RICE BASED CROPPING SYSTEM ANALYSIS IN KERALA

By

M. R. CHIDANANDA PILLAI

THESIS

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1993

DECLARATION

I hereby declare that this thesis entitled "RICE BASED CROPPING SYSTEM ANALYSIS IN KERALA", is a bonafide record of esearch work done by me during the course of research and that the thesis has not previously formed e basis for the award to me of any degree, diplc, associateship, fellowship or other similar ti f any other university or society.

Vellayani,
5-11-1993.

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Vellayani,
15-11-1993.

M. R. CHIDANANDA PILLAI

CERTIFICATE

Certified that this thesis entitled "RICE BASED CROPPING SYSTEM ANALYSIS IN KERALA", is a record of research work done independently by Sri. M. R. Chidananda Pillai under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Vellayani.

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ABREVIATIONS USED IN THIS THESIS

AICARP - All India Co-ordinated Agronomic Research Project

AICRIP - All India Co-ordinated rice improvement Project

FAO - Food and Agriculture organisation

FYM - Farm yard manure

IARI - Indian Agricultural Research Institute

K - Potassium

KAU - Kerala Agricultural University

M - Meter

N - Nitrogen

P - Phosphorus

Ha - Hectare

kg - Kilogram

RARS - Regional Agricultural Research Station

TNAU - Tamil Nadu Agricultural University

INTRODUCTION

1. INTRODUCTION

In Kerala, rice is traditionally grown in the low lands where drainage is very poor during rainy seasons and where no crop other than rice is possible. Rice is also cultivated in command areas where adequate monsoon and irrigation is available both in first and second crop seasons. In summer season where irrigation facilities are available a third crop of rice also is raised to a small extent. Majority of the rice cultivated area in Kerala is left fallow during the summer months. However, in some areas where there is adequate residual moisture or where there is availability of irrigation to a small extent different summer crops are grown.

Different summer crops in the rice fallows exert their effects on the succeeding rice crops differently. Growing of rice during summer amounts to monoculture of rice resulting in the depletion of the same nutrient elements from the same feeding zone. This also leads to the poor soil structure due to continuous submergence resulting in yield decline of the rice crop. On the contrary growing different dry land crops helps in maintaining soil productivity. The leguminous crops will fix atmospheric nitrogen and also extract phosphorus and potassium from the deeper layers of the soil and will be made available to the succeeding rice crops. The organic matter status of the soil is also likely to be improved due to availability of crop residues. The FYM applied to the summer crops also impart residual effect to the succeeding crop.

The rice based cropping systems practiced in different parts of Kerala at present are varying. Sesamum-rice-rice is being practiced since long back as a rainfed system in sandy coastal region. In the single crop rice fields of north Kerala, rice-blackgram-vegetable system is of recent origin. In the coastal tract of Kasaragod district various rice based cropping system such as rice-sweet potato-vegetables, rice-rice-vegetables, rice-rice-tobaco are being practiced. In the southern districts of the state adjoining to suburban areas, rice-rice-vegetables is the common cropping system followed. A two year cropping system of rice-nendran banana-cassava is in vogue in Trichur district. In Malappuram district a system of rice and nendran banana relay cropping is followed (Pillai, 1979). Another system practiced in Malappuram district is rice-nendran banana-cassava+rice (Gopalakrishnan, 1983). In the eastern and middle regions of Palghat district, rice-rice-green manure (dhaincha) and rice-rice-green manure (kolinji) + sesamum are being followed. In parts of Quilon district the cropping systems are rice-rice-cassava and rice-rice-colocasia. In Trivandrum district rice-rice-cowpea, rice-rice-sweet potato and rice-rice-vegetables are common.

Thus it is seen that different summer crops are grown indiscriminately in different parts of the state without considering the impact of the summer crop, on the succeeding rice crops. Some crops exhaust the soil fertility while some are soil enrichers and still some others are labour intensive. Monoculture of rice result in poor physical condition of the soil.

The period available for the summer crop also varies from place to place depending on source of irrigation and discipline of cropping system in the locality. In the above situations the farmer is in a confusion as to which summer crop is to be grown for meeting his requirements without affecting the productivity of the soil in the long run. Hence the farmer has to be given a cafeteria of crops for the summer season based on which he can choose the crop. In view of the existing diversity it has become necessary to standardise the crop sequences in the rice based cropping system. Different crops such as short duration casssava, cowpea, groundnut bhendi and rice have been selected as summer crops in the present study.

Short duration cassava was selected as a summer crop for areas having a long summer fallow at least for a period of five months with limited irrigation resources. Growing of this crop helps exposure of the soil to the weather conditions. The crop harvested in the off season will have a great demand in the market and will fetch more income.

Cowpea is a short duration crop which can be successfully raised in areas with residual soil moisture after the harvest of the second crop of rice, especially in command areas of irrigation projects. The bhusa of the crop can serve as a palatable fodder during summer months when fodder production is scarce. Off late groundnut also has attracted farmers as a cash crop due to the high monetory returns, the bhusa of which also provides fodder for the cattle during summer. The above cultivation also contribute to N enrichment.

Bhendi is an important vegetable crop fetching very high returns. It also provides employment for the family labour during the lean agricultural season.

When more than one crop is grown on a system basis, application of fertilizer is to be resorted to the system rather than for crops individually. Swaminathan (1981) emphasized the need for application of nutrients to the cropping system as a whole for increasing the fertilizer use efficiency and economising the use of costly mineral fertilizers. The residual effect of fertilizers applied to the previous crop also must be assessed while developing a fertilizer schedule for the system (Biswas et al, 1987).

Since the adoption of cropping system by the farmers is greatly influenced by various factors it is very important to give a basket of multiple choices in cropping system to suit the needs of the individual farmers. However, it should be ensured that the cropping systems are biologically productive, economically profitable, and environmentally sustainable (Hegde, 1992a)

With the above objectives in view, an investigation on rice based cropping system incorporating crops which are extensively grown in summer rice fallows was laid out at the RARS, Pattambi with the following objectives:

1. To assess the residual effects of nutrients added to the summer crops on succeeding rice crops in effecting fertilizer economy

2. to identify the system which result in maximum production efficiency

3. to find out the maximum energy generating cropping system

4. to evaluate the best economic crop combination for the double crop wet rice fields of Kerala.

5. to study the impact of rice based cropping system on soil fertility conditions.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

A salient review of work done on rice based cropping systems with special reference to major nutrient requirements of cropping system as a whole and of individual crops and economics of different cropping systems, are reviewed below.

2.1. Rice based cropping systems

Long term experiments have revealed that soil is exhausted by continuous cropping and as such yield declines. (Nambiar and Ghosh (1984). To over come this, suitable cropping systems are to be identified for better yield and thereby better economy for the farmers.

Sadanandan and Mahapatra (1972a) observed that maximum net profit per hectare was obtained from crop sequence potato-rice-rice at Central Rice Research Station, Cuttack. Mishra et al. 1973 found from the economic point of view that the pattern rice-rice-green gram was best, followed by chillies for the irrigated lands of Orissa. Out of the different cropping systems tried rice-rice-cassava (H-165) and rice-rice-bhendi gave the highest yield in kerala (Anonymous, 1978). Purushothaman (1979) reported that rice-rice-green gram was best suited for Coimbatore region.

Sasidhar and Sadanandan (1980) recorded that from the five rice based cropping sequences studied the rice-rice-cowpea gave highest yield of rice than other cropping patterns. Vedaprakash et al. (1982) reported that highest average annual net return and benefit cost ratios were recorded using rice-chick pea rotation, followed by rice-lentil, rice-field pea and rice-wheat sequences.

Verma (1987) found that rotational cropping of rice-wheat and cowpea is good for maintaining fertility status of soil. Mahapatra et al. (1987) recorded that highest yield was obtained with rice-potato, and was the most efficient sequence. Single crop of rice in double crop rice field was the most inefficient one. Highest net profit was obtained with Rice-potato in Orissa. Gangawar (1987) reported that pulses, oilseeds and cereals performed well in residual soil moisture during rice fallows. This indicates that intensive cropping is feasible in Andamans and cropping intensity could be increased by 200 to 300 per cent. Of the crop sequences studied Rice-black gram, rice-sorghum and rice-rice green gram gave highest yields respectively.

Karwara et al. (1987) observed that a two year rotation of rice-wheat ~~sequence~~ - potato-black gram gave the highest rice equivalent grain yield. Rice-linseed-black gram gave the lowest. They have also opined that the best one year crop rotation was rice-tapioca/wheat-black gram. The rice-linseed-maize (fodder) gave the highest net return equal to rice-wheat, and rice-wheat-black gram.

Patel (1987) recorded that rice crop (Jaya) transplanted in July after the cowpea and fertilized with 100:50:50) kg NPK ha^{-1}yielded 4 t ha^{-1}. Sahu et al. (1988) reported that Rice-pea nut and rice-black gram had the highest total grain yields closely followed by rice-wheat. Selvaraj et al. (1988) found that a rice based cropping sequence with sesamum, pearl millet, turmeric and cotton gave the highest net profit with a cost benefit ratio of 1:1.5. The sequence could increase the production in the region by 174 per cent. Biswas et al. (1988) noticed that highest yield of rice was obtained after potato. Rice after mustard and fallow gave identical yields.

Uttaray et al. (1988) reported that rice yield was highest from rice-peanut sequences followed by rice-wheat. Singh and Yadav (1988) reported that rice yield equivalents of rice-wheat and rice-mustard crops were highest with rice-barley next in order.

2.2. Production potential of cropping systems

Break through in Agriculture in our country is characterized by the maximization of production per unit of land per unit of time brought about by multiple cropping and by the introduction of high yielding varieties which utilize higher level of fertilizers than older ones. This new strategy in Agriculture could produce still higher yields from unit land area per unit of time by the adoption of appropriate cropping systems suited to each situation.

Under the AICARP at many experiment stations, the yield of crops in three or four crop rotations amounted to 10 to 15.3 t ha^{-1} per year. The average grain production in these worked out to 40 to 48 kg day^{-1}. (Ramamoorthy et al., 1971). Sadanandan and Mahapatra (1972) reported that the production was doubled in Cuttak by growing potato-rice-rice, instead of the normal practice of growing only two crops in a year and that the net income was Rs. 8755 ha^{-1}.

Experiments conducted at IRRI, Philippines in the seventies with three or four crops in a sequence resulted in a total production ranging from 10 to 12 t ha^{-1} (IRRI, 1972). According to Raghavulu and Sreeramamoorthy (1975), rice-wheat-green gram rotations seemed to be the best under the agro-climatic conditions of Nizamabad district of Andhra Pradesh which produced an yield of 9.5 t ha^{-1} per year. With four crops a year, 15 tonnes of food materials were produced during a period of 342 days, which worked out to 44 kg day^{-1} (Misra and Misra, 1975). Sahu and Patro (1975) reported that on the basis of dry weight recovery in kg ha^{-1}., the treatment rice (Jaya)-potato (Up-to-date)-rice (Jaya) was found to be the best. In trials with five crop rotations on well drained light textured soils in Orissa, potato-rice-rice, groundnut-jute-rice and rice-jute-rice rotations gave the highest net profit and stable yield (Padalia, 1976). At Coimbatore, three crop sequence with IR 8 rice produced 12-13 t ha^{-1} grains (Subbiah, 1976).

Rice-rice system gave the highest productivety with a per day production of 31.5 kg ha^{-1} in Madurai. (Robinson, 1977). Thirunavukkarasu and Goutham (1977) reported that rice-rice-greengram was a highly productive system for Pondicherry region. At Coimbatore, rice-rice-rice system recorded the maximum production of 13.9 t ha^{-1} (Palaniappan et al., 1978). With rice-rice system highest grain production of 16.8 t ha^{-1} was obtained at Manglore (Karnataka), 13.4 t ha^{-1} at Bhavanisagar (Tamilnadu) and 11.9 t ha^{-1} at Bhuvaneswar in Orissa (Anon., 1978). Purushothaman (1979) reported the rice-rice-finger millett greengram gave the highest productivity with the most intensive land use at Coimbatore. While reviewing the results of the Model Agronomic Experiments, Mahapatra *et al*. (1987) reported that crop sequence of rice-wheat-rice for Varanasi and Kalyani centres, rice-finger millet-rice for Maruteru and rice-rice-rice for Bhuvaneswar, Karamana and Manglore centres were the most productive cropping systems.

Inclusion of pulses in the systems considerably increased the production at many locations and inclusion of potato boosted the productivity to a very high level at Masodha in Uttar Pradesh. Finger millet-rice-groundnut at Thanjavur, rice-rice-cowpea/groundnut at Mangalore and greengram/cotton-sunflower at Siruguppa were the most promising cropping systems under South Indian conditions (Pillai *et al*., 1978). Selvaraj *et al*. (1988) obtained the highest economic yield of 25.1 t ha^{-1} in a rice based cropping system involving rice-sesamum-pearl millet-turmeric-cotton in two year sequence at Bhavanisagar.

Kumar and Reddy (1991) obtained highest total grain yield and B/C ratio in rice-maize sequence followed by rice-groundnut sequence. Misra and Vyas (1992) reported that in a groundnut wheat cropping system higher pod yield (1327 kg ha^{-1}) and higer net return (Rs 9617 kg ha^{-1}) were recorded at 20:80:20 NPK (100 per cent of recommended dose).

Significantly higher grain yield of wheat (5950 kg ha^{-1}) were recorded under 75 per cent recorded fertilizer dose with net return of Rs 14028 kg ha^{-1}). The total monetory return of the groundnut-wheat sequence was higher in 75 per cent recommended fertilizer dose applied to both the crops.

From the above, it might be concluded that the cropping systems are highly location specific and many systems are followed in different places within the country. Continuous cropping of rice recorded highest production in many places, while in other places inclusion of pulses or legumes considerably increased the productivity of the system and augmented the soil fertility. The review indicated the research need to evolve rice based cropping system to suit local condition.

2.3. Effect of a crop on succeeding crop in a given cropping system

It has been known for many centuries that crops play a decided influence on the growth and production of crops which follow (Ripley, 1941). The principle involved in the rotation of crops is based on the above observation and is not an idea of modern age, but dates back far into antiquity. However, to Boussingault ~~(1834)~~ goes the honour of having introduced the concept of rotation in Agricultural

Science (Russel, 1973). Various crops when grown on soils leave certain after effects which exert a marked influence on the growth of subsequent crops. In some cases the effect is beneficial and in some other cases it may be injurious.

The beneficial effects of groundnut on the succeeding crops have been reported by many workers. In Malaya, growing rice after groundnut recorded an increased yield of 24 per cent over rice grown after rice (Hartley and Keeping, 1950). According to Seshadri et al. (1954), the groundnut crops is very valuable in many crop rotations for the role it plays in fetching enhanced yields from crops rotated with it. They also reported that there was no benefit derived by groundnut following cereals.

Magne (1960) reported that inclusion of rice in a rotation along with groundnut allowed continuous cropping without soil depletion and brought high returns. Racho and De Datta (1968) reported that application of fertilizers to rice, irrespective of rates of application had no residual value for the succeeding crop. Hence it is clear that rice crop in cropping patterns has no beneficial effect on succeeding crop. Verkoc et al. (1969) obtained highest yield of winter wheat when the preceding crop was pea. Bains and Sadaphal (1971) obtained an increase in returns by 13 to

15 per cent when jowar, bajra or paddy was taken as a kharif crop after the inclusion of an unfertilised legume (cowpea) in the rotation.

According to Sardor (1975) preceding leguminous crop increased the yield of rice by 12.8 to 37.7 per cent. Tajudeen et al. (1989) observed that in a five year field experimentation the residual effect of summer crops like green manure green gram, groundnut and cowpea on the subsequent wet season and dry season rice were more or less same. But the long term effect of summer cropping on paddy was considerable. At the end of the fifth year plots grown with groundnut in summer registered the highest yield increase (63 per cent) in dry season rice.

2.4. Nutrient response to rice in the cropping system

2.4.1. Nitrogen

2.4.1.1. Growth characters

The benificial effect of nitrogen on rice growth has been reported by many authers. Application of N increases tiller production. (De Datta, 1981; Kannan, 1982; Krishnakumar, 1986) dry matter production. (Sadayappan, 1982; Reddy, 1985 and Venkitaswamy, 1986).

