. and Shibles, R.M. (1985b). An analysis of competition between intercropped cowpea and maize. 11. The effect of fertilization and population density. Field Crops Res., 12: 145-152.

Chatterjee, B.N., Mukherjee, A.K., Bhattacharya, K.K., Mandal, S.R., Rana, S.K. and Mandal, B.K. (1978). Production potentiality of forage cropping systems and their effects on soil and crop productivity in the gangetic plains of Eastern India. Forage Res. 4: 73-80.

Chauhan, G.S. and Dungarwal (1980). Companion cropping of maize with legumes for forage. Madras agric. J., 67: 233-238.

Cordero, A. and McCollum, R.E. (1979). Yield potential of interplanted annual food crops in south eastern US. Agron. J., 71: 834-842.

Dalal, R.C. (1974). Effects of intercropping maize with pigeonpeas on grain yield and nutrient uptake. Expl. Agric., 10: 219-224.

Dalal, R.C. (1977). Effect of intercropping of maize with soybean on grain yield. Trop. Agric., 54: 189-192.

Datta, H.H. and Prakash, R. (1974). Economics of fertilizer. Indian J. Agric. Sci., 44: 572-574.

Davis, J.H.C. and Garcia, S. (1983). Competitive ability and growth habit of indeterminate beans and maize for intercropping. Field Crops Res., 6: 59-75.

Davis, J.H.C. and Garcia, S. (1987). The effects of plant arrangement and density on intercropped beans (Phaseolus vulgaris) and Maize. 1. Traits related to dry matter and seed productivity. Field Crops Res., 16: 105-115.

De, R., Gupta, R.S., Singh, S.P., Pal, M., Singh, S.N., Sharma, R.N. and Kaushik, S.K. (1978). Interplanting maize, sorghum and pearl millet with short duration grain legumes. Indian J. Agric. Sci., 48: 132-137.

*Deshmukh, M.G., Gove, S.B., Mungikar, A.M. and Joshi, R.N. (1974). The yields of leaf protein from various short duration crops. J. Sci. Fd. Agric., 25: 717-724.

Faroda, A.S. (1973). Note on the effect of different levels of nitrogen, phosphorus and potash on fodder production of cowpea (Vigna sinensis). Indian J. Agric. Res., 7: 217-218.

Faroda, A.S. and Tomer, P.S. (1975). Nutrients uptake by fodder varieties of cowpea under phosphatic nitrogenous and bacterial fertilization. Forage Res., 1: 217-218.

Fisher, N.M. (1979). Studies in mixed cropping 111. Further results with maize-bean mixtures. Expl. Agric., 15: 49-58.

*Fox, N.F. (1960). Cowpeas in a cropping system for the coastal Burnett. Queensl. Agric. J., 86: 673-676.

Francis, C.A. (1978). Multiple cropping potentials of beans and maize. Hort. Sci., 13: 12-17.

Francis, C.A., Flor, C.A. and Temple, S.R. (1976). Adapting varieties for intercropping systems in the tropics. In: Multiple Cropping, ASA Special Symposium, Publ. 27. Madison, Wisconsin. pp. 235-253.

*Francis, C.A., Flor, C.A. and Prager, M. (1978). Effect of bean association on yields and yield components of maize. Crop. Sci., 18: 140-142.

Freyman, S. and Venkateswarlu, J. (1977). Intercropping on the rainfed redsoils of the Deccan plateau, India. Can. J. Plant Sci., 57: 697-705.

*Gangro, M. (1978). Effect of increased nitrogen rates and plant density on the grain protein content of maize hybrids. Bisk 5A, Bisk 21-22 and Pan 280 and their lines. Poljoprivercina Znanstvena Smotra 44: 399-417.

Gangwar, B. (1980). Maize-legume partnership-a money earner. Indian Farm Digest, 13 (3 @ 4): 27-29.

Gangwar, B. and Kalra, G.S. (1978). Influence of nitrogen on the root growth of maize grown in association with different legumes under rainfed conditions. Madras agric. J., 65: 505-508.

Garg, D.K. and Kayande, K. (1962). Studies on growth in sorghum as affected by different doses of nitrogen and phosphate and varying row spacing. Madras agric. J., 50: 312.

Garg, K.P., Sharma, A.K. and Thakur, B.S. (1970). Manuring of cowpea 1. Studies on the effect of different rates of phosphorus and molybdenum on the growth and yield of cowpea fodder and residual effect on wheat. Indian J. Agron., 15: 112-116.

Gautam, O.P., Shah, Y.H. and Nair, K.P.M. (1964). Agronomic investigations with hybrid maize. 11. Study of intercropping, row spacing and method of phosphorus application with hybrid maize. Indian J. Agron., 9: 247-254.