2.4.1.2. Yield attiributes

Many of the yield components of rice are positively influenced by the addition of nitrogen. Increase in number of panicles by unit area by incremental doses of nitrogen have been recorded by Sharma and De (1979) Subbiah _et al_. (1983) Salam (1984). Nitrogen application resulted in more number of filled grains per panicle (Chandrasekharan, 1984; Sankaranarayana, 1985 and Krishnakumar, 1986).

Rethinam _et al_ (1975) noticed steady increase in yield with enhanced dose of nitrogen and the highest yield was obtained with 160 kg N ha^{-1}. Pillai _et al_. (1978) suggested that more than 100 kg N ha^{-1} need not be applied for realising yield potential and maximum yield for dwarft rice. Singh and Mondyal (1978) reported that optimum rate for maximum yield for the dwarf variety Jaya was 158 kg N ha^{-1}.

Singh _et al_. (1978) have shown that the optimum and most profitable nitrogen rate for rice variety Jaya was 140 kg N ha^{-1}. Sharma (1986) found that for dwarf rice increase in nitrogen rates from zero to 150 kg ha^{-1} increased average yield from 1.76 to 5.56 t ha^{-1}. He also observed that further increase in nitrogen rates encountered with no profit.

Rao and Ramanujam (1971) reported that increases of nitrogen level from zero to 180 kg ha^{-1} increased straw yield of rice. Venkiteswaralu (1978) stated that straw yield increased with nitrogen levels upto 200 kg ha^{-1} and beyond which it declined.

2.4.1.3. Nitrogen in soil fertility

Digar (1960) found that laterite soils poor in fertility status responded well to the application of nitrogen, phosphorus and organic matter.

Venkita Rao and Badigar (1971) observed that nitrogenous fertilizers were almost completely utilized. Appreciable increase in availabile nitrogen content in the soil could be expected due to the application of nitrogenous fertilizers. Prasad and Jha (1973) found that due to continous cropping there had been a significant loss of soil nitrogen and that the loss was more with levels of nitrogen application. Sharma and Mishra (1988) reported that nitrogen application increased the amount of NH_4-N where as P and K had no effect. Application of nitrogen caused a slight decrease in available P content of soil as well P concentration in soil solution.

2.4.2. Phosphorus

Rice in some soils do not respond to phosphorus, whereas the upland crops show a response to this nutrient. Lack of response is due to an increase in the availability of phosphorus in wet land soils during submergence for rice cultivation.

2.4.2.1. Uptake of phosphorus by rice plant

Shapiro (1958) recorded that flooding increased the availability of soil P and paddy utilised P more efficiently under submerged conditions resulting in an increased uptake. Sahu and Lenka (1966) also observed that phosphorus response is increased when it is applied in conjunction with nitrogen.

Mehrotra *et al*. (1968) found tha the rate of phosphorus absorption continued to increase through out the growth period.

Sinha *et al*. (1980) observed that uptake of total phosphorus and fertilizer phosphorus increased from 0 to 90 kg ha^{-1} while utilization percentage of the applied phosphorus decreased. Increase in phosphorus rates increased grain and straw yields and decreased uptake of soil phosphorus. Rastogi et al. (1981) recorded that increasing level of applied phosphorus increased in total uptake and fertilizer phosphorus uptake, but decreased available soil phosphorus uptake and utilization percentage of the applied phosphorus at the tillering, flowering and maturation stages.

2.4.2.2. Effect of phosphorus on yield attributes

2.4.2.2.1. Productive tillers and panicles

Place et al. (1970) reported that the number of panicles were increased with increase in levels of phosphorus. Nair et al. (1972) found that the number of productive tillers per hill was highly influenced by phosphorus application. Bhattacharya and Chatterjee (1978) reported that application of P aided early tillering which resulted in more panicle bearing tillers.

Alexander et al. (1973) found that application of different levels of phosphorus did not have any possitive effect on the percentage of productive tillers. Sadanandan and Sasidhar (1976) also observed that increasing rates of applied phosphorus had no significant effect onthe number of productive tillers per hill.

2.4.2.2.2. Number of grains per panicle

Aron *et al*. (1971) reported that increased application of phosphorus increased the number of grains per panicle. Singh and Varma (1971) observed an increase in the number of grains per panicle with higher rates of phosphorus application. Sasanki and Wada (1975) reported that low levels of phosphorus increased the percentage of sterile grains and can be altered by the level of applied phosphorus.

Alexander *et al*. (1973) reported that the grain number/panicle was unaffected by phosphorus application. Kalyanikutty and Morachan (1974) showed that phosphoric acid did not have any marked effect on the number of grains. Sanandan and Sasidhar (1976) found no significant effect on the number of filled grasins per panicle with increased rates of applied phosphorus. Suseelan *et al*. (1977) reported that phosphorus application did not significantly influence the percentage of filled grain.

2.4.2.2.3. Thousand grain weight

Majumdar (1971) observed that thousand grain weight was increased with increase in phosphorus application. Thandapani and Rao (1974) reported that phosphorus levels increased the thousand grain weight. Chowdhury *et al*. (1978)

reported that thousand grain weight increased with increasing P application.

Place *et al*. (1970) recorded that a decrease in thousand grain weight with increase in levels of phosphorus. Alexander *et al*. (1973) observed that different levels of phosphorus did not have any positive effect on the thousand grain weight. Rao *et al*. (1974) reported that the thousand grain weight was not significantly nfluenced by the levels of phosphorus. Kalyanikutty and Morachan (1974) observed that phosphoric acid did not have any marked effect on the thousand grain weight.

2.4.2.3. Effect of phosphorus on yield

Khatua and Sahu (1970) reported that application of 40 kg phosphorus per hectare resulted in increased rice yield compared to no phosphorus application. Majumdar (1971) also observed increase in paddy yields with incremental doses of phosphorus application. Increase in grain yields with phosphorus application was also reported by kalyanikutty and Morachan (1974). According to Gopalakrishnan *et al*. (1975) grain yield was influenced by phosphorus application. Tiwari and Thakur (1976) found that phosphorus significantly increased grain yield of dwarf rice varieties IR-8 and Jaya. Chowdhary *et al*. (1978) reported that phosphorus application influenced paddy yield significantly. Ittiyavarah et al. (1979) reported that yields were adversely suffected by omiting the application of phosphorus in alternate years. Shiota et al. (1980) observed that without phosphorus yields were reduced by 40-50 per cent. Mahimairaja and Mayalagu (1985) found that phosphorus application increases grain yield of rice.

Sadanandan and Sasidhar (1976) observed that there was no significant difference in the yield of grain due to various levels of phosphatic fertilizers. Suseelan et al. (1977) revealed that the grain yield was not influenced by phosphorus application. Krishnamoorthy et al. (1979) reported that in rice cultivar IR-20, out of 12 crops tried, applied phosphorus increased the yield of only six crops.

Place et al. (1970) observed that increasing phosphorus application increased straw yield but decreasd tha plant height. Gupta et al. (1975) obtained higher straw yield with 60 ppm phosphorus. Singh and Prakash (1979) reported that the crop showed significant response to phosphorus application. Sinha et al. (1980) also reported increase in straw yield with phosphorus application.

The foregone review shows possitive effect of applied phosphorus on yield increase of rice as well as no effect on yield increase. It can be due to the abundence or absence of native phosphorus as well due to varying soil reaction.

2.4.2.4. Effect of phosphorus on the uptake of major nutrients

Mohankumar (1967) observed a decrease in nitrogen content with increase in phosphate application in rice. Varma (1971) reported that N uptake in grain and straw increased with increasing rates of both N and P. Singh and Prakash (1979) found that the application of P increased the uptake of N significantly over control.

Mohankumar (1967) observed an increase in the phosphorus content with increase in the rates of phosphorus application. Terman and Allen (1970) reported that the percentage of plant phosphorus from labelled fertilizer phosphorus increased in all situation with the amount of aplied phosphorus and decreased with increase in soil phosphorus level.

Suseelan et al. (1978) reported that there was significant increase in the uptake of phosphorus by the plant with increasing levels of phosphorus.

Singh and Prakash (1979) found that P application brought about increased uptake of P. Rastogi *et al*. (1981) showed that increasing levels of applied phosphorus increased the total phosphorus uptake and fertilizer phosphorus uptake, Agarwal (1980) reported that increase in the potassium uptake was from 35.5 to 129.9 kg ha^{-1} due to phosphorus application.

2.4.3. Potassium

The growing crops require adequate potassium supply. The potassium concentration in soil solution is in equilibrium with the potash reserve of the soil. Rice plant absorbs much more potassium than nitrogen and phosphorus. For many given varieties the yield level rises with increase in potassium.

Ponnamperuma (1965) reported that submerging the soil enhances the release of exchangeable potassium in the soil. He also reported that increase in exchange of potassium after submergence is highest in strongly acid latosolic soils rich in iron. The increase in the solubility of potassium under flooded condition helps to increase greater availability, at the same time causing higher leaching losses.

Huang (1969) found that potash requirement of rice ranges from 30 to 60 $kgha^{-1}$ and on badly drained soils 80 to

120 $kgha^{-1}$. Kemmler (1971) recorded that for rice there was good responses to K in the presence of nitrogen and phosphorus. Primavesi and Primavesi (1971) noticed that dry soil on submergence increases potassium levels in soil solution. Kanwar (1974) reported that yield increase of high yielding varieties was obtained from the application of 60 kg K_2O ha^{-1}.

Ganeshmoorthy and Biswas (1985) reported that continuous cropping did not affect the exchangeable K content of soil. Barnes et al. (1986) also reported that for growth and yield K fertilization is essential and the yield increases with increase in K fertilization.

2.5. Removal of nutrients by crop in the system

2.5.1. Rice

Sharma and Rajendra Prasad (1980) reported that rice crop yielding 50 q of grain removed 80 kg N, 18 kg P and 100 kg ha^{-1}.

De Datta (1981) have reported that under tropical conditions for the production of every ton of rice the crop removes 16.2 kg of N, 2.8 kg of P_2O_5 and 16.7 kg of K_2O. Grist (1986) have recorded that for the production of one ton of rice the crop removes 16.3 kg N 8.6 kg P_2O_5 and 18.3 kg K_2O.

2.5.2. Cassava

Kumar et al. (1987) reported that cassava variety 1687 (Sreevisakh) cultivated in the upland conditions with an average yield of 35 t ha^{-1} wiht 10 months duration removed 196.3 kg N, 13.2 kg P_2O_5, 106 kg K_2O, 408 kg ca and 21.8 kg Mg ha^{-1}. They have also reported that the same variety which was cultivated in a rice-cassava sequence in rice field with a duration of 7 months giving an average yield of 41.7 t ha^{-1} removed 204.9 kg N, 35.0 kg P_2O_5 and 308.5 kg K_2O ha^{-1}.

2.5.3. Cowpea

Jacquinot (1967) reported that about 40 kg nitrogen is removed by each tonne of cowpea seed harvested from hectare of land. Richie and Robert (1974) reported that each tonne of cowpea seed removes from the soil 40 kg nitrogen 17 kg phosphorus and 48 kg potassium. Godsase and Dougale (1984) reported that on an average the cowpea crop absorbed 1.87 kg N q^{-1} of grain yield.

2.4.4. Groundnut

According to Puhtamkar and Batkal (1967) groundnut crop removed a maximum of 51.09 kg of nitrogen and 14.24 kg of phosphorus from one hectare.

Sichman et al. (1970) reported that nitrogen (in kg ha^{-1}) removed in fruits and green materials (shown in brackets) of a groundnut crop of 16000 plants on a fertile latasol were N-142(201), P-15(6), K-30 (140) Ca-5(113) Mg-10(20) and S-15(16). According to Dahiya and Rastogi (1976) ground nut yielding two tonnes ha^{-1} removed 170, 30, 110 kg ha^{-1} of nitrogen, phosphorus and potash respectively.

Aulak et al. (1985) have recorded that an average crop of groundnut yielding 19 q ha^{-1} removed about 170 kg N, 30 kg P_2O_5 and 100 kg K_2O ha^{-1}. From the above findings it can be observed that the groundnut crop removes large quantities of nutrients especially nitrogen and potassium from the soil.

2.5.5. Bhendi

Maurya et al. (1987) found that a bhendi crop with an yield of 67.39 q ha^{-1} removed 87.81 kg N, 20.57 kg P_2O_5 and 103.91 kg K_2O ha^{-1}.

2.6. Effect of NPK on cropping system

2.6.1. Nitrogen

Organic matter status of soil is considered as an index of its fertility. Under tropical humid conditions, cultivation and cropping exhaust the soil organic matter more rapidly and the productivity of the soil declines.

Salter and Green (1933) observed that crop rotations including legumes maintained organic matter to soil at an optimum level. Mohant and Singh (1969) reported that continuous cultivation of rice decreases organic matter content of soil.

Sharma and Saxena (1970) found that under double cropping sequences a positive balance of nitrogen could be maintained. Nair and Singh (1971) have reported slight increase in available N and organic matter at the end of a rice based cropping experiment.

Prasad and Jha (1973) observed that due to continuous cropping there had been significant loss of N and it was more with the levels of nitrogen application. Nair *et al*. (1973). reported that available nitrogen and organic matter content of soil slightly improved after legumious crops are grown. Sadanandan and Mahapatra (1975). reported maximum decrease in organic carbon content of soil in continuous cultivation of rice, compared to other cropping patterns.

Meelu and Rekhi (1981) found that in rice-wheat cropping system green-manuring of 60 days old daincha effected an economy of 60-80 Kg N ha^{-1} in normal and salt affected soils. Green manuring did give residual effects in some places. Combined use of 12 t FYM and 80 Kg N ha^{-1} gave as much rice yield as with the application of 120 Kg N ha^{-1} thus effecting a saving of 40 kg N ha^{-1}. It also gave residual effect equivalent to 30 kgs each of N and P_2O_5 ha^{-1} in the succeeding wheat crop. The result on N use in berzeem rice cropping system suggested the possibility of reducing N dose to rice when grown in a system of berzeem.

Mandal <u>et al</u>. (1982) reported that after 5 years of jute-rice-wheat about 18 per cent loss of N was seen in control, followed by 15 per cent loss of nitrogen in 50 per cent NPK treated plot and 10 per cent loss of nitrogen in 100 per cent NPK treated plots. Wivutronguania and Tiyawallee (1984) observed that multiple cropping systems depletes the soil fertility differently, soil organic matter was depleted under all cropping systems. But it was slightly enhanced where legumes were included. Deka ~~and~~ et al. (1984) found that in a crop cycle of 4 years with six annual crop sequences organic carbon and total nitrogen content of soil increased in all the rotations except pure cereal (rice-wheat), maximum being in rice berzeem.

Mandal et al. (1984) found that results of wheat yield and status of soil nutrients after eight years intensive cropping ~~that soil~~ showed a declining trend in organic carbon and total nitrogen.

Azam et al. (1986) noticed that growing legumes in the cropping system increases mineralisable nitrogen in soil. Prasad and Palaniappan (1987) found that in a pulse crop-rice rotation, soybean added more residues than green gram. Chemical analysis showed that soybean residue added 52 Kg N ha^{-1} and green gram residue 43 Kg N ha^{-1}. Returns were highest when soybean stalks were incorporated without fertilizer application to rice.

Sahu et al. (1988) recorded that the soil organic carbon increased with cropping patterns. The least organic per cent was noted in rice-wheat-sequence and highest in rice-cowpea sequence.

2.6.2. Phosphorus

Cultivation of crops singly or in sequence have no effect on total phosphorus content of soil. Sadanandan and Mahapatra (1973) reported that there was no noticeable gain or loss of total phosphorus in all cropping patterns studied. Ghosh and Kanzaria (1964) found that in continuous cropping system higher status of available phosphorus in soil was noted in plots which received superphosphate.

Nair et al. (1973) noticed that available phosphorus slightly improved after leguminous crops were grown in multiple cropping. Raghavalu and Sreeramamoorthy (1974) recorded slight increase in available phosphorus at the end of three years in all the rotations involving cereals and pulses.