Geethakumari, V.L. (1981). Phosphorus nutrition of cowpea (Vigna sinensis (L.) Saviex Hassk). M.Sc.(Ag.) thesis, Kerala Agricultural University.

Gill, A.S., Maurya, R.K., Pandey, R.K., Mukhtar Singh, N.D., Mannikar and Abichandani, C.T. (1972). Effect of different levels of nitrogen, and phosphorus on fodder yield and chemical composition of sorghum and cowpea. Indian J. Agric. Res., 7: 185-190.

*Girenko, A.P. and Livenskii, A.I. (1974). Fertilization for maize-soybean mixture. Kukuruza, 5: 21-22.

*Glogov, L.V. (1969). Nutrient uptake by maize plants at different stand densities. Herb. Abstr., 40: 751.

Groneman, A.F. (1974). Effect of deep placement of nitrogen, phosphorus and potassium fertilizer on dry matter production, nodulation chemical composition and yield of soybean. Dissertation Abstr. International Bull., 34: 4787.

*Guljaev, E.I. and Ronsal, G.A. (1962). The effect of root secretions of annual legumes on intercropped maize. Bot. Z. SSSR., 47: 1152-1159.

*Haizel, K.A. (1974). The agronomic significance of mixed cropping. 1. Maize interplanted with cowpea. Abstr. Trop. Agric., 1: 141.

Hiebsch, C.K. and McCollum, R.E. (1987). Area-x-Time Equivalency Ratio (ATER) - A method of evaluating the productivity of intercrops. Agron. J., 79: 15-22.

Jackson, M.L. (1967). Soil Chemical Analysis Prentice Hall of India Pvt. Ltd. New Delhi. 2nd Ed. 498 pp.

Jaleesa, K. (1987). Response of maize varieties grown in rice fallows to graded levels of nitrogen. M.Sc.(Ag.) thesis, Kerala Agricultural University.

John, H.W. (1979). The effects of some nutrients on grass legume interactions. J. Aust. Inst. Agric. Sci., 45: 126-127.

*Jokinen, R. (1979). The effect of magnesium, potassium and nitrogen fertilizers on the contents and ratio of nutrients in Spring Cereals and Grassland Crops. Ann. Agric. Fenn., 18: 188-202.

Kalra, G.S. and Khokhar, J.S. (1979). Effect of nitrogen and potash on yield and quality of legume plus non legume fodder mixture. Forage Res., 5: 57-62.

*Karim, M., Baksh, A. and Shah, P. (1983). Effect of plant population, nitrogen application and irrigation on yield components of synthetic-66 maize. J. Agric. Res. Pakistan, 21: 57-69.

Kassam, A.H. (1976). Crops of the West African Semi arid tropics. Annual Report Hyderabad. pp. 37-40.

Kawamoto, Y., Masuda, Y. and Goto, J. (1988). Sorghum + Legume mixed cropping - high yields of high quality forage. JARQ, 22: 114-120.

Khan, S.A. and Singh, V. (1976). Note on the performance of maize varieties at different times of sowing. Indian J. Agric. Res., 10: 275-276.

Kharkar, R.T. (1980). Effect of nitrogen and phosphorus application on growth parameters and yield of hybrid maize Ganga-101 under rainfed condition. J. Maharashtra Agric. Univ., 266-267.

Kumar, D., Rana, D.S. and Kapur, M.L. (1983). Economising fertilizer nitrogen through farmyard manure in maize (Zea mays : ¾) in relation to dry matter production and nitrogen utilization. J. Res. Punjab Agric. Univ., 20(3): 293-301.

Kumaraswamy, K., Gopalaswamy, A., Rangaswamy, K. and Murugasabhapathy, P. (1975). Response of hybrid maize (Zea mays L.) to nitrogen, phosphorus and potassium fertilization. Madras agric. J., 62: 299-304.

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

Lincy Xavier (1986). Response of maize varieties to graded levels of nitrogen grown under open and partial shade condition. M.Sc.(Ag.) thesis, Kerala Agricultural University.

Maloth, S. and Prasad, R. (1976). Relative efficiency of rock phosphate and superphosphate for cowpea (Vigna sinensis) fodder. Pl. Soil, 45: 295-300.

Mannikar, N.D. and Subbiah, B.V. (1972). Root activity and uptake of subsoil phosphorus by maize (Zea mays L.) and berseem (Trifolium alexandrinum Juslen) as influenced by phosphorus levels in surface layer using p32 as a tracer. Indian J. Agric. Sci., 42: 592-595.

Mead, R. and Willey, R.W. (1980). The concept of a Land Equivalent Ratio and advantages in yields from intercropping. Expl. Agric., 16: 217-228.

Meenakshi, K., Fazlullabkhan, A.K. and Appaduri, R. (1975). Effect of population densities and fertilizers on the yield of hybrid and composite maize. Madras agric. J., 62(5): 259-264.

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

Mercy George (1981). Fodder production potential of Maize-Legume mixtures in coconut gardens. M.Sc.(Ag.) thesis, Kerala Agricultural University.

Mercy George and Mohamed Kunju, U. (1983). Fodder production potential of different maize - legume mixtures under graded levels of nutrition. Agric. Res. J. Kerala, 21: 55-56.

Mercy George and Kunju, U.M. (1984). Effect of different maize - legume mixtures on the quality of forage under graded levels of nutrition. Agric. Res. J. Kerala, 22: 83-86.

Mittal, S.P., Grewal, S.S., Agnihotri, Y. and Singh, P. (1985). Economics of intercropping legumes in maize under rainfed condition. Int. J. Trop. Agric. 3: 187-191.

Morachan, Y.B., Palaniappan, S.P., Theetharappan, T.S. and Kamalam, N. (1977). A note on the studies on intercropping in sorghum with pulses. Madras agric. J., 64: 607-608.

*Morgado, L.B. (1986). Fertilizer levels for intercropping effects of nitrogen on maize in sole cropping and intercropped with cowpeas under soil water deficit. Pesquisa Agropecuaria Brasileria, 21: 375-382.

Mudd, A.J. (1976). The influence of heavily fertilized grass on mineral metabolism of dairy cows. J. Agric. Sci. Camb., 74: 11-12.

Natarajan, M. and Willey, R.W. (1980). Sorghum/pigeonpea intercropping and the effects of plant population. 1. Growth and yield. J. Agric. Sci. Camb., 95: 51-58.

Nihal Singh and Khatri, P.B. (1972). Effect of phosphate fertilization of legumes on soil fertility. Indian J. Agron., 17: 49-53.

Nuttal, W.F. (1980). Effect of nitrogen and phosphorus fertilizers on a brome grass and alfalfa mixture grown under two systems of pasture management. 11. Nitrogen and phosphorus uptake and concentration in herbage. Agron. J., 72: 295-299.

Ofori, F. and Stern, W.R. (1986). Maize/cowpea intercrop system. Effect of nitrogen fertilizer on productivity and efficiency. Field Crops Res., 14: 241-261.

Ofori, F. and Stem, W.R. (1987a). Relative sowing time and density of component crops in a maize/cowpea intercrop system. Expl. Agric., 23: 41-52.

Ofori, F. and Stern, W.R. (1987b). The combined effects of nitrogen fertilizer and density of the legume component on production efficiency in a maize/cowpea intercrop system. Field Crops Res., 16: 43-52.

Olsen, F.J. (1974). Effects of fertilization and cutting management on yield and botanical composition of permanent pasture. E. Afr. Agric. For. J., 39: 391-397.

Osiru, D.S.O. and Willey, R.W. (1972). Studies on mixtures of dwarf sorghum and beans (Phasedus vulgaris). J. Agri. Sci. Camb., 79: 531-540.

Palaniappan, S.P. (1985). Cropping systems in the tropics - Principles and Management. Wiley Eastern Ltd.

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

*Permeti, M. (1969). The increase of protein in green bulk of summer crops, maize and sorghum through their mixture with bean plants. Herb. Abstr., 41: 166.

Pushpangadan, K. and George, C.N. (1975). Effect of date of sowing and nitrogen fertilization with micronutrients on the yield and quality of hybrid maize - Decan makka. Agric. Res. J. Kerala, 13: 80-84.

Rajesh Chandran (1987). Effect of different levels and yield of vegetable cowpea var. Kurutholapayar (Vigna unguiculata (L.) Walp.) grown as an intercrop in coconut gardens and in the open. M.Sc.(Ag.) thesis, Kerala Agricultural University.

Ram, D., Tomer, P.S. and Tripathi, H.P. (1970). Effect of number of cuttings and levels of phosphorus and nitrogen on summer cowpea forage. Soils Fert., 35: 2616.

Rathore, D.N., Singh, K. and Singh, B.P. (1976). Effect of nitrogen and plant population on the yield attributes of maize. Indian J. Agric. Res., 10: 79-82.

Relwani, L.L. and Kumar, A. (1971). Growing maize for fodder. Indian Dairyman, 23(6): 122-125.

Remison, S.V. (1980). Interaction between maize and cowpea at various frequencies. J. Agric. Sci., 94: 617-622.

Santos, G.L. and Olsen, T.J. (1977). Response of hybrid and open pollinated maize cultivars to nitrogen fertilizer in Southern Brazil. Trop. Agric., 54: 107-111.