Biswas et al. (1977) have shown that with continuous application of phosphorus during the crop cycle there was an accumulation of available phosphorus the contents of which rose from the initial low status to medium or higher levels commensurate with the fertlizer dose. The plots which received 50 per cent of the optimum P (83 kg ha^{-1} in two years) raised the level to medium whereas the treatments of 100 and 150 per cent of optimum resulted in the accumulation of available P to a high level. But where no P was applied its status declined markedly from initial value of 8.8 to 2.1 kg ha^{-1} as a result of intensive cropping.

Subba Rao and Ghosh (1981) reported that the intensive cropping effects less depletion of inorganic P and more depletion of organic P in soils. Meelu and Rekhi (1981) found that in rice-wheat system wheat was more responsive to phosphorus than rice. They also reported that application of 60 kg $P_{2O}5$ ha^{-1} to wheat was sufficient to meet the phosphorus requirements of the succeeding rice crops in the wheat-rice cropping system. In potato-rice-wheat cropping system if 60 kg $P_{2O}5$ ha^{-1} was applied to potato, the dose of phosphorus could perhaps be halved in wheat and omitted in rice without reduction in yield.

Gill and Meelu (1982) found that in a rice-wheat crop sequence, rice did not responded to graded levels of P (0, 9, 18 and 20 kg ha^{-1}) applied across treatments with 120 kg N ha^{-1} alone. However rice respond to farm yard manure, nitrogen and the combination. In a second experiment in the same field rice did not respond to direct application of fertilizer. But wheat responded significantly, and consistently higher yields were obtained with application of 26 kg $P_{2O}5$ ha^{-1}. Direct application of recommended P to wheat achieved the highest yield. Wheat yield was 50 per cent lower when P was applied only to rice in the rotation.

There was no cumulative effect from P application to both crops.

Nad and Goswami (1984) observed that continuous application of phosphatic fertilizer in a rice-wheat cropping sequence for over 10 seasons resulted an increase in soil phosphorus particularly in Al-p and Fe-p fractions. Wivutronguania and Tiyawalees (1984) reported that in a three year experiment, application of P fertlizers consecutively for two years gave a high soil 'p' for the third year.

Rana et al. (1984) recorded from their study on crop yields and nutrient uptake in a cropping sequence that nitrogen and phosphorus up take of cropping decreased with curtailment in fertilizer dose. Yadav (1985) recorded from his study of the different cropping system that available p decreased from 18.4 kg ha^{-1} to 14.5 kg ha^{-1}.

Sagar et al. (1986) found that in wheat-rice-rotation fertilizer should be applied to wheat rather than rice and that if wheat receives adequate p application over time p-application to rice can be reduced. P increased was fastest when p was applied to rice. P was more available after rice harvest than after wheat harvest because soil p is more available in submerged than in aerated soils, and available P decreased after the next rice crop. Verma et al. (1987) observed that in continuous cropping increased P status over initial value was found when P was applied in the cropping sequence. Gill et al. (1987) observed that in ground nut-wheat and greengram-wheat crops sequence on soil low and medium in phosphorus both groundnut and greengram responded well to phosphate application and had marked residúal effect on the succeeding wheat crop.

Sahu et al. (1988) reported that available p and exchangeable K decreased in rice-black gram sequence, which had highest grain production. Dhillon and Dev (1993) observed that maximum removal of phosphorus was in a rice-wheat rotation and that phosphate application was relatively more economical in this rotation. Available P status was lowered more in this rotation where no P was applied, but application of P helped in maintaining soil P status.

2.6.3. Potassium

Sturgis (1963) reported reduction in the exchangeable potassium content of soil by continuous cultivation of rice.

Ghosh and Kanzaria (1964) observed that there was no change in total potash in soil by continuous cultivation with addition of potassic fertilizer. Nair et al. (1973) recorded that available potassium slightly improved after leguminous crops were grown in a field experiment consisting of five rice-based cropping sequences. Sadanandan and Mahapatra (1974) observed that in the cropping pattern rice-rice, there was a slight gain in exchangeable potassium. Raghavulu and Sreeramamoorthy (1975) noticed that in all rotations involving cereals and pulses, the available potassium status decreased. Wivutronguania and Tiyawallee (1984) reported their results of fertility changes under different multiple cropping systems having two legumes that available K was still relatively higher in soil after three years. Mandal et al. (1984) noted that continuous cropping and manuring in a jute-rice-wheat rotation increases the available K status of soil in plots where fertilizer was applied.

Verma et al. (1987) recorded that in their studies on the effect of continuous cropping and fertilizer application that the decrease in available K was less in plots which received potassic fertilizers than those which did not receive it.

2.6.4. Organic carbon status in cropping system

Poyser et al. (1957) reported that there was an over all decrease of 27.5 per cent of organic carbon during 25 years of cropping. Doyle and Halmlyn (1960) reported that a reduction in organic carbon content of soil takes place as a result of continuous cropping.

Sadanandan and Mahapatra (1975) also have recorded that there was a decrease in organic carbon content of soil due to continuous cropping. The maximum decrease is observed in rice-rice-rice cropping sequence. Sasidhar (1977) also found that the continuous cropping affects the organic carbon content of soils. The maximum decrease is observed in rice-rice-sequence. The least is noted in rice-rice-cowpea/pulses.

Gill et al. (1984) observed that critical level of organic carbon was 0.45 per cent for Punjab soils and this was good for the nitrogen supply of crops. Cropping sequences decreases the organic carbon content of crops. Mandal et al. (1984) reported that continuous cropping decreases the organic carbon per cent in soil. Deka et al. (1984) recorded that organic carbon and total nitrogen content decreased in soil after continuous cropping for 8 years. The loss was maximum in rice-wheat rotation.

Sanchez and Lopez (1986) observed decline in organic carbon in soil due to continuous cultivation. The decline was minimum in plots which received organic matter or green manure. Sahu et al. (1988) also reported that continuous cropping with cereals decreases the organic carbon content of soil. But organic content of soil increases with cropping patterns like rice-cowpea, rice-greengram, and rice peanut.

2.7. Economics of cropping system

Multiple cropping offers extended opportunities in the use of the same land resources within a calendar year through repeated croppings. In this system, more can be produced from the land effectively, attaining as much increased production as if both land and capital were increased under conventional cropping patterns (Agarwal and Heady, 1970). Bains (1968) found that in relay cropping systems of 400 per cent intensity, the farmers can get a profit of about Rs. 11,500 per hectare per year. They studied the economics of two cropping patterns: mung-maize-toria-wheat and mung-maize-potato-wheat. From the first relay cropping sequence they got a net profit of about Rs. 10000/- per hectare, whereas, from the second relay cropping sequence they got a net profit of about Rs. 11500/-. Mahapatra and Patrick (1969) reported that the cultivators in Cuttack district of Orissa State obtained a net profit ranging from Rs. 2860/- to Rs. 5698/- by adopting the cropping pattern, rice-potato-rice.

In a study with five high intensity crop rotations with rice, Nair and Singh (1971) found that the maximum gross return of Rs. 12692 and net profit of Rs. 7367 were obtained from the rice-potato-wheat rotation. At Pantnagar, Nair and Singh (1971) obtained a net return of Rs. 1.75 per rupee invested from rice-lahi-soybean rotation. Very high net returns per hectare per year under multiple cropping have also been reported by Guptha (1972). According to Sadanandan and Mahapatra (1972 d), the cropping pattern potato-rice-rice has shown the maximum production potentiality during 1967-68 and 1968-69, the net income from the cropping pattern being Rs. 8775/- in the second year. The cropping pattern rice-potato-potato was the best with an approximate profit of Rs. 5700 per hectare in Punjab in the studies conducted by Shahi (1973). In Sambalpur district of Orissa, Panda et al. (1973) studied ten high intensity single year crop rotations involving cereals, pulses and vegetables. They found that the rotation rice-tomato-rice-mung resulted the highest production with a net profit of Rs. 11025/- per hectare. Pillai (1973) suggested that a suitable crop rotation should give not less than Rs. 1000/- per acre net income, although in dry land conditions such a large income can not be expected. Under assured irrigation and 400 per cent relay cropping, it can go up to Rs.2000/- per acre. Studies in the scarcity zone of Maharashtra revealed that double cropping increased gross money returns from two to four times than that of the monoculture which hardly yielded about Rs. 500/- per hectare (Pharande et al., 1973). Sahu and Patro (1975) recorded that the cropping pattern rice-cauliflower-maize reported the maximum net profit of Rs. 8398.74 ha^{-1} in Orissa. According to Singh and Singh (1975), increased cropping intensity and increased area under high yielding varieties resulted in higher employment and higher level of income per unit area. Kumar and Reddy (1991) have reported that in Andhra Pradesh of the different rice based crop sequence tried total grain yield was highest with rice-maize. Rice sunflower recorded highest net income, but had the lowest benefit cost ratio where as benefit cost ratio was higher in rice maize sequence. Sharma and Tomar (1991) have reported that at different crop sequences tried rice-berzeam gave the highest production and benefit cast ratio. Its net return was 42 per cent higher than that of dominant rice wheat cropping sequence in the irrigation cannal command areas in Rajasthan.

Hegde (1992-b) who conducted economic analysis of different rice based cropping systems concluded that there is scope for curtailment in fertilizer use in some crop sequences at selected location without any adverse effect on the profitability.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

A field experiment on rice based cropping system was laid out starting from summer season of 1983 for a period of two years in Block No. V of the Regional Agricultural Research Station, Pattambi, Kerala State. The details of the materials used and the methods adopted in the experiment are presented in this chapter.

3.1. Materials

3.1.1. Location

The Regional Agricultural Research Station, Pattambi is situated at 10^{o} 48" N latitude and 76^{o} 12" E longitude and 25 M above mean sea level. It is situated in the middle land laterite part of the Kerala State according to the topographical classification of the State. In the middle land the conventional double crop paddy fields are lying in the valleys in between the hilly portions on either sides.

3.1.2. Climatic conditions

The area receives S.W. monsoon abundantly and the first crop of rice is mostly grown with this. N.E monsoon is scarce and the second crop of rice will be successful only with supplementary irrigation. Summer season receives very little rain and summer rice is grown only with irrigation.

The normal climatic condition prevailing at Pattambi (average of 10 years from 1973 to 1982) is presented in Appendix I.

The annual normal rainfall is 2696 mm, the major portion of which is received during June to August. The contribution of rainfall from the South West and North East monsoons and from summer showers are 1886, 530 and 221 mm respectively. The mean maximum and minimum temperature during the period are 32.3°C and 22.5°C respectively. March is the hotest month and January is the coolest. Maximum relative humidity of 96.3 per cent at 7 am prevails during July where as in January it is only 79.3 per cent. Maximum daily sunshine hours (9.8) is recorded during January while the minimum is recorded in the month of July (2.4). Highest evaporation of 7.1 mm is recorded during March while the lowest is in July (3.6 mm).

3.1.3. Climatic condition during the crop period

The cropping period was from January 1983 to February 1985. The mean monthly data on the meteorological parameters recorded at the agro-met observatory attached to

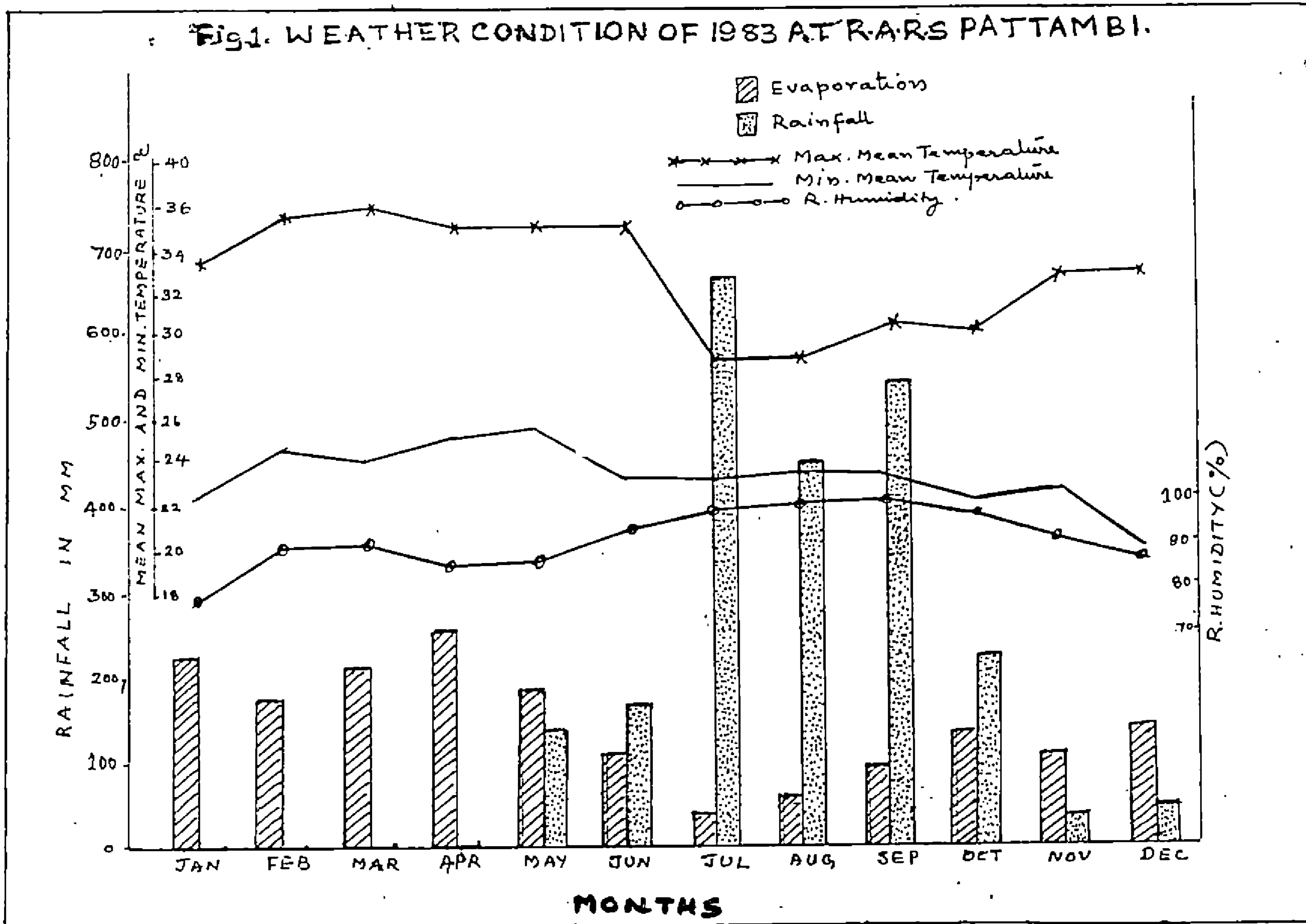
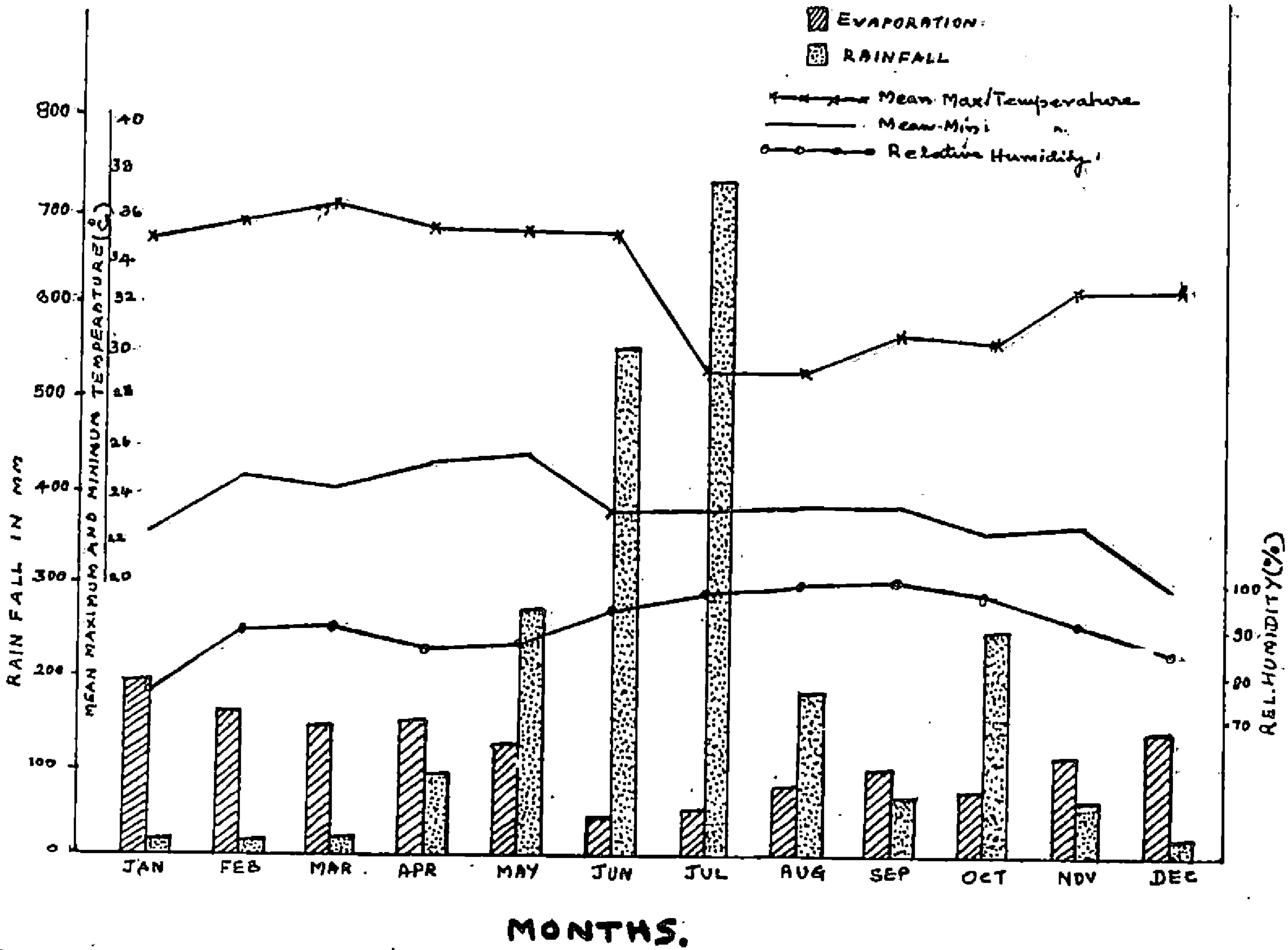


Fig.1. WEATHER CONDITION OF 1983 AT R.A.R.S PATTAMBI.
Evaporation
Rainfall
Max. Mean Temperature
Min. Mean Temperature
R. Humidity.
RAINFALL IN MM
800
700
600
500
400
300
200
100
0
MEAN MAX. AND MIN. TEMPERATURE
40
36
34
32
30
28
26
24
22
20
18
R. HUMIDITY (%)
100
90
80
70
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTHS

Fig. 2. WEATHER CONDITION OF 1984 AT RARS PATTAMBI.



the RARS, Pattambi during the above period are presented in Appendix II (a) and II (b) and Figures 1 and 2.

During first year (1983) the summer was more severe than normal. There was no summer rains from January to April. Rains during may and June were sub-normal. During second year (1984) summer showers were above normal and during may 1984 the rains were far above normal. During 1983 and 1984 eventhough the total number of rainy days were above normal the total quantity of rainfall received were sub-normal. The total evaporation from January to May 1983 was much higher than the corresponding period of 1984.

3.1.4. The cropping history

The crops raised in the experimental field during the preceding years before the commencement of the present experiment were bulk crops of rice.

3.1.5. Crop varieties

3.1.5.1. Rice cv. Jaya

The variety used for the experimental purpose was Jaya during first and second crop season. It is from a cross between TN-1 x T 141 and was released for cultivation in 1968 from the AICRIP Hyderabad. The crop takes 128 days to mature in Kharif season and 125 days in Rabi season. Jaya had a good yield stability and potential to give a grain of 3.5 to 4.0 t ha^{-1} under optimum conditions of weather and crop management. Under Kerala conditions it has moderate resistance to bacterial leaf blight, tungro virus, blast, stem borers ad leaf hoppers.

3.1.5.2. Rice cv: Triveni

This is a short duration photoinsensitive rice variety with a duration of about 100 days. It is a hybrid derivative of a cross between Annapoorna x PTB-16 (Kavungin-Poothala). It is tolerant to brown plant hopper but susceptible to blast and sheath blight diseases. (KAU 1982).

3.1.5.3. Cassava cv: Malavella

This is a short duration variety of cassava with a duration of 5 months during summer and giving a tuber yield of 10-15 t ha^{-1}. This variety is used as a catch crop in the summer rice fallows of Malappuram district within the interval period after the harvest of rabi rice and before the sowing of Kharif rice (January to June) Cooking quality of tuber is very good (Santha et al.1988).

3.1.5.4. Cowpea cv. Krishnamony

This is a cross between P-118 x Kolinji payar. It has a short duration of 55 to 60 days, suitable for cultivation in summer rice fallows. It is a grain type, bushy and non trailing. It has a very short flowering phase and requires only one or two pickings. It can also withstand moisture stress which is usual during the post rice summer period (Chandrika, et al. 1983).

3.1.5.5. Groundnut cv. TMV.2.

It is a bunch type of groundnut maturing within 90 to 105 days. It is released from the Oil Seeds Research Station, Tindivanam by mass selection from the local variety Gudiatham bunch (Seshadri, 1962) and found to be suitable as a catch crop in summer rice fallows (Kurup et al. 1979).

3.1.5.6. Bhendi cv. Pusa sawani

It is a variety with high yield stability and resistant to yellow vein mosaic disease. This variety is released from IARI, New Delhi. It gives an yield of more than 60 q ha^{-1} within a period of 4 months.

3.1.6. <u>Physical and chemical properties of the soil</u>

The physical and chemical analysis of the soil of

Table 1. Physical and chemical properties of soil of the experimental field (Block No. V of RARS, Pattambi)

Properties	Mean value	Method followed
A. Physical properties		
1. Particle size distribution (percentage)		International pipette method (Piper, 1966)
i Sand	79.14	
ii Silt	8.78	
iii Clay	11.65	
Textural class	Sandy loam	I.S.S.S. System
B. Electro chemical properties		
i Soil reaction (pH) (1:2.5 Soil water ratio)	5.3	Elico pH meter with glass electrode (Jackson, 1973)
ii Electrical conductivity ($dS\,m^{-1}$) at 25°C	0.02	Conductivity bridge (Jackson, 1973)
iii Redox potential (Eh) (milli volts)	+110	Platinum electrode (Hesse, 1971)
C. Chemical properties		
i Organic carbon (Percentage)	1.17	Walkley and Black Rapid titration method (Jackson, 1973)
ii Available nitrogen ($kg\ ha^{-1}$)	223.40	Alkaline Permanganate method (Subbiah and Asija, 1956)
iii Available Phosphorus ($kg\ ha^{-1}$)	12.67	Bray and Kurtz method using Bray No.1 extractant (Jackson, 1973)
iv Available potassium	184.25	Neutral normal NH_4 OAc method using Atomic Absorption Spectrophotometer (Jackson, 1973)

Block No. V of RARS, Pattambi in which the field experiment was conducted is given in table 1.

3.1.7. Experimental layout

The field experiment was laidout in a split - split plot design. The layout plan of the experiment during summer, kharif and rabi seasons are presented in figures 3, 4 and 5. In summer season the entire area was divided in to six segments allotting the treatments to each segment at random. During first crop season each segment was divided in to ten first crop plots and treatments alloted randomly. During second crop season each first crop plots were again divided into two equal halves and the treatments alloted.

3.1.7.1. Technical programme

The experiment started with raising of summer crops as per the main plot treatments.

3.1.7.1.1. Main plot treatments

S_1 - Cassava cv. Malavella

S_2 - Cowpea cv. Krishnamony

S_3 - Ground nut cv. TMV-2

S_4 - Bhendi cv. Pusasawani (green)

S_5 - Summer rice cv. Triveni

S_6 - Summer fallow

Fig.3. Layout of summer season

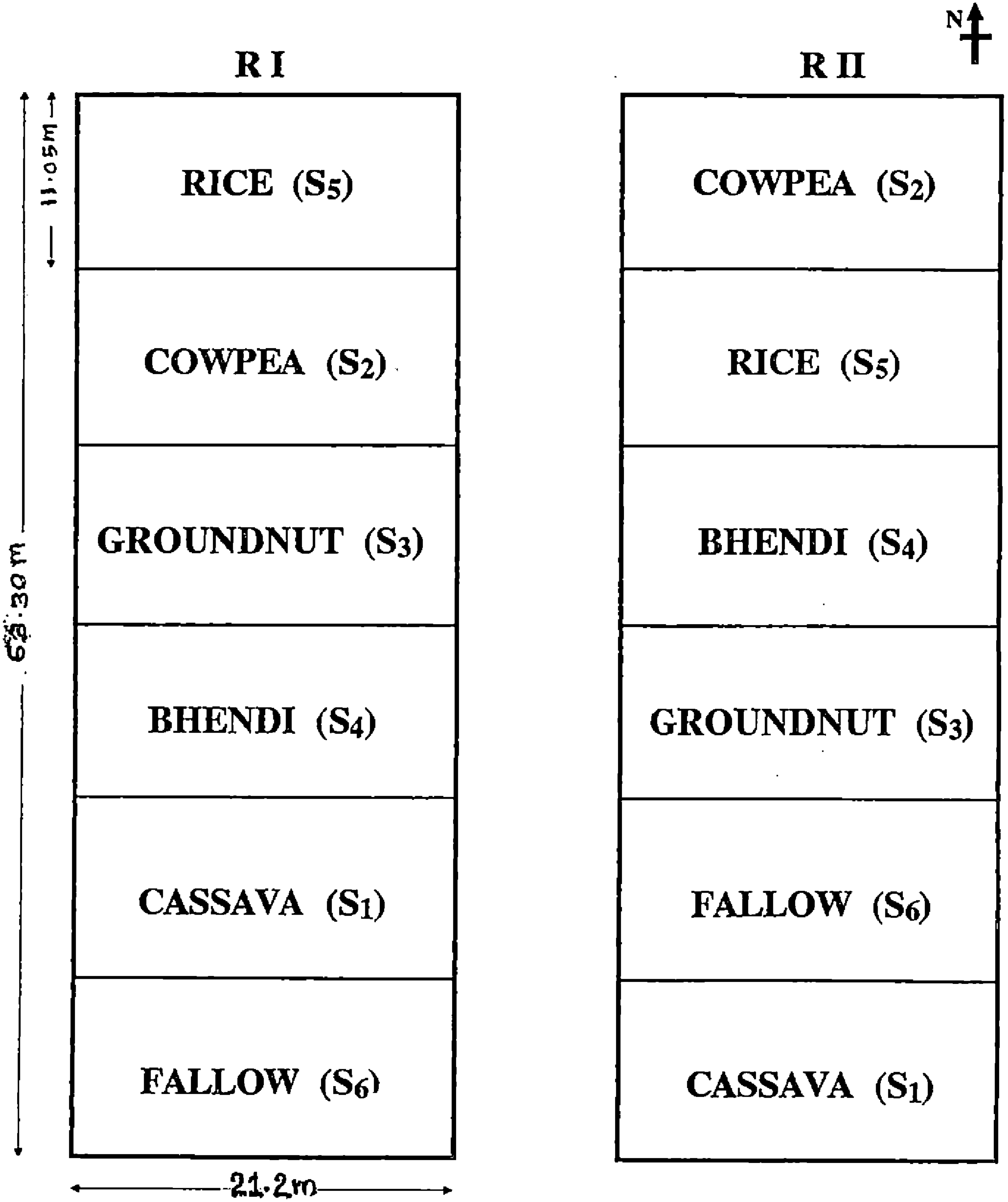


Fig. 4. Layout — kharif season

N

R I (63.30m × 21.2m)

F_7	F_3	F_0	F_1	F_8	S_5
F_2	F_5	F_9	F_4	F_6	
F_1	F_6	F_2	F_8	F_3	S_2
F_9	F_0	F_4	F_7	F_5	
F_6	F_8	F_3	F_9	F_0	S_3
F_4	F_1	F_5	F_2	F_7	
F_0	F_3	F_7	F_1	F_8	S_4
F_5	F_2	F_4	F_9	F_6	
F_8	F_5	F_0	F_1	F_4	S_1
F_3	F_7	F_2	F_8	F_9	
F_9	F_0	F_3	F_2	F_8	S_6
F_6	F_1	F_7	F_5	F_4	

R II

F_6	F_2	F_7	F_8	F_1	S_2
F_0	F_4	F_9	F_3	F_5	
F_9	F_0	F_3	F_2	F_8	S_5
F_4	F_6	F_1	F_7	F_5	
F_3	F_7	F_2	F_8	F_9	S_4
F_4	F_1	F_0	F_5	F_6	
F_6	F_9	F_4	F_2	F_7	S_3
F_0	F_3	F_1	F_5	F_8	
F_4	F_1	F_5	F_4	F_7	S_6
F_6	F_8	F_3	F_0	F_9	
F_5	F_7	F_4	F_9	F_0	S_1
F_1	F_6	F_2	F_8	F_3	

Fig.5. Lay out - rabi season

63·30M

F_6M_0	F_9M_0	F_3M_0	F_8M_0	F_5M_0	F_0M_0	F_4M_0	F_6M_0	F_1M_0	F_9M_0	F_2M_0	F_7M_0
F_6M_1	F_9M_1	F_3M_1	F_8M_1	F_5M_1	F_0M_1	F_4M_1	F_6M_1	F_1M_1	F_9M_1	F_2M_1	F_7M_1
F_1M_1	F_0M_1	F_7M_1	F_5M_1	F_2M_1	F_3M_1	F_1M_1	F_8M_1	F_6M_1	F_0M_1	F_5M_1	F_3M_1
F_1M_0	F_0M_0	F_7M_0	F_5M_0	F_2M_0	F_3M_0	F_1M_0	F_8M_0	F_6M_0	F_0M_0	F_5M_0	F_5M_0
F_7M_0	F_3M_0	F_2M_0	F_0M_0	F_4M_0	F_7M_0	F_5M_0	F_3M_0	F_2M_0	F_4M_0	F_9M_0	F_0M_0
F_7M_1	F_3M_1	F_2M_1	F_0M_1	F_4M_1	F_7M_1	F_5M_1	F_3M_1	F_2M_1	F_4M_1	F_9M_1	F_0M_1
F_5M_1	F_2M_1	F_8M_1	F_1M_1	F_1M_1	F_1M_1	F_2M_1	F_9M_1	F_8M_1	F_7M_1	F_4M_1	F_1M_1
F_5M_0	F_2M_0	F_8M_0	F_1M_0	F_1M_0	F_1M_0	F_2M_0	F_9M_0	F_8M_0	F_7M_0	F_4M_0	F_1M_0
F_4M_0	F_8M_0	F_9M_0	F_4M_0	F_xM_0	F_8M_0	F_7M_0	F_0M_0	F_3M_0	F_5M_0	F_6M_0	F_8M_0
F_4M_1	F_8M_1	F_9M_1	F_4M_1	F_xM_1	F_8M_1	F_7M_1	F_0M_1	F_3M_1	F_5M_1	F_6M_1	F_8M_1
S6		S1		S4		S3		S2		S5	