Sasidhar, V.K. and Sadanandan, N. (1972). Note on the performance of hybrid maize varying plant population and different levels of nitrogen in redloam soils of Kerala. Agric. Res. J. Kerala, 10: 46-48.

Satyanarayana, T., Badanur, V.P. and Havangi, G.V. (1978). Response of maize to nitrogen, phosphorus and potassium on acid sandy loam soils of Bangalore. Indian J. Agron., 23: 49-51.

Savithri, K.E. (1980). Nutritional requirement of green gram (Vigna radiata (L.) Wilczek). M.Sc.(Ag.) thesis, Kerala Agricultural University.

Searle, P.G.E., Comudom, Y., Shedden, D.C. and Nance, R.A. (1981). Effect of maize + legume intercropping systems and fertilizer nitrogen on crop yields and residual nitrogen. Field Crops Res., 4: 133-145.

Shanmugasundaram, V.S., Arunachalam, N., Srinivasan, T.R., Sankaran, N. and Morachan, Y.B. (1974). Response of hybrid maize (Ganga-5) for nitrogen fertilization. Madras agric. J., 61: 738-740.

Sharma, R.K. (1973). Yield potentialities of maize - hybrids and composites. Madras agric. J., 60: 1307-1309.

Sharma, S.C. and Singh, H.G. (1972). Effect of methods of intercropping maize with cowpea on the production of animal feed. Indian J. Agric. Sci., 42: 904-908.

Short, K.E., Islam, M.S., Pahlwan, A.A. and Roy, S.K. (1982). Yield responses of maize to different rates of nitrogen and sulphur during the kharif season in Bangladesh. Bangladesh J. Agric., 7: 40-47.

Simpson, J.E., Adair, C.R., Kohler, G.O., Dawson, B.H., Debald, H.A., Kaester, E.B. and Klick, J.T. (1965). Quality evaluation studies of foreign and domestic races. Tech. Bull. 1331. Service USDA, 1-180.

Singh, S.P. (1979). Intercropping studies in sorghum. Proc. of the International Workshop on Intercropping ICRISAT, 10-13. January 1979: 22-24.

Singh, N.P. (1980). Sheep nutrition-some suggestions. Indian Fmg., 30(9): 27-29.

Singh, C.M. and Chand, P. (1979). Nitrogen accumulation in maize intercropped with grain legume under varying levels of nitrogen. Food Fmg. Agric., 10: 314-316.

Singh, C.M. and Chand, P. (1980). Note of economics of grain legume intercropping and nitrogen fertilization in maize. Indian J. Agric. Res., 14: 59-64.

Singh, C.M. and Guleria, W.S. (1979). Effect of intercropping and fertility levels on growth, development and yield of maize (Zea mays L.). Food Fmg. Agric., 10: 242-245.

Singh, D. and Ghosh, A.B. (1984). Effect of graded doses of potassium on dry matter yield and potassium uptake by maize, cowpea and wheat. Indian J. Agron., 29: 246-248.

Singh, D. and Relwani, L.L. (1978). Mixed cropping of maize (Zea mays) with cowpea (Vigna sinensis) and velvet bean (Stizolobium deeringianum) on the yield and chemical composition of fodder. Indian J. Dairy Sci., 31: 28-33.

Singh, N.B. and Singh, P.P. (1984). Effect of intercropping legumes on grain yield of maize and its residual effect on succeeding wheat. Indian J. Agron., 29: 295-298.

Singh, R.M. and Jain, T.C. (1966). Effect of phosphate and molybdate on the growth characters of Russian Giant Cowpea (Vigna sinensis). Allahabad Farmer, 46: 29-32.

Singh, T.P., Akhter, S.A., Prasad, S.K. and Jha, N.D. (1982). Note on the adaptability of some Yugoslav maize varieties. Indian J. Agric. Sci., 52: 339-340.

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

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. Oxford and IBH Publishing Co., Calcutta, 16, 6th Ed.

*Spitters, C.J.T. (1980). Concurrentie tussen cenjarige Soorten 31e Heterosis-Cursus 1980/81. Wageningen, pp. $F_1$-$F_{10}$.

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

Subramonian, P.S., Kolandaiswamy, S. and Subramonian, S. (1982). Effect of seasonal and nitrogen fertilization on uptake of nutrients in maize var. Ganga-5. Madras agric. J., 69: 690-692.

*Syarifuddin, A., Effendy, S., Ismail, I.G. and Melntosh, J.I. (1974). Performance of corn, peanuts, mungbean and soybean in monoculture and intercrop combinations of corn and legumes in dry season. Contributions Central Research Institute for Agriculture (Indonesia) No. 12.

Tarhalkar, P.P. and Rao, N.G.P. (1981). Genotype plant density considerations in the development of an efficient intercropping system for sorghum. In International Workshop on intercropping, 10-13 January 1979. ICRISAT, Hyderabad, pp. 35-40.