F_1M_0	F_5M_0	F_6M_0	F_9M_0	F_0M_0	F_6M_0	F_4M_0	F_3M_0	F_4M_0	F_9M_0	F_0M_0	F_6M_0
F_1M_1	F_5M_1	F_6M_1	F_4M_1	F_0M_1	F_6M_1	F_4M_1	F_3M_1	F_4M_1	F_9M_1	F_0M_1	F_6M_1
F_6M_1	F_7M_1	F_8M_1	F_1M_1	F_9M_1	F_9M_1	F_1M_1	F_4M_1	F_6M_1	F_0M_1	F_4M_1	F_2M_1
F_6M_0	F_7M_0	F_8M_0	F_1M_0	F_9M_0	F_9M_0	F_1M_0	F_4M_0	F_6M_0	F_0M_0	F_4M_0	F_2M_0
F_2M_0	F_4M_0	F_3M_0	F_5M_0	F_1M_0	F_4M_0	F_0M_0	F_2M_0	F_1M_0	F_3M_0	F_9M_0	F_7M_0
F_2M_1	F_4M_1	F_3M_1	F_5M_1	F_1M_1	F_4M_1	F_0M_1	F_0M_1	F_4M_1	F_3M_1	F_9M_1	F_7M_1
F_8M_1	F_9M_1	F_0M_1	F_4M_1	F_5M_1	F_2M_1	F_5M_1	F_8M_1	F_7M_1	F_2M_1	F_3M_1	F_8M_1
F_8M_0	F_9M_0	F_0M_0	F_4M_0	F_5M_0	F_2M_0	F_5M_0	F_8M_0	F_7M_0	F_2M_0	F_3M_0	F_8M_0
F_3M_0	F_0M_0	F_9M_0	F_7M_0	F_7M_0	F_xM_0	F_6M_0	F_9M_0	F_5M_0	F_8M_0	F_5M_0	F_1M_0
F_3M_1	F_0M_1	F_9M_1	F_7M_1	F_8M_1	F_7M_1	F_6M_1	F_9M_1	F_5M_1	F_8M_1	F_5M_1	F_1M_1
S1		S6		S3		S4		S5		S2	

3.1.7.1.2. Subplot treatments

Different combinations (proportions) of N, P and K fertilizers (Package of Practice recommendations of 90:45:45 kg ha^{-1} of NPK taken as 100 per cent) were applied to the kharif rice crop cv: Jaya raised in the subplots as detailed below:

		N	P	K		N	P	K	
F0	–	0	0	0	per cent	0	0	0	kg ha^{-1}
F1	–	50	50	50	"	45.00	22.50	22.50	"
F2	–	50	75	75	"	45.00	33.75	33.75	"
F3	–	50	100	100	"	45.00	45.00	45.00	"
F4	–	75	50	50	"	67.50	22.50	22.50	"
F5	–	75	75	75	"	67.50	33.75	33.75	"
F6	–	75	100	100	"	67.50	45.00	45.00	"
F7	–	100	50	50	"	90.00	22.50	22.50	"
F8	–	100	75	75	"	90.00	33.75	33.75	"
F9	–	100	100	100	"	90.00	45.00	45.00	"

3.1.7.1.3. Sub-sub Plot treatments

During the rabi season the sub plots of the kharif season were divided into two sub-sub plots. In one sub-sub plot rabi rice cv. Jaya raised without any fertilizer application (M_0) and in the other the same cv. was raised with application of fertilizers as per package of practice recommendations (M_1).

3.1.7.2. Fertilizer/manure application for different crops

The fertilizers and manures, applied to the crops as per the package of practices recommendations (KAU, 1982) are given in table 2 (a).

Table 2.a. Recommended doses of fertilizers/manures

Sl. No.	Crop	FYM t ha^{-1}	LIME kg ha^{-1}	Fertilizer nutrients ($kgha^{-1}$)		
				N	P_2O_5	K_2O
1.	Rice (MD)	5.0	600	90	45	45
2.	Rice (SD)	5.0	600	70	35	35
3.	Cassava (SD)	2.5	---	50	50	50
4.	Cowpea	---	250	20	30	10
5.	Groundnut	2.0	1500	10	75	75
6.	Bhendi	12.0	----	50	8	30

SD - Short duration MD - Medium duration

For all the crops nitrogen was applied in the form of urea (46 per cent N) phosphorus as musoorie rock phosphate (24 per cent P_2O_5) and potash as muriate of potash (60 per cent K_2O). The farm yard manure contained 0.4 per cent nitrogen, 0.3 per cent P_2O_5 and 0.2 per cent K_2O. The lime used had a neutralising value of 136 [$Ca(OH)_2$].

3.1.7.2.1. Rice (MD) kharif and Rabi seasons

50 per cent of the nitrogen was applied basally and the remaining N applied in two equal split doses, one at tillering and the other at panicle initiation. Entire quantity of P and k were applied basally.

3.1.7.2.2. Rice (SD)

Two third dose of nitrogen and full dose of P and K were applied basally and the remaining one third dose of N applied as a single top dressing one week prior to panicle initiation.

3.1.7.2.3. Cassava

50 per cent N, full dose of P and 50 per cent K were applied basally at the time of planting and the remaining 50 per cent N and 50 per cent K applied 2 months after planting.

3.1.7.2.4. Cowpea

50 per cent N, full dose of P and K were applied basally and the remaining 50 per cent N applied as foliar spray 20 days after sowing with 2 per cent urea solution in 250 litres of water ha^{-1} sprayed after 3 pm.

3.1.7.2.5. Groundnut

The entire quantity of recommended fertilizers were applied basally prior to dibbling of the kernels. Lime at 1.5 t ha^{-1} was applied at the time of flowering and incorporated with the top soil by earthing up.

3.1.7.2.6. Bhendi

50 per cent N and full quantity of P and K were applied basally at the time of dibbling the seeds. The remaining 50 per cent of N was top dressed one month after sowing.

3.1.8. <u>Cultural Operations</u>

During the summer season 1983 the field was initially ploughed with tractor and brought to the required tilth by ploughing with iron plough. Each main plot was demarkated by bunds of 20 cm width, with a buffer channel of 25 cm between the two bunds on alternate rows to safeguard against the entry of water and to minimise the movement of nutrients from one plot to another. The bunds of summer rice plots were lined with polythene sheets to overcome seepage to the adjacent plots. Prior to planting of first crop, these plots were subdivided in to ten sub plots with bunds of 20 cm width and 15 cm height and same sub plots were again divided into two plots by putting hand bunds through the center of the sub plots prior to planting of second crop. The layout remained same during the second year period till the experiment was over.

3.1.8.1. Rice

In a well puddled and levelled land nurseries were sown on raised beds using a seed rate of 1.5 kg of sprouted seed in an area of 45 M^2 for both rice varieties Jaya and Triveni. No fertilizer was applied in the nursery. Breeder seed produced at the RARS, Pattambi was used for raising seedlings.

In the sub plots and sub sub plots the land was dug with mammotties and puddled without disturbing the bunds. The age of the seedlings of summer rice crop (Triveni) was 20 days and that of the kharif and rabi rice crop (Jaya) was 25 days. The summer rice crop was given a spacing of 15 x 10 cm with two seedlings per hill (67 hills M^{-2}). For the kharif rice crop a spacing of 20 x 15 cm (33 hills M^{-2}) for rabi rice a spacing of 20 x 10 cm (50 hills M^{-2}) were given with two seedlings per hill. Weeding was attended to prior to top dressing and the weeds were trampled within the plots itself.

3.1.8.2. Cassava

The plot was made into ridges and furrows at a spacing of 75 cm by working with mammotty and short duration tapioca setts cut to a length of 15 cm were planted at a spacing of 75 cm on the ridges. Gap filling was attended to as and when required in the early stages of the crop. The plots received one earthing up cum weeding prior to top dressing with N and k fertilizers.

3.1.8.3. Cowpea

The plots were brought to the required tilth with mammotty and levelled. Rhizobium treated cowpea seeds were dibbled at a spacing of 15 x 15 cm with 2 seeds per hole. One earthing up cum weeding was given 25 days after planting using hand hoes. Harvesting was done by hand picking. The crop residues was cut and removed for use as fodder.

3.1.8.4. Groundnut

The plots were brought to the required tilth by digging and clode breaking with mammotties. Groundnut seeds were dibbled at a spacing of 15 x 15 cm with one seed per hole. Gap filling was attended to during the early period of crop growth. The plots were earthed up at flowering, with the application of lime at 1.5 t ha^{-1}. Harvesting was done by hand pulling the plants. The bhusa was removed from the field for use as fodder.

3.1.8.5. Bhendi

The plots were brought to the required tilth by digging and clode braking. Seeds were dibbled in small furrows made by hand spades at a pacing of 60 x 30 cm. Two seeds were dibbled per hole and later thinned to one seedling. One month after sowing the plot was earthed up and furrows drawn in between rows to facilitate irrigation. Tender fruits were harvested once in four days and the stubbles up rooted and removed after the harvest was over.

3.1.9. Irrigation

The summer crops included in the cropping system were irrigated as per package of practice recommendations (KAU, 1982). Gap filling weeding and plant protection operations were done as per package of practice recommendations as and when necessitated. Details on the date of planting and harvest of the crop in each cropping system during 1983 and 1984 are given in table 2.b and 2.c.

Table 2.b. Cropping programme for 1983-84

Cropping System	Crop	Variety	Period of cropping From	to	Field duration (days)
S_1	Cassava	Malavella	31-1-83	23-6-83	144
	Rice	Jaya	10-6-83	15-10-83	128
	Rice	Jaya	1-10-83	3-2-84	125
S_2	Cowpea	PTB-2	11-2-83	21-4-83	70
	Rice	Jaya	10-6-83	15-10-83	128
	Rice	Jaya	1-10-83	3-2-84	125
S_3	Groundnut	TMV-2	11-2-83	17-5-84	96
	Rice	Jaya	10-6-83	15-10-83	128
	Rice	Jaya	1-10-83	3-2-84	125
S_4	Bhendi	Pusa sawani	11-2-83	17-5-83	96
	Rice	Jaya	10-6-83	15-10-83	128
	Rice	Jaya	1-10-83	3-2-84	125
S_5	Rice	Triveni	25-1-83	6-5-83	101
	Rice	Jaya	10-6-83	15-10-83	128
	Rice	Jaya	1-10-83	3-2-84	125
S_6	Fallow				
	Rice	Jaya	10-6-83	15-10-83	128
	Rice	Jaya	1-10-83	3-2-84	125

Table 2.C. Cropping programme for 1984-85

Cropping System	Crop	Variety	Period of cropping From	to	Field duration (days)
S_1	Cassava	Malavella	12-2-84	25-6-84	134
	Rice	Jaya	12-6-84	17-10-84	128
	Rice	Jaya	15-10-84	16-2-85	125
S_2	Cowpea	PTB-2	20-2-84	30-4-84	70
	Rice	Jaya	12-6-84	17-10-84	128
	Rice	Jaya	15-10-84	16-2-85	125
S_3	Groundnut	TMV-2	10-2-84	11-5-84	92
	Rice	Jaya	12-6-84	17-10-84	128
	Rice	Jaya	15-10-84	16-2-85	125
S_4	Bhendi	Pusa sawani	10-2-84	5-6-84	117
	Rice	Jaya	12-6-84	17-10-84	128
	Rice	Jaya	15-10-84	16-2-85	125
S_5	Rice	Triveni	26-2-84	6-6-85	101
	Rice	Jaya	12-6-84	17-10-85	128
	Rice	Jaya	15-10-84	16-2-85	125
S_6	Fallow				
	Rice	Jaya	12-6-84	17-10-84	128
	Rice	Jaya	15-10-84	16-2-85	125

3.2. Methods

3.2.1. Observations

In the summer crops observations are limited to the yield, dry matter production and uptake of major nutrients, since the major emphasis is on the effect of these crops on the productivity of the succeeding crops of rice. In the succeeding rice crops the observations are limited to yield attributes and yield. Two hill x two hill sampling units marked in the net plots were taken for recording the observations (Gomez, 1972).

3.2.1. Cassava

3.2.1.1. Weight of fresh tuber

The net plots were harvested leaving one row as border. The weight of the fresh tuber after removing the soil was recorded and expressed as kg ha^{-1}.

3.2.1.2. Dry matter production

The unit weight of the fresh tuber as well as stem were sundried till constant weights were obtained and dry matter production recorded kg ha^{-1}.

3.2.2. Cowpea

3.2.2.1. Yield of grain

After leaving the border the net plots were harvested. The pods were sundried and the grains were separated from the pods, the grains were again sundried and the weight of the grains expressed as kg ha^{-1} at 13 per cent moisture.

3.2.2.2. The yield of haulms

The cowpea were cut at ground level and the fresh weight of green matter was expressed as kg ha^{-1}.

3.2.2.3. Dry matter production

The unit weight of green matter as well as pods were sundried till constant weights were obtained and the dry matter expressed as kg ha^{-1}.

3.2.3. Ground nut

3.2.3.1. Yield of pods

The net plots were harvested after leaving two border rows. The well developed pods were separated from the plants and the weight of pods in each net plot was recorded and expressed in kg ha^{-1}.

3.2.3.2. Yield of haulms

After separating the well developed pods the fresh weight of green matter was recorded and expressed as kg ha^{-1}.

3.2.3.3. Dry matter production

The unit weight of green matter as well as pods were sundried hill constant weights were obtained and the dry matter expressed as kg ha^{-1}

3.2.4. Bhendi

3.2.4.1. Yield of fresh fruits

The weight of fresh fruits from the harvests of net plots were added together and the weight of fresh fruits expressed as kg ha^{-1}.

3.2.4.2. Wet weight of plants

After the harvest of the fruits were over, plants from net plots were up rooted, their weight recorded and expressed as kg ha^{-1}.

3.2.4.3. Dry matter production

Unit weight of fresh fruits and green plants were sundried till constant weights were obtained and the dry matter production expressed as kg ha^{-1}.

3.2.5. Rice

3.2.5.1. Number of productive tillers m^{-2}

The productive tillers from the four hills were recorded before harvest and expressed as productive tillers m^{-2}.

3.2.5.2. Number of filled grains $panicle^{-1}$

All the filled grains in each panicle of four hills collected at maturity were counted and the mean value recorded.

3.2.5.3. 1000 grain weight

1000 grain weight was recorded as per the procedure described by Gomez (1972).

3.2.5.4. Grain yield

Harvesting and threshing grains from each net plot after leaving two border rows, were sundried for three days and the grain and chaff were separated. Grain yield was expressed in kg ha^{-1} at 14 per cent moisture.

3.2.5.5. Straw yield

After separating the grains by threshing the straw from the net plots were sundried repeatedly and the straw yield expressed as kg ha^{-1}.

3.2.5.6. Dry matter production

The plant samples already marked were cut above ground level and the dry matter expressed as kg ha^{-1} on oven dry basis.

All the above observations were recorded in both first and second crops of rice. In summer rice only the yield of grain, straw and dry matter production were recorded as observations.

3.2.6. Collection and analysis of soil samples

Soil samples from the main plots were collected before the starting of the experiment, after the completion of one year, two years of crop sequences and analysed for available NPK and oganic carbon.

3.2.6.1. Soil analysis

The soil samples were dried in shade seived through 2 mm seive and used for the following estimations. For the estimation of the organic carbon Walkely and Blacks wet digestion method was followed (Piper,1966). Available N of soil was estimated by alkaline permanganate method (Subbiah and Asija, 1956). Available P of soil was extracted with Bray No.1 solution and estimated by chlorostanous reduced molybdophosphoric acid blue colour method as reported by Jackson (1973). Available K, was extracted with neutral normal ammonium acetate and estimated as per the procedure suggested by Jackson (1973).

3.2.7. Analysis of plants

N content of plant samples were determined by Micro kjeldahl method and P of triacid digested extract by vanadomolybdophosphoric yellow colour method as suggested by Jackson (1973). The K content of the extract was read in a flame photometer (Jackson 1973).

3.2.8. Economics of cropping system under different fertilizer levels

The cost of cultivation, total income and net returns and cost benefit ratio for each cropping system were worked out at price levels at the time of experimentation (1983 and 1984) and out put of produce, and the relative merits of the cropping systems and fertilizer treatments were calculated.

3.2.9. Energy equivalents of cropping system

In the study of rice based cropping systems it is a common practice to evaluate the different cropping systems in terms of rice equivalents based on the market value of the different produces obtained in the cropping systems. Since the price of an agricultural produce is determined by factors beyond the control of the farmer, in the present study the various cropping systems are evaluated in terms of energy values of the edible produces obtained from cropping systems. The energy values of the edible outputs under various cropping systems were worked out based on the calorific values given by Gopalan et al. (1984).

3.2.10. Statistical analysis

The experimental data were statistically analysed applying the technique of analysis of variance appropriate to the experiment (Gomez and Gomez 1984). Critical difference are estimated at 5 per cent level of probability.

RESULT AND DISCUSSION

4. RESULT AND DISCUSSION

The results of the experiments conducted to study the performance of rice based cropping systems, their effect on soil fertility, the economics of various cropping systems under different levels of nutrients and the residual effect of summer crops on the succeeding rice crop are presented and discussed in this chapter.

The discussion of the results is attempted first on summer crops followed by first and second crops of rice. This has also enabled to examine the cropping systems as a whole rather than individual crops.

Even though the biometrical observations on all the growth characters, yield attributes were taken in the rice crops grown in the first and second crop seasons only such of those observations which are directly useful and relevant for the interpretation of the data are included in the thesis. However the references are made to the data of the observations taken where ever necessary. The voluminous nature of the work as well as the large number of tables to be handled necessitated the reduction of the bulk to the bare minimum.

One of the main objectives of the study is to assess the impact of the summer crops on the succeeding crops in the rice based cropping system. Hence only yield, dry matter production and uptake of nutrients alone are taken for consideration for discussion of summer crops.

In the case of succeeding rice crops also only observation such as yield attributes, yield of grain and straw and uptake of N, P and K are taken as observations and combined discussion is attempted on the cropping system as a whole.

The pooled analysis of the data on the observations of the first and second crops of rice of both years was not attempted since interaction of treatments over years were absent. In the case of observations on second crops of first and second years the mean values of treatments (M_0 and M_1) are considered for deducing the residual effect of the fertility variations of the first crop treatments, since the residual effect are better manifested in the mean values than in M_0 and M_1 values individually. Only treatments which gives maximum yield and are significantly on par with them during both the years are taken into consideration for discussion.

4.1. Cassava-rice-rice system

4.1.1. Cassava

Cassava cv. malavella was raised as a summer crop in the S_1 cropping system and the results of the observations are presented in tables 3 a and 3 b and discussed below.

In the first year this crop recorded 14000 kg ha^{-1} fresh tuber and in the second year 9625 kg ha^{-1}. In the case of dry matter production the respective figures were 9423 and 5469. The reduction in second year with regard to the yield of tuber as well as DMP is attributed to the adverse climatic conditions, especially rainfall received during the bulking period or the cassava. The uptake of the nutrients in the respective years also shows a similar trend. The reduction of yield during second year is partly due to the impact of the previous two crops of rice which is discussed else where. The nutrient content of the soil analysed after one year sequence showed (Tables 60, 62 & 64) that there was a reduction in the nutrient status especially N and K when compared to its initial analysis.

The uptake of nutrients which is found to be proportional to the tuber yield is in agreement with the findings of Kumar *et al*. (1987).

Table 3.a. Yield of summer crops (kg) during 1983 and 1984

	1983	1984
1. Cassava (CV: Malavella)		
Weight of fresh tuber	14,000	9625
Dry matter production	9423	5469
2. Cowpea (CV: Krishnamony)		
Weight of sundried grain	1050	1200
Dry matter Production	2320	2600
3. Ground nut (CV: TMV-2)		
Weight of dry pods.	2250	2510
Dry matter production	7040	7433
4. Bhendi (CV: Pusa Sawani)		
Weight of fresh fruits	6400	5850
Dry matter production	4365	3893
5. Rice (Triveni)		
Weight of grain	3210	3020
Dry matter Production	5682	5390

Table No: 3b. Uptake of nutrients by summer crops ($kg\ ha^{-1}$)

	1983			1984		
	N	P	K	N	P	K
Cassava	94.32	13.26	108.50	84.83	9.64	76.43
Cowpea	56.63	7.42	34.82	58.46	8.05	36.21
Groundnut	108.24	12.40	42.41	110.53	12.86	43.63
Bhendi	46.55	9.89	43.28	42.61	8.73	39.40
Rice (SD)	65.36	10.93	68.30	60.64	10.42	64.46

Table 4a. 1983. Kharif rice - Yield of grain (kg ha^{-1})

Cropping Systems	Fertilizer doses F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
S1	2564	3227	3267	3332	3442	3472	3521	3578	3600	3662	3366
S2	2650	3232	3350	3372	3480	3552	3630	3665	3665	3675	3424
S3	2700	3247	3352	3375	3477	3527	3527	3535	3567	3637	3394
S4	2745	3252	3337	3347	3347	3547	3652	3652	3667	3682	3435
S5	2500	2872	3117	3232	3275	3222	3445	3260	3470	3482	3217
S6	2510	2672	2847	2965	3175	3227	3262	3352	3452	3550	3101

SE/Plot = 10.4 CD (S) = 16.9 CD (F within S) = 29.4

Table 4b. 1984 Kharif rice - Yield of grain (kg ha^{-1})

Cropping Systems	Fertilizer doses F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
S1	2565	3227	3267	3332	3437	3467	3550	3567	3600	3667	3368
S2	2647	3232	3345	3372	3480	3550	3632	3657	3665	3670	3425
S3	2745	3252	63337	3332	3470	3545	3652	3655	3682	3677	3435
S4	2700	3245	3352	3372	3475	3527	3527	3535	3567	3637	3394
S5	2532	2850	3122	3232	3272	3387	3445	3460	3470	3482	3225
S6	2510	2672	2847	2965	3165	3165	3257	3350	3452	3535	3098

SE/Plot = 11.7 CD (S) = 8.2 CD (F within S) = 33.2

4.1.2. Kharif rice

4.1.2.1. Grain yield (kg ha^{-1})

The result of grain yield are presented in tables 4 a and 4 b respectively.

The mean yield recorded under the S_1 system over varying fertilizer levels were 3366 kg ha^{-1} (1983) and 3368 kg ha^{-1} (1984) indicating that there was practically no difference in yield over years. The control plot recorded an yield of 2564 kg ha^{-1} and 2565 kg ha^{-1}. In 1983 the increase in yield from F_1 to F_9 was progressive and it was significant upto F_8. F_8 and F_7 were on par F_9 gave significantly higher yield than all other treatments. In 1984 the same trend was obtained. F_7 and F_6, were on par. Others were significantly inferior. Since the treatments F_9 and F_8 are on par there is an economy of 25 per cent of P and K in the S_1 system. This must have resulted from the residual effect of 12 t ha^{-1} of FYM given to the summer crop. Since the cropping system is continuous the second year results are more relevant. Here the F_8 is significant and between treatments F_8 and F_7 the farmer can choose either one depending on the economics.

Cassava being an exhaustive crop application of NPK over no fertilization is definitely advantageous and as the level of nutrition is more there is a corresponding increase in the productivity of the rice in the kharif crop of both the years.

4.1.2.2. Number of productive tillers

The result on the number of productive tillers of kharif rice are presented in tables 5 a and 5 b respectively.

In 1983 and 1984 the mean number of productive tillers recorded under S_1 system over varying fertilizer levels were 271.00 and 270.60, indicating that there was no appreciable variation in this yield attribute over years. The control plots recorded 221.00 productive tillers in 1983 and 225.50 in 1984. The highest number of productive tillers of 300 was recorded under F_9 in the first year and 301.50 under F_9 in the second year. The same trend was recorded for the grain yield of kharif crop also under the S_1 system of cropping. The increase in the number of productive tillers from F_1 to F_9 was progressive and significantly superior to F_0 in the first and second years.

Cassava being an exhaustive crop application of NPK over no fertilization is definitely advantageous and as the level of nutrition is more there is a corresponding increase able 5a. 1983 Kharif rice - No. of productive tillers M^{-2} at maturity

opping stems	FO	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
	Fertilizer doses										
S1	221.00	250.00	256.00	265.00	270.00	278.50	285.00	289.50	295.00	300.00	271.00
S2	222.00	247.00	254.40	264.00	272.50	280.50	286.00	293.50	301.50	306.50	272.80
S3	224.50	245.50	255.50	260.50	269.00	281.50	288.00	294.00	296.50	301.50	271.65
S4	224.50	253.00	257.50	263.50	272.50	280.50	286.00	291.00	296.50	307.50	273.25
S5	226.00	243.50	254.00	263.50	273.50	281.00	286.50	295.00	305.00	306.00	273.40
S6	220.00	241.00	250.00	254.00	264.00	274.00	280.00	284.50	294.50	300.50	266.25

SE/Plot = 1.218 CD (S) = 2.863 CD (F within S) = 3.464

able 5b. 1984 Kharif rice - No. of productivity tillers M^{-2} at maturity

ropping ystems	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Mean
	Fertilizer doses										
S1	225.50	251.00	255.00	264.50	270.00	278.50	283.50	286.50	293.00	301.50	370.60
S2	221.00	246.00	254.00	263.00	263.00	272.50	285.50	292.50	300.00	307.00	272.10
S3	224.50	244.00	252.50	259.00	267.50	280.50	286.00	291.50	297.00	297.50	270.10
S4	223.50	225.00	225.50	262.00	274.00	281.50	287.00	290.50	293.50	306.00	272.85
S5	226.50	243.50	251.00	266.00	273.50	279.00	285.00	295.00	305.00	303.00	272.80
S6	221.50	243.00	250.50	253.50	264.50	276.50	282.50	284.50	293.50	299.00	266.90

SE/Plot = 1.671 CD (F within S) = 4.750 Means of (s) = Not. sig

Table 6a. 1983 Kharif rice – No. of filled grains/pancile

Cropping Systems	Fertilizer doses F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
S1	56.50	65.60	65.95	67.70	66.10	67.80	67.25	71.05	72.20	71.60	67.07
S2	57.75	66.10	66.00	65.80	68.10	69.85	43.25	71.90	73.00	72.70	68.01
S3	56.90	65.50	66.55	66.40	68.80	69.20	69.25	71.10	72.55	72.15	67.84
S4	58.75	65.30	66.25	66.10	67.75	68.00	69.90	72.00	72.90	72.95	68.19
S5	56.80	64.10	65.10	65.80	66.60	66.30	65.30	68.30	68.15	69.95	66.64
S6	56.70	62.90	63.70	63.70	65.80	66.60	66.55	70.00	69.35	69.85	65.51

SE/Plot = 0.423 CD (F within S) = 1.200 CD(s) = 0.545

Table 6b. 1984 Kharif rice – No. of filled grains/pancile

Cropping Systems	Fertilizer doses F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Mean
S1	56.80	62.90	63.80	63.45	65.80	66.70	65.95	69.75	69.85	67.30	65.23
S2	58.75	66.25	66.10	67.75	68.00	69.90	71.90	72.50	72.45	72.70	68.63
S3	56.90	65.50	66.55	66.40	68.80	69.20	69.25	71.10	72.45	72.00	67.81
S4	57.40	66.10	65.00	65.75	68.00	69.95	69.85	71.90	72.70	72.35	67.90
S5	56.80	64.00	65.10	65.80	66.70	66.10	65.30	68.30	68.15	69.95	65.62
S6	56.85	65.60	65.95	67.75	66.10	67.80	67.25	69.85	72.05	71.25	67.04

SE/Plot = 0.403 CD (S) = 0.837 CD (F within S) = 1.445

in the number of productive tillers in the kharif crop of both years.

It may also be seen from the tables that during 1983 the treatments F_9, F_8, F_7 and F_6 recorded significantly higher number of tillers than the rest and they themselves were significantly different and the same trend followed during 1984 also. Thus it could be seen that the optimum production of this yield attribute is best expressed at 100 per cent recommended NPK dose ie. at 90:45:45 kg ha^{-1}. (Place et al., 1970; Nair et al., 1972; Bhattacharya and Chatterji, 1978).

4.1.2.3. Number of filled grains $panicle^{-1}$

The results recorded on the number of filled grains $panicle^{-1}$ in 1983 and 1984 are presented in table 6 a and 6 b respectively.

The mean number of filled grains in 1983 was 67.02 and in 1984 it was 65.23. The control plots recorded the number of filled grains $panicle^{-1}$ of 56.50 and 56.80 in the first and second years respectively. The control plots recorded 56.5 filled grains $panicle^{-1}$ in 1983 and 56.8 filled grains $panicle^{-1}$ in 1984. The maximum number of filled grains of 72.20 (1983) and 69.85 (1984) were obtained under

F_8 treatments. In general there was a progressive increase in the number of filled grains panicle^{-1} from F_1 to F_9 in both the years. Grain filling is attributed to be a function of nitrogen and potassium and this is amply substantiated with the N and K nutrients contained in treatments F_8 (Chandrasekharan, 1984; Sankaranarayana, 1985; Krishna kumar, 1986; Singh and Varma, 1971; Singh and Prakash 1979). Thus there is an economy of 25 per cent of recommended dose of P and K for the maximisation of this yield attribute in the kharif rice under S_1 system of cropping. This 25 per cent P and K must have come from the residual effect of the FYM applied to the summer crop of cassava at 12 t ha^{-1}.

4.1.2.4. 1000 grain weight (g)

The result recorded on 1000 grain weight (g) in 1983 and 1984 are presented in tables 7 a and 7 b. The mean 1000 grain weight in 1983 was 28.11 g and in 1984 it was 28.00 g. The control plots recorded 26.60 g in 1983 as well as in 1984. The 1000 grain weight under varying treatments from F_1 to F_9 ranged from 26.60 g to 28.80 g in 1983, and from 26.60 g to 28.65 g in 1984. The treatments F_9, F_7 and $_6$ are on par in 1983. This shows that 75 per cent of N and 100 per cent of P and K are sufficient for attaining maximum values in this yield character. Even though 1000 grain weight is a genetically governed attribute it is reported by

Table 7a. 1983 Kharif rice – 1000 grain weight(g)

Cropping Systems	Fertilizer doses F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Mean
S1	26.60	27.55	27.55	27.60	28.40	28.35	28.65	28.85	28.75	28.80	28.11
S2	27.05	27.55	27.45	27.25	28.00	28.30	28.25	28.55	28.75	28.75	27.99
S3	26.80	27.15	27.25	27.35	28.15	28.35	28.15	28.70	28.80	28.65	27.93
S4	27.05	27.35	27.40	27.45	27.85	28.15	28.15	28.35	28.55	28.70	27.90
S5	26.55	27.10	27.20	27.35	27.80	28.40	28.25	28.35	28.45	28.75	27.84
S6	26.75	27.10	27.40	27.50	27.70	27.60	27.70	28.30	28.25	28.30	27.66

SE/Plot = 0.138 CD (S) = 0.193 CD (F within S) = 0.392

Table 7b. 1984 Kharif rice – 1000 grain weight (g)

Cropping Systems	Fertilizer doses F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Mean
S1	26.60	27.55	27.55	27.60	28.40	28.35	28.55	28.55	28.25	28.65	28.00
S2	27.05	27.55	27.35	27.50	28.50	28.05	28.30	28.65	28.60	28.65	28.02
S3	27.05	27.35	27.40	27.45	27.75	28.15	28.15	28.35	28.55	28.70	27.89
S4	26.80	27.15	27.25	27.50	27.35	28.15	28.35	28.15	28.70	28.50	27.79
S5	26.65	27.10	27.35	27.50	27.70	27.60	27.30	28.30	28.35	28.45	27.63
S6	26.65	27.10	27.20	28.35	28.40	28.25	28.60	28.45	28.50	28.60	27.91

SE/Plot = 0.140 CD (S) = [illegible] CD (F within S) = [illegible] many authors that this character is also influenced by nutrition (Majumdar, 1971; Chaudahury et al., 1978; and Venkittasubbiah et al.,1982). In 1984 treatments F_9, F_7, F_6, F_5, F_4 and F_8 are on par. This shows that there is a saving of 25 per cent of N or 50 per cent of P and K in this system. This also reveals that when N is applied at 100 per cent level only 50 per cent of P and K need be applied. Nitrogen helps in filling up of the grains very effectively through its enhanced role in photosynthesis and accumulation of starch in the grain where as when N application is reduced to 75 per cent, P and K is to be applied in full quantities to compensate the reduction in the dose of nitrogen. In other words 25 per cent of the recommended N (22.5 kg ha^{-1}) is equivalent to 22.5 kg ha^{-1} each of P and K. This means that an unit quantity of N can fulfill the role of equal quantities of P and K put together.