Tariah, N.M. and Wahua, T.A.T. (1985). Effects of component populations on yields and Land Equivalent Ratios of intercropped maize and cowpea. Field Crops Res., 12: 81-89.

Tarilla, A.G.I., Ormrod, D.P. and Adetiloye, N.O. (1977). Effects of phosphorus nutrition and light intensity on growth and development of cowpea (Vigna unguiculata L. Ann. Bot., 41: 75-83.

Thomas, D. (1975). Grass-legume establishment under maize - New technique for the tropics. SPAN, 18: 80-82.

Tisdale, S.L., Nelson, W.L. and Beaton, J.D. (1985). Soil Fertility and Fertilizers. Macmillan Inc. New York, 4th Ed. 732 pp.

Tiwana, M.S., Puri, K.P. and Gill, G.S. (1978). Assessment of production potential of forage crops in monocultures and mixtures. J. Res., 15: 58-60.

Trenbath, B.R. (1976). Plant interactions in mixed crop communities. Pages 129-170 in Multiple Cropping, eds. R.I. Papendick, P.A. Sanchoz and G.B. Triplett. Wisconsin, USA, American Society of Agronomy.

Tripathi, H.P. (1971). Quality of summer maize (Zea mays L.) in relation to nitrogen levels, plant population and irrigation regimes. Madras agric. J., 58: 551-554.

*Tripathi, H.P. (1979). Effect of leguminous and non leguminous forage crops fertilized with different levels of phosphorus on nitrogen requirement of succeeding wheat crop. Thesis Abstr., 5: 76.

Tripathi, Singh, R.A. and Gill, A.S. (1984). Evaluation of cowpea varieties for forage and seed yields under different row spacings and levels of phosphate. Agricultural Science Digest, India, 4(2): 102-104.

Uddin, S. and Irabagen, J.A. (1986). Production efficiency of corn-legume intercrop as influenced by crop combinations and planting arrangements. Philipp. J. Crop Sci., 11: 51-S57.

Umrani, N.K., Shinde, S.H. and Dhonde, P.M. (1984). Studies on intercropping of pulses in Kharif sorghum. Indian J. Agron., 29: 27-30.

Venkateswarlu, J., Sanghi, N.K., Bhaskara Rao, U.M. and Hanumanta Rao, Ch. (1981). Maximising production in a sorghum/pigeonpea intercropping system in the semi arid tropics. In: International Workshop on Intercropping, 10-13 January 1979, ICRISAT Hyderabad, pp. 30-34.

Virmani, S.N., Dhaliwal, A.S. and Randhava, N.S. (1970). Effect of nitrogen on the uptake and utilization of soil and fertilizer phosphorus. J. Res. Punjab Agric. Univ., 7: 308-311.

Viswanath, D.P. (1975). Effect of repeated application of heavy doses of fertilizers on physical and chemical properties of soils and uptake of nutrients by hybrid maize. Mysore J. Agric. Sci., 9: 713-714.

Waghmare, A.B. and Singh, S.P. (1984). Sorghum-legume intercropping and effects of nitrogen fertilization. 1. Yield and nitrogen uptake by crops. Expl. Agric., 20: 251-259.

Wahua, T.A.T. (1983). Nutrient uptake by intercropped maize and cowpeas and a concept of nutrient supplementation index (NSI). Expl. Agric., 19: 263-275.

Wahua, T.A.T. and Miller, D.A. (1978). Relative yield total and yield comparison of intercropped sorghum and soybeans. Agron. J., 70: 287-291.

Wetselaar, R., Akobsen, J.J. and Chaplin, G.R. (1973). Nitrogen balance in crop systems in tropical Australia soil. Biochem., 5: 35-40.

Willey, R.W. (1979). Intercropping - its importance and its research needs. 1. Competition and yield advantages. Field Crop Abstr., 32: 1-10.

Willey, R.W. and Osiru, D.S.O. (1972). Studies of mixtures of maize and beans (Phaseolus vulgaris) with particular reference to plant population. J. Agric. Sci. Camb., 79: 517-529.