4.1.2.5. Yield of straw kg ha^{-1}

The results recorded on the yield of straw in 1983 and 1984 are presented in tables 8 a and 8b. The mean yields of straw in 1983 was 3474 kg ha^{-1} and in 1984 it was 3476 kg ha^{-1}. The yields of straw in the control plots were 2717 kg ha^{-1} in 1983 and 2710 kg ha^{-1} in 1984. In 1983 the highest Yield of straw was under F_9 (3717 kg ha^{-1}) followed by F_8 and F_7 which were on par with F_8. In 1984 also maximum straw yield was under F_9 followed by F_7 and F_8 which were on par with F_9. This shows that for the maximum production of straw an NPK combination of 100:50:50 percentage of the recommended dose is sufficient under cassava-rice-rice system. The remaining 50 per cent of P and K might have been absorbed from the soil in the presence of higher dose of nitrogen. Depletion of N would have taken place by cultivation of cassava and hence this response to nitrogen. Uptake of N by cassava was exhaustive (table 3 b). In the case of P there was an increase from 12.67 kg ha^{-1} to 14.70 kg ha^{-1} after the first year sequence and 14.80 kg ha^{-1} after the second year sequence (tables 62 and 63). This indicates that there was considerable enrichment of soil P by the rice cropping probably due to the accumulation of the stubbles. The entire quantity of P added to the system also was not fully utilised with the result that both first and second crop of rice required only 50 per cent of the fertilizer phosphorus. In the case of potash also much depletion has not taken place in spite of two successive rice crops per year. The added K for cassava and succeeding rice crop has left a considerable quantity still in the soil there by reducing the fertilizer K requirement also to 50 per cent. The residual effect of FYM applied to the summer cassava crop at 12 t ha^{-1} also can be another source for the soil P and K supply.

Table 8a. 1983 Kharif rice - Yield of straw (kg ha^{-1})

Cropping Systems	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
			Fertilizer doses								
S1	2717	3305	3372	3612	3612	3610	3637	3695	3702	3717	3474
S2	2790	3335	3505	3535	3550	3655	3615	3660	3792	3825	3526
S3	2897	3320	3415	3500	3540	3622	3662	3730	3785	3835	3530
S4	2865	3367	3460	3445	3547	3575	3602	3700	3720	3795	3507
S5	2705	3332	3295	3452	3451	3505	3482	3622	3657	3670	3417
S6	2695	3312	3290	3262	3395	3435	3462	3502	3535	3555	3344

SE/Plot = 13.5 CD (S) = 33.2 CD (F within S) = 38.3

Table 8b. 1984 Kharif rice - Yield of straw (kg ha^{-1})

Cropping Systems	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
			Fertilizer doses								
S1	2710	3292	3372	3357	3620	3650	3640	3700	3697	3722	3476
S2	2785	3325	3480	3530	3522	3630	3635	3652	3792	3825	3517
S3	2890	3325	3390	3500	3540	3615	3627	3732	3752	3827	3520
S4	2852	3365	3475	3450	3532	3575	3572	3697	3717	3800	3503
S5	2730	3334	3295	3452	3460	3505	3482	3610	3635	3660	3416
S6	2720	3312	3242	3262	3392	3440	3460	3502	3452	3552	3342

SE/Plot = 20.9 CD (S) = 23.6 CD (F within S) = 59.6

Table 9a. 1983 Kharif rice - Nitrogen uptake by rice (kg ha^{-1}) at maturity

Cropping Systems	Fertilizer doses F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
S1	54.75	59.05	65.50	68.25	73.00	75.10	74.95	79.80	80.40	80.30	71.11
S2	57.85	63.65	64.80	66.10	78.65	78.65	79.20	80.05	81.10	81.00	73.10
S3	57.35	64.00	64.80	66.10	78.65	78.65	78.05	80.75	81.20	81.80	73.07
S4	58.15	64.85	65.05	64.90	77.85	78.85	79.05	80.00	81.95	81.25	73.19
S5	53.95	58.50	59.05	60.20	68.60	69.95	70.00	73.20	74.10	75.00	66.25
S6	55.45	65.10	65.05	65.50	71.05	70.90	71.95	74.50	76.70	76.60	69.28

SE/Plot = 0.398 CD (S) = 0.340 CD (F within S) = 1.132

Table 9b. 1984 Kharif rice - Nitrogen uptake by rice (kg ha^{-1}) at maturity

Cropping Systems	Fertilizer doses F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
S1	54.95	58.55	65.50	68.20	73.00	75.10	74.75	79.80	80.85	80.30	71.09
S2	57.85	63.80	64.80	66.00	78.65	78.50	78.70	80.05	81.10	81.00	73.04
S3	58.15	64.85	65.05	64.90	77.85	78.85	78.80	78.75	81.95	81.25	73.04
S4	57.35	64.00	64.45	65.20	78.95	78.95	78.05	80.75	81.20	81.90	73.08
S5	55.35	65.10	65.15	65.50	71.05	70.90	71.90	74.50	76.70	76.70	69.28
S6	53.95	58.50	59.05	60.20	68.60	69.95	70.00	73.20	74.10	75.15	66.27

SE/Plot = 0.414 CD (S) = 0.375 CD (F within S) = 1.177

4.1.2.6. Uptake of nitrogen kg ha^{-1}

The result on the total uptake of nitrogen by kahrif rice of 1983 and 1984 are presented in table 9 a and 9 b.

In 1983 the mean uptake of nitrogen was 71.11 kg ha^{-1} and in 1984 71.09 kg ha^{-1} in S_1 system indicating that there was no difference in the uptake of nitrogen by kharif crop under S_1 system over years. The control plots recorded nitrogen uptake of 54.75 kg ha^{-1} (1983) and 54.95 kg ha^{-1} (1984). The uptake of nitrogen under different fertilizer levels (F_1 to F_9) varied from 59.05 kg ha^{-1} to 80.30 kg ha^{-1} in 1983 and from 58.55 kg ha^{-1} to 80.30 kg ha^{-1} in 1984.

In general there is an increase in N uptake with increased levels of fertilizer. The treatments F_9, F_8 and F_7 are on par. The uptake is proportionate to the fertilizer doses and not seen related to the inherent soil fertility.

4.1.2.7. Uptake of phosphorus kg ha^{-1}

The result of the uptake of phosphorus by kharif rice in 1983 and 1984 are presented in table 10 a and 10 b.

The mean uptake of phosphorus in 1983 was 11.40 kg ha^{-1} and 11.42 kg ha^{-1} in 1984 under the S_1 system. The uptake of phosphorus in the control plots were 8.60 kg ha^{-1} (1983) and 8.50 kg ha^{-1} (1984). Though there is a trend of a slight increase in the uptake of phosphorus from F_1 to F_9 in both years the increase is not commensurate with the nutrient supplied. This can be attributed to the inherent capacity of the flooded rice soils to release sufficient quantities of native phosphorus to the crop as recorded by many workers. (Shapiro, 1958; Ponnmperuma, 1965; Patrick and Mahapatra, 1968). Less uptake response of phosphorus applied at enhanced rates can be due to fixation under acidic condition as recorded by Khanna and Mahajan, (1971), Bendra, (1974).

4.1.2.8. Uptake of potassium kg ha^{-1}

The results on uptake of K is presented in tables 11 a and 11 b.

The mean uptake of K over different fertilizer levels in 1983 was 61.31 kg ha^{-1} and 61.11 kg ha^{-1} in 1984, thus indicating little variation on the uptake of potassium over years by kharif rice. The control plots recorded an uptake of 48.50 kg ha^{-1} in 1983 and 48.25 kg ha^{-1} in 1984. In 1983 the maximum uptake of 68.45 kg ha^{-1} was recorded under F_9 and all other treatments were inferior. In 1984 maximum uptake of 66.90 kg ha^{-1} was under F_9 followed by F_8

Table 10a. 1983 Kharif rice - Phosphorous uptake by rice ($kg\ ha^{-1}$) at maturity

Cropping Systems	Fertilizer doses F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
S1	8.60	10.70	11.40	11.70	11.25	11.50	11.70	12.40	12.25	12.50	11.40
S2	8.70	11.10	11.50	11.30	11.10	12.60	12.20	12.30	12.40	12.55	11.57
S3	8.95	11.00	11.40	11.60	11.50	11.65	12.10	11.90	12.10	12.45	11.46
S4	8.70	10.60	11.00	11.40	11.50	11.65	12.10	12.20	12.50	12.65	11.43
S5	8.50	10.30	10.70	11.10	11.00	11.00	11.40	11.55	12.20	12.25	11.03
S6	8.60	10.35	10.80	10.70	11.15	11.35	11.15	11.80	11.65	11.95	10.95

SE/Plot = 0.119   CD (S) = 0.219   CD (F within S) = 0.338

Table 10b. 1984 Kharif rice - Phosphorus uptake by rice ($kg\ ha^{-1}$) at maturity

Cropping Systems	Fertilizer doses F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
S1	8.50	10.70	11.40	11.65	11.50	11.65	11.70	12.40	12.25	12.50	11.42
S2	8.70	11.10	11.50	11.30	11.10	12.20	12.20	12.30	12.40	12.55	11.53
S3	8.95	11.00	11.40	11.60	11.55	11.75	12.10	11.90	12.40	12.55	11.52
S4	8.70	10.60	11.00	11.40	11.50	11.65	12.10	12.20	12.50	12.65	11.43
S5	8.50	10.30	10.70	11.10	11.60	11.00	11.55	11.85	12.20	12.25	11.10
S6	8.60	10.35	10.80	10.70	11.15	11.35	11.15	11.70	11.70	11.90	10.94

SE/Plot = 1.542   CD (S) = 0.223   CD (F within S) = 0.438

Table 11a. 1983 Kharif rice - Potassium up take by rice (kg ha^{-1}) at maturity

Cropping Systems	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
	Fertilizer doses										
S1	48.50	55.30	56.65	58.10	63.45	64.00	65.40	66.45	66.80	68.45	61.31
S2	47.95	56.15	57.20	58.90	64.00	64.95	66.40	67.80	68.50	68.30	62.01
S3	49.05	55.15	56.55	58.25	64.05	64.90	65.35	67.10	67.55	68.25	61.62
S4	49.70	54.60	56.40	56.30	63.70	65.30	65.25	66.65	67.30	68.00	61.32
S5	48.10	53.10	54.40	54.50	61.50	62.70	63.15	65.05	66.05	66.70	59.22
S6	48.25	56.00	57.70	58.30	62.95	64.80	65.30	64.65	66.20	67.00	61.11

SE/Plot = 0.341 CD (S) = 0.568 CD (F within S) = 0.971

Table 11b. 1984 Kharif rice - Potassium uptake by rice (kg ha^{-1}) at maturity

Cropping Systems	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	Mean
	Fertilizer doses										
S1	48.25	56.00	57.70	58.30	62.95	64.80	65.25	64.70	66.30	66.90	61.11
S2	49.70	54.60	56.40	56.20	63.70	65.25	65.75	65.25	67.30	68.00	61.21
S3	47.95	56.15	57.20	59.00	64.00	64.95	66.40	68.10	68.40	68.30	62.04
S4	49.05	55.00	56.55	58.25	64.05	64.90	65.35	67.10	67.55	68.25	61.60
S5	48.10	53.10	54.50	54.50	61.50	62.70	65.05	66.05	66.70	68.40	60.06
S6	48.50	55.30	56.65	58.10	63.45	64.00	65.40	66.45	66.80	68.45	61.31

SE/Plot = 0.411 CD (S) = 0.593 CD (F within S) = 1.169

which was on par with F_9. This shows that there can be a saving of 25 per cent of the recommended dose of K for kharif rice crop under the cassava-rice-rice system. In general there is an increased uptake of K with increase in the application of the nutrient. This also shows that in the absence of K supplied through fertilizer, this nutrient is released from the soil in sufficient quantities. This is also evidenced by the fact that the total uptake of K under different treatments are more than what is supplied through fertilizers.

4.1.3. Rabi rice

4.1.3.1. Grain yield kg ha^{-1}

The results of grain yield of rabi rice recorded in 1983 and 1984 is presented in table 12.

In 1983 F_9 gave maximum grain yield and the treatments F_0, F_1, F_2 and F_4 are significantly inferior. In 1984 rabi also F_9 recorded the maximum grain yield and treatments F_0, F_1, F_2 and F_4 were inferior. From this it can be inferred that residual effect of fertilizer applied to the kharif crop is transmitted to the succeeding rabi crop only if fertilizer levels F_5 and above are applied to the kharif crop.

The treatments F_8, F_7, F_6 and F_5 are on par with F_9. This shows that N, P and K applied at the level of 100 per cent each exhibited residual effect to the succeeding rice crop. If the N can be increased to 100 per cent the P and K can be reduced to 50 per cent of the recommended dose. Balanced application of NPK at 75 per cent of recommended dose also gave significant residual effect.

In a cassava-rice-rice system of cropping the cassava being an exhaustive feeder must have foraged all the nutrients and hence the succeeding rice crop at least must get P and K at 50 per cent level if N is maintained at 100 per cent level of recommended dosage for obtaining residual effect to the next rice crop.

4.1.3.2. Number of productive tillers m^{-2}

The result on number of productive tillers in 1983 and 1984 is presented in table 13.

The mean number of productive tillers over varying fertilizer levels in 1983 was 247.37 and in 1984 it was 247.10. This yield attribute was consistently higher under the fertilizer levels F_9, F_8 and F_6 during both the years and the lowest was under F_1 and F_2. Treatments such as F_7, F_5, F_3 and F_4 have recorded lesser number of productive tillers than F_9, F_8 and F_6.

Table 12. Rabi rice-yield of grain (kg ha^{-1}) cassava-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	2439	3008	2723	2482	2991	2736
F_1	2501	3005	2753	2490	2995	2742
F_2	2471	3027	2749	2473	2967	2720
F_3	2507	3064	2785	2499	3048	2774
F_4	2491	3075	2783	2480	2996	2738
F_5	2470	3099	2784	2503	3048	2775
F_6	2507	3082	2795	2475	3075	2775
F_7	2539	3072	2804	2488	3085	2784
F_8	2529	3084	2807	2523	3055	2789
F_9	2558	3121	2834	2563	3103	2832
Mean	2501	3064	2782	2497	3036	2766
SEm	31.80			28.02		
CD(F)			66.56			56.63
CD (Fxm)	94.13			82.92		

Table 13. Rabi rice - No. of productive tillers m^{-2} at maturity Cassava-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	225.00	266.00	245.50	226.00	266.00	246.00
F_1	226.50	260.50	243.50	224.50	260.50	242.50
F_2	222.50	264.50	243.50	222.00	265.50	243.75
F_3	224.50	266.00	245.25	225.00	266.00	245.50
F_4	225.00	269.00	247.00	225.00	269.00	247.00
F_5	230.00	265.50	247.75	225.50	265.50	245.50
F_6	232.50	265.00	248.75	232.50	265.50	249.00
F_7	229.00	266.00	247.50	227.00	266.00	247.50
F_8	232.00	272.50	252.50	231.50	272.50	252.00
F_9	233.50	272.00	252.75	233.50	273.00	253.25
Mean	228.05	266.70	247.37	227.25	266.95	247.10
SEm	1.642			1.535		
CD (F)			3.437			3.212
CD (F x M)	4.861			4.861		

The higher number of productive tillers recorded under fertilizer levels of F_9 and F_8 is evidently due to the residual effect of at 100 per cent of the recommended dose of nitrogen. The treatment F_6 contains 75 per cent of recommended dose of N and 100 per cent of P and K. Here the deficiency of 25 per cent of N might have been compensated due to the residual and cumulative effect of 12 t ha^{-1} of FYM applied to the summer cassava crop under the S1 system.

4.1.3.3. Number of filled grains $panicle^{-1}$

The result recorded on the number of filled grains $panicle^{-1}$ on rabi crop during 1983 and 1984 is presented in table 14.