* Originals not seen

# APPENDICES

Appendix I

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

| Period | Rainfall (mm) | | Temperature °C | | | | Relative humidity | | Number of rainy days | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1988 | Variation | Maximum | | Minimum | | 1988 | Variation | 1988 | Variatio |
| | | | 1988 | Variation | 1988 | Variation | | | | |
| March 18-24 | 7.84 | +4.21 | 33.64 | +0.29 | 25.65 | -0.13 | 75.00 | -5.22 | 2 | +1 |
| 25-31 | - | -2.24 | 33.24 | -0.48 | 25.34 | -0.62 | 73.36 | -4.26 | - | -1 |
| 1-April 7 | - | -1.86 | 33.08 | -0.82 | 25.45 | -0.92 | 74.07 | -4.39 | - | -1 |
| 8-14 | 3.34 | +1.20 | 32.58 | -1.22 | 24.90 | -0.86 | 80.79 | +3.45 | 1 | - |
| 15-21 | 1.21 | -3.22 | 32.51 | -1.02 | 24.50 | -0.48 | 80.50 | +2.89 | 1 | - |
| 22-28 | 4.09 | +2.41 | 33.08 | +1.22 | 24.30 | -1.42 | 79.70 | -4.12 | 1 | - |
| 29-May 5 | 5.07 | +1.42 | 32.86 | +0.92 | 24.97 | -0.86 | 77.43 | -4.32 | 2 | +1 |
| 6-12 | 1.44 | +1.12 | 33.02 | +0.56 | 25.89 | +0.22 | 74.93 | -0.61 | 1 | - |
| 13-19 | 0.26 | -0.24 | 33.01 | +0.64 | 26.09 | -0.42 | 77.43 | +5.24 | 1 | - |
| 20-26 | 0.86 | +0.21 | 32.60 | +0.12 | 25.40 | +0.12 | 79.92 | +1.41 | 1 | - |
| 27-June 2 | 4.74 | +0.89 | 31.56 | +0.72 | 24.18 | +0.24 | 86.12 | +5.21 | 2 | +1 |
| 3-9 | 19.18 | -21.06 | 28.60 | -2.42 | 24.17 | +1.12 | 80.36 | -8.23 | 2 | -2 |
| 10-16 | 8.79 | -18.40 | 30.60 | -2.24 | 23.63 | +1.24 | 77.00 | -7.02 | 2 | -3 |
| 17-23 | 2.57 | -20.50 | 30.58 | -1.20 | 24.50 | +0.81 | 72.79 | -4.52 | 1 | -3 |

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

Appendix II

Abstract of analyses of variance of data on height and number of leaves of maize

| Source | df | Mean squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant height | | | | Number of leaves (Transformed) | | | |
| | | 20 DAS | 40 DAS | 60 DAS | Harvest | 20 DAS | 40 DAS | 60 DAS | Harvest |
| Block | 2 | 312.90** | 1052.00** | 588.38** | 1509.75** | 0.0524** | 0.010 | 0.0420** | 0.0450** |
| Crop arrange-ments(s) | 5 | 57.10** | 39.95 | 121.95** | 261.15** | 0.0310** | 0.069** | 0.0610** | 0.0600** |
| Error(a) | 10 | 8.53 | 15.40 | 21.35 | 13.10 | 0.0017 | 0.003 | 0.0030 | 0.0026 |
| Fertility levels(F) | 2 | 590.80** | 1467.13** | 1634.88** | 4157.75** | 0.0420** | 0.263 | 0.2040** | 0.2100** |
| S x F | 10 | 9.80 | 26.33 | 49.68 | 76.05* | 0.0084** | 0.003 | 0.0046 | 0.0057 |
| Error(b) | 24 | 8.00 | 11.72 | 49.10 | 25.99 | 0.0014 | - | 0.0044 | 0.0042 |

## Appendix III

Abstract of analyses of variance of data on height, number of leaves of cowpea at different stages of growth , fodder yield & leaf/stem ratio of cowpea at the time of harvest

| Source | df | Mean squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Height | | | Number of leaves (Transformed) | | | Fodder yield | Leaf/stem ratio |
| | | 15 DAS | 30 DAS | Harvest | 15 DAS | 30 DAS | Harvest | | |
| Block | 2 | 6.805* | 43.22* | 28.94* | 0.1340** | 0.1890** | 0.0474* | 2.27 | 0.037 |
| Crop arrangements (s) | 4 | 9.607* | 15.68 | 38.31* | 0.0107 | 0.0064 | 0.0310 | 247.87** | 0.011 |
| Error(a) | 8 | 1.408 | 5.11 | 6.36 | 0.0080 | 0.0044 | 0.0075 | 3.24 | 0.034 |
| Fertility level(F) | 2 | 105.080** | 307.91 | 395.59** | 0.6710** | 0.0990** | 0.1650* | 8.54** | 0.063 |
| S x F | 8 | 2.500 | 9.54 | 20.59 | 0.0071 | 0.0051 | 0.0082 | 2.28 | 0.003 |
| Error(b) | 20 | 1.300 | 7.26 | 16.93 | 0.0125 | 0.0058 | 0.0067 | 1.08 | 0.030 |