The mean number of filled grains $panicle^{-1}$ produced in 1983 was 60.65 and in 1984 it was 60.75. Higher number of filled grains $panicle^{-1}$ was recorded under the fertilizer levels F_9, F_8 and F_7 consistently during both the years. This indicates that adequate and balanced nutrition is required for contributing residual effect to the succeeding rabi crop for the full expression of this yield attribute. In treatment F_9, 100 per cent of the recommended dose of N, P and K is available. Lower number of productive tillers were recorded corresponding to the kharif treatments F_0, F_2, F_3 and F_4 indicating lesser or no residual effect under lower rate of application of major nutrients to the kharif crop. The same trend was recorded in the case of rabi grain yield also where in F_9 registered maximum yield during both the years.

4.1.3.4. 1000 grain weight (g)

The result on 1000 grain weight on rabi rice in 1983 and 1984 is presented in table 15.

The mean values of 1000 grain weight in 1983 was 27.25 g and 1984 it was 27.27 g. The result shows that the residual effect of kharif treatments in increasing the 1000 grain weight of rabi crop is profound under treatments F_8, F_9, F_6 and F_7 during both the years. Thus the higher weight of 1000 grain obtained under the above mentioned treatments can be attributed to the residual effect of balanced nutrients (N, P and K) at higher levels.

Cassava being a very exhaustive feeder there was good response to the applied fertilizers especially at higher doses. This is reflected in the yield of kharif season. In rabi also there is increased yield due to residual effect of treatments which received higher doses of fertilizer during kharif season.

Table 14. Rabi rice - Number of filled grains panicle^{-1}
Cassava-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean (F)	MO	M1	Mean (F)
FO	56.80	63.55	60.17	56.90	63.90	60.40
F1	58.00	63.55	60.97	57.30	64.60	60.95
F2	57.80	62.15	60.40	57.80	62.15	59.97
F3	57.55	62.85	60.20	57.85	63.40	60.62
F4	56.80	64.05	60.42	56.75	64.10	60.42
F5	57.45	64.15	60.80	57.55	64.30	60.92
F6	57.80	63.65	60.72	57.80	64.00	60.97
F7	57.50	64.35	60.92	58.05	64.05	61.05
F8	58.10	64.15	61.12	58.00	64.00	61.00
F9	58.65	64.25	61.45	58.40	64.15	61.25
Mean	57.64	63.67	60.65	57.64	63.86	60.75
SEm	0.642			0.391		
CD (F)			1.344			
CD (F x M)	1.900			1.159		

Table 15. Rabi rice - 1000 grain weight (g) Cassava-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	26.20	27.25	26.97	26.30	27.65	26.97
F1	26.15	28.45	27.30	26.30	28.35	27.32
F2	26.35	28.00	27.17	26.25	28.10	27.17
F3	26.55	27.70	27.12	26.50	27.75	27.12
F4	26.35	27.60	26.97	26.30	27.65	26.97
F5	26.30	28.50	27.40	26.40	28.55	27.47
F6	26.35	28.35	27.35	26.35	28.40	27.37
F7	26.35	28.40	27.37	26.35	28.40	27.37
F8	26.50	28.45	27.47	26.60	28.50	27.55
F9	26.65	28.25	27.37	26.50	28.40	27.45
Mean	26.36	28.14	27.25	26.40	28.15	27.27
SEm	0.146			0.109		
CD (F)			0.306			0.228
CD (F x M)	0.433			0.323		

Table 16. Rabi rice-yield of straw (kg ha^{-1}) cassava-rice-rice system

Treatments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean(F)
F_0	2460	2659	2559	2469	2659	2564
F_1	2431	2710	2571	2440	2710	2575
F_2	2452	2695	2574	2461	2680	2570
F_3	2459	2633	2546	2462	2647	2554
F_4	2465	2650	2557	2467	2647	2557
F_5	2476	2681	2578	2477	2685	2579
F_6	2511	2722	2616	2505	2730	2617
F_7	2544	2655	2600	2550	2642	2596
F_8	2556	2731	2643	2565	2745	2655
F_9	2537	2729	2633	2545	2700	2622
Mean	2489	2686	2587	2493	2684	2588
SEm	9.92			10.82		
CD(F)			20.77			22.64
CD(FxM)	29.28			32.02		

4.1.3.5. Straw yield kg ha^{-1}

The results on straw yield of rabi rice (1983 and 1984) is presented in table 16. The mean yield of straw over various fertility levels was 25 87 kg ha^{-1} in 1983 and 2588 kg ha^{-1} in 1984.

In the case of straw yield the treatment receiving higher levels of fertilizers such as F_8, F_9, F_6 and F_7 have given better performance in both years than the other treatments. Being a vegetative character the plots which received more nitrogen when compared to P and K recorded higher straw production. It may be noted that the effect of fertilizer applied to the kharif crop is definitely carried over to the next rabi crop especially with reference to nitrogen. It may be seen that N added must have ultimately resulted to exhibit more residual effect than the direct effect of fertilizer nitrogen for the maximum production of straw.

4.1.3.6. Uptake of nitrogen kg ha^{-1}

The result on N uptake in 1983 and 1984 is presented in table 17. The mean uptake values of nitrogen for 1983 was 64.82 kg ha^{-1} and in 1984 it was 64.86 kg ha^{-1}. It more or less follows the pattern of straw yield. F_8, F_9, F_7, F_6 and F_5 have recorded more nitrogen uptake than other treatments. The lower uptake of nitrogen was recorded under the treatments, F_0, F_1 and F_2 in both the years. During the kharif season also, the pattern of uptake of N was higher under treatments supplied with higher dose of nitrogen. It is natural that the plots which received higher nutrients especially nitrogen have recorded higher straw yield and consequent higher nitrogen uptake indicating the residual effect of higher doses of nutrients added to the kharif crop to the succeeding rabi crop.

4.1.3.7. Uptake of phosphorus kg ha^{-1}

The result recorded on phosphorus uptake of rabi rice in 1983 and 1984 is presented in table 18.

The mean values of P uptake over varying fertility levels in 1983 was 10.54 kg ha^{-1} and in 1984 it was 10.55 kg ha^{-1}. In 1983 the treatment F_9 recorded the maximum P uptake followed by F_8, F_6, F_5 and F_7 which were on par with F_9. In 1984 the maximum P uptake was under the treatment F_9 followed by F_8 and F_6 which were on par with F_9. The above result clearly indicates that the uptake of P is propotional to the quantity of N and K applied. The absorption of P in treatments supplied with lower level of the nutrients behaving on par with F_9 can be due to the release of P under submerged condition prevailed through out the rice crop season.

Table 17. Rabi rice-Uptake of N (kg ha^{-1}) Cassava-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	50.80	77.05	63.92	51.10	76.80	63.95
F1	51.30	75.85	63.57	51.80	76.20	64.00
F2	51.95	75.95	63.95	52.00	75.95	63.97
F3	53.05	76.80	64.92	53.05	76.80	64.92
F4	53.05	76.75	64.90	53.00	76.70	64.85
F5	53.00	77.05	65.02	53.00	77.10	65.05
F6	54.05	76.70	65.37	54.15	76.55	65.35
F7	53.90	77.00	65.45	53.90	77.00	65.45
F8	53.90	77.40	65.65	53.90	77.40	65.65
F9	53.05	78.00	65.52	63.05	77.95	65.50
Mean	52.80	76.85	64.82	52.89	76.84	64.86
SEm	0.393			0.383		
CD (F)			0.822			0.803
CD (F x M)	1.163			1.135		

Table 18. Rabi rice - Uptake of P (kg ha^{-1}) Cassava-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	8.85	11.70	10.27	8.50	11.75	10.12
F1	8.55	11.75	10.15	9.40	11.55	10.47
F2	9.25	11.75	10.50	9.25	12.10	10.67
F3	8.85	11.70	10.27	9.30	11.70	10.50
F4	8.75	12.15	10.45	9.25	11.70	10.47
F5	9.25	12.15	10.70	8.75	11.75	10.25
F6	9.30	12.25	10.77	9.30	12.30	10.80
F7	9.30	12.10	10.70	9.05	12.00	10.52
F8	9.25	12.40	10.82	9.35	12.30	10.82
F9	9.50	12.15	10.82	9.55	12.30	10.92
Mean	9.08	12.01	10.54	9.17	11.94	10.55
SEm	0.103			0.122		
CD (F)			0.215			0.255
CD (F x M)	0.305			0.361		

Table 19. Rabi rice-Uptake of K (kg ha^{-1}) Cassava-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	48.35	62.95	55.65	48.40	62.95	55.67
F_1	48.80	62.50	55.65	49.00	62.50	55.75
F_2	49.70	63.10	56.40	48.95	63.85	56.40
F_3	49.10	63.90	56.50	49.65	63.10	56.37
F_4	49.00	62.90	55.95	49.00	62.90	55.95
F_5	49.30	62.80	56.05	49.30	62.80	56.05
F_6	49.20	62.05	55.62	49.15	62.10	55.62
F_7	50.00	62.40	56.20	50.05	62.55	56.30
F_8	49.70	63.10	56.40	49.65	63.10	56.37
F_9	49.65	63.80	56.72	49.85	63.75	56.80
Mean	49.29	63.01	56.16	49.31	63.03	56.17
SEm	0.372			0.302		
CD (F)			0.779			0.893
CD (F x M)	1.102			1.263		

4.1.3.8. Uptake of potassium kg ha^{-1}

The results of the uptake of potassium by rabi rice in 1983 and 1984 is presented in table 19.

The mean uptake of K over varying fertility levels in 1983 was 56.16 kg ha^{-1} and in 1984 it was 56.17 kg ha^{-1}. In the case of K uptake the treatments which received either 100 per cent or 75 per cent of the recommended dosage have recorded a higher K uptake than the rest. This is presumably due to the fact that the consumption is more when the K application is high and vice versa.

The uptake of K is commensurate with the quantity supplied to the crop where in, there is increased rate of absorption with incremental supply of the nutrient.

In the case of straw yield also the treatment which received 100 per cent or 75 per cent of the K fertilizer has given more straw yield than others. This would have resulted more residual potash left. in the soil by way of contribution through stubbles.

Even though the maximum yield was obtained in F_9 in both the years and was significantly different from F_8 the sufficient number of filled grains $panicle^{-1}$ and 1000 grain weight could be obtained with F_6. However number of productive tillers responded to the maximum level of fertilizer. This shows that the number of productive tillers is the crucial character which influence the grain yield in this study. In the case of filled grains as well as 1000 grain weights there was a progressive increase from F_6 to F_9, eventhough F_6 was on par with F_9. The probable reason for attaining statistical significance is due to the combined effect of all the three yield attributes.

4.2. Cowpea-rice-rice system

4.2.1. Cowpea.

Cowpea cv. PTB-2 (krishnamomy) was raised as an irrigated summer crop in S_2 cropping system and its results are presented in table 3 a and 3 b.

In 1983 the cowpea recorded grain yield of 1200 kg ha^{-1} and in 1984 the yield was only 1050 kg ha^{-1}. This reduction in yield can be attributed to the excess rain received during summer months of 1984 resulting in wet soil condition throughout the crop growth.

The cowpea crop produced a total dry matter of 2320 kg ha^{-1} in 1983 and 2600 kg ha^{-1} in 1984 with an uptake of

56.63 kg N ha^{-1}, 7.42 kg P_2O_5 ha^{-1} and 34.84 kg K_2O ha^{-1} in 1983 and 58.46 Kg N, 8.05 kg P_2O_5 and 36.21 kg K_2O ha^{-1} in 1984. The higher production of dry matter and uptake of nutrients in 1984 can be attributed to the luxuriant vegetative growth owing to the wet soil condition that prevailed through out the growing season of the crop as a result of more rain received in 1984 summer than in 1983 summer (Vide Appendix IIa, IIb and Fig. 1 and 2).

4.2.2. Kharif ri(

4.2.2.1. Grain yield kg ha^{-1}

The result on the grain yield of kharif crops 1983 and 1984 are presented in tables 4 a and 4 b.

The mean yield of kharif rice over varying fertility levels in 1983 was 3424 kg ha^{-1} and in 1984 it was 3425 kg ha^{-1}, indicating that there was no appreciable variation in yield over years, under the S_2 system of cropping. The control plots recorded an yield of 2650 kg ha^{-1} in 1983 and 2647 kg ha^{-1} in 1984. In the S_2 system also there was a progressive increase in yield in both years as the level of fertilization was increased. In the first year treatments F_9 recorded maximum grain yield and F_8 was on par. In the second year also the treatments F_9 recorded the maximum yield and F_8 was on par indicating that addition of

100 per cent N with 75 per cent of P and K is sufficient for maximum grain production under S_2 system. It is seen that growing a cowpea crop is not able to satisfy the nitrogen requirement of the succeeding rice crop. Such a trend in yield have been recorded by Bains and Sadaphal (1971) when jowar, bajra or paddy was raised as a kharif crop after cowpea in the previous season. In this experiment after the harvest of cowpea grain the bhusa was also removed. The turn around time between the harvest of the cowpea and the transplanting of the succeeding rice is around 15 days. During this period some amount of N would have been lost by leaching due to premonsoon showers

4.2.2.2. Number of productive tillers

The results on the number of productive tillers in Kharif rice of 1983 and 1984 are presented in table 5 a and 5 b.

The mean number of tillers over varying fertilizer levels in 1983 was 272.80 and it was 272.10 in 1884, thus indicating little difference in the number of productive tillers over years. The control plots recorded 222.00 tillers m^{-2} in 1983 and 211.00 tillers m^{-2} in 1984. From F_1 to F_9 in both years there was steady increase in the number of productive tillers with increased application of fertilizers. The maximum number of productive tillers was recorded under F_9 in both years indicating that even under a cropping system involving a legume like cowpea succeeding kharif rice should be applied with full recommended dose of nutrients for the production of maximum number of productive tillers. (Bains and Sadaphal, 1971; Nair et al., 1972).

4.2.2.3. Number of filled grains panicle^{-1}

The result of the number of filled grains in kharif rice of 1983 and 1984 are presented in table 6 a and 6 b.

The number of filled grains panicle^{-1} over varying fertilizer levels are 68.01 (1983) and 68.63 (1984). Control plots recorded 57.75 and 58.75 number of filled grains panicle^{-1} in 1983 and 1984 respectively.

The higher number of filled grains are recorded in F_8 followed by F_9 and F_7 in 1983 and F_9 followed by F_8 and F_7 in 1984. This means for the production of higher number of filled grains in a cowpea-rice-rice system 50 per cent less of P and K than the recommended dosage is sufficient. This can be due to the residual effect of P and K released by the root stubbles of the cowpea crop. According to FAO (1952) 18-20 per cent of the biomass of the legumes are left behind as root stubbles.

4.2.2.4. 1000 grain weight (g)

The results on 1000 grain weight (g) recorded in 1983 and 1984 are presented in tables 7 a and 7 b respectively. The mean 1000 grain weight over varying fertilizer levels in 1983 and 1984 were 27.99 g and 28.02 g respectively. The control plots recorded a 1000 grain weight of 27.05g in 1983 as well as in 1984. In 1983 the treatments F_9 and F_8 recorded the highest 1000 grain weight of 28.7 g followed by F_7, F_6 which were on par. In 1984, F_9 and F_7 recorded the highest 1000 grain weight of 28.65 g followed by F_8, and F_6. The above findings indicate that for a higher 1000 grain weight under S_2 system a minimum fertilizer supply of not below F_6 level (75 per cent N, and 100 per cent each of P and K) should be given. (Majumdar, 1971, Chaudhury et al., 1978, Venkitasubbiah et al., 1982).

4.2.2.5. Yield of straw kg ha^{-1}

The results on the yield of straw in 1983 and 1984 are presented in tables 8 a and 8 b respectively. The mean yieldover varying fertilizer levels were 3526 kg ha^{-1} (1983) and 3517 kg ha^{-1} (1984). The control plots recorded 2790 kg ha^{-1} (1983) and 2785 kg ha^{-1} (1984). There was a progressive increase in yield of straw with increase in fertilizer doses from F_1 to F_9. In the first year the highest yield of 3825 kg ha^{-1} was obtained under F_9 treatment followed by F_8 which was on par with F_9. Same trend was observed in the second year also (Rao and Ramanujam, 1971; Venkitesvarlu, 1978). This shows that for maximum straw yield the treatment F_8 is sufficient. Twenty five per cent of the P and K must have been made available from the deeper layers of the soil