## Appendix IV

Abstract of analyses of variance of data on 50% silking, leaf/stem ratio, number of cobs per plant, length of cob, girth of cob, number of grains per cob, 1000 grain weight, dry weight of grains/cob and Harvest Index of maize

| Source | df | Mean squares | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Days to 50% silking (transformed) | Leaf/stem ratio | Number of cobs/plant | Length of cob | Girth of cob | Number of grains/cob | 1000 grain weight | Dry weight of grains/cob | Harvest Index |
| Block | 2 | 0.151 | 0.00039 | 0.0018 | 0.24 | 2.02 | 6913.50$^{**}$ | 77.38 | 11.11 | 0.00005 |
| Crop arrangements (s) | 5 | 0.072 | 0.06400$^{**}$ | 0.0068$^{*}$ | 6.40$^{**}$ | 1.89 | 11520.40$^{**}$ | 164.90 | 1461.38$^{**}$ | 0.00016$^{*}$ |
| Error (a) | 10 | 0.130 | 0.00120 | 0.0013 | 0.53 | 0.76 | 946.50 | 214.75 | 58.23 | 0.00004 |
| Fertility levels (F) | 2 | 0.041 | 0.00075 | 0.0032$^{*}$ | 9.20$^{**}$ | 5.31$^{**}$ | 150679.00$^{**}$ | 3724.00$^{**}$ | 10797.84$^{**}$ | 0.00310$^{**}$ |
| S x F | 10 | 0.170 | 0.00390$^{**}$ | 0.0012 | 0.79 | 0.57 | 1279.80 | 183.69 | 99.48 | 0.00004 |
| Error (b) | 24 | 0.097 | 0.00090 | 0.0008 | 0.76 | 0.672 | 3310.89 | 132.29 | 133.45 | 0.00008 |

## Appendix V

Abstract of analysis of variance of data on stover yield, grain yield, N, P and K content of plant and grain, N, P and K uptake and protein content of grain of maize

| rce | df | Mean squares | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stover yield | Grain yield | N, P and K content in plant | | | N, P and K content in grain | | | Uptake of N, P and K | | | Protein content of grain |
| | | | | N | P | K | N | P | K | N | P | K | |
| ock | 2 | 0.110 | 0.0930** | 0.0200* | 0.00003 | 0.0041* | 0.0082 | 0.0009* | 0.0015 | 193.30 | 9.11 | 71.80* | 0.32 |
| op range- nts(s) | 5 | 0.300** | 0.0190** | 0.0740** | 0.02000** | 0.0051** | 0.0490 | 0.0061** | 0.0200* | 633.10** | 298.32* | 381.50** | 1.91 |
| ror(a) | 10 | 0.033 | 0.0002 | 0.0040 | 0.00030 | 0.0007 | 0.0184 | 0.0002 | 0.0051 | 71.80 | 3.21 | 11.10 | 0.72 |
| rtility vels(F) | 2 | 5.090** | 6.8900** | 0.8600** | 0.06400** | 0.1300** | 1.1400** | 0.0230** | 0.0390** | 35818.80** | 1850.4** | 7057.10** | 44.53** |
| x F | 10 | 0.034 | 0.0024 | 0.0220** | 0.00045 | 0.0022** | 0.0610** | 0.0010** | 0.0082 | 344.75* | 9.98* | 66.04 | 2.38** |
| ror(b) | 24 | 0.081 | 0.0044 | 0.0074 | 0.00042 | 0.0006 | 0.0183 | 0.0002 | 0.0056 | 130.19 | 3.27 | 38.00 | 0.71 |

Appendix VI

Abstract of analysis of variance of data on N, P and K content, N, P and K uptake and protein content of cowpea

| Source | df | Mean squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | N, P and K content | | | N, P and K uptake | | | Crude protein |
| | | N | P | K | N | P | K | |
| Block | 2 | 0.018 | 0.0023* | 0.070 | 465.00 | 9.30 | 262.84 | 0.69 |
| Crop arrangements(s) | 4 | 0.049* | 0.0032** | 1.070** | 10516.57** | 318.10** | 2231.63** | 1.94* |
| Error(a) | 8 | 0.012 | 0.0004 | 0.041 | 189.35 | 8.57 | 197.07 | 0.50 |
| Fertility levels(F) | 2 | 1.750** | 0.0570* | 0.654** | 3316.81** | 110.10** | 1143.34** | 68.38** |
| S x F | 8 | 0.020 | 0.0011 | 0.077 | 215.50 | 4.22 | 149.05 | 0.81 |
| Error(b) | 20 | 0.018 | 0.0005 | 0.025 | 114.82 | 2.58 | 59.52 | 0.69 |

Appendix VII

Abstract of analysis of variance of data on available N, P and K in the soil and net returns from maize-cowpea intercropping system

| Source | df | Mean squares | | | |
|---|---|---|---|---|---|
| | | N | P | K | Net returns |
| Block | 2 | 5425.00 | 0.3200 | 168.50* | 1211648.00 |
| Crop arrangements(s) | 6 | 5673.83** | 3.7400** | 18981.00* | 2618637.00 |
| Error(a) | 12 | 896.50 | 0.7400 | 43.00 | 706389.30 |
| Fertility levels(F) | 2 | 971.50** | 67.9900** | 11713.00** | 2186816.00** |
| S x F | 12 | 373.00 | 1.4949* | 247.46** | 561024.00 |
| Error(b) | 28 | 348.28 | 0.6680 | 23.04 | 333138.30 |

Appendix VIII

Abstract of analysis of variance table for LER, LEC, ATER, Monetary Advantage & IER

| Source | df | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | LER | LEC | ATER | MA | IER |
| Block | 2 | 0.0230 | 0.0197 | 0.0110 | 2423072 | 0.0116 |
| Crop arrangements (S) | 3 | 0.1300** | 0.1200** | 0.0410** | 1241600** | 0.1475** |
| Error (a) | 6 | 0.0110 | 0.0110 | 0.0034 | 1191605 | 0.0082 |
| Fertility levels (F) | 2 | 0.0110 | 0.0113* | 0.0064* | 1037984 | 0.0104 |
| S x F | 6 | 0.0051 | 0.0038 | 0.0047 | 446197.4 | 0.0042 |
| Error (b) | 16 | 0.0043 | 0.0028 | 0.0017 | 311412.0 | 0.0033 |

ABSTRACT

An investigation was carried out during the summer season of 1987-'88 in the Instructional Farm attached to the College of Agriculture, Vellayani to determine the best crop arrangement for a grain maize + fodder cowpea intercropping in summer rice fallows under different fertility levels. The different crop arrangements tried were pure crop of maize at normal row arrangement, maize at normal row arrangement + one row of cowpea in between the maize rows, maize at normal row arrangement + two rows of cowpea in between the maize, pure crop of maize at paired row arrangement, maize at paired row arrangement + two rows of cowpea in the interpair spaces, maize at paired row arrangement + three rows of cowpea in the interpair spaces and pure crop of cowpea. The fertilizer levels tried were 100, 75 and 50 per cent of the recommended levels of nutrients of maize, cowpea and maize + cowpea, depending on crop arrangement and the area occupied by each crop. The experiment was laid out in split plot design with three replications. The crop arrangements were allotted to main plots and the fertility levels to the subplots.

Plant height and number of leaves per plant of maize were maximum in the crop arrangement where maize at normal rows alternated with one row of cowpea. In cowpea the plant

height was maximum in the pure crop arrangement.

The fodder yield of cowpea was affected by different crop arrangements and pure crop of cowpea was the best yielder. The number of cobs per maize plant, length of cob, number of grains per cob, dry weight of grain per cob, harvest index 1000 grain weight and grain and stover yield of maize were affected by different crop arrangements. Pure crop of maize at normal row arrangement performed best for these characters. Among the different intercropping arrangements maize at normal rows alternated with one row of cowpea was found to be the best for these characters.

The crop arrangements also influenced the nitrogen, phosphorus, and potassium content of both maize and cowpea, protein content of maize grain and cowpea fodder and uptake of nitrogen, phosphorus and potassium by both maize and cowpea.

The various indices like land equivalent ratio, land equivalent coefficient, area x time equivalency ratio, monetary advantage based on LER, income equivalent ratio and net profit were found to be superior in the crop arrangement where maize at normal rows alternated with two rows of cowpea.

The plant height and number of leaves of both maize and cowpea were affected by different fertility levels. Full recommended dose was found to be the best.

The fodder yield of cowpea, number of cobs/plant of maize, length of cob, girth of cob, number of grains per cob, 1000 grain weight, dry weight of grains per cob, harvest index, grain yield and stover yield of maize were affected by fertilizer levels and 100 per cent of recommended level recorded the highest value for all these characters.

The nitrogen, phosphorus and potassium content and their uptake by both maize and cowpea, protein percentage of maize grain and cowpea fodder and available nitrogen, phosphorus and potassium content in the soil after the experiment were influenced by nutrient levels and full recommended dose was found to be the best in all the above cases.

Land equivalent coefficient and area x time equivalency ratio were maximum in the 75 per cent level of the combined fertilizer recommendation of both crops. For net returns 100 per cent level was found to be the best.

From a detailed analysis it is seen that maize at normal row arrangement alternated with one row of cowpea under full recommended level of nutrients and maize at normal row arrangement alternated with two rows of cowpea under 75 per cent of the recommended level of nutrients, are the best in providing higher profit to the farmer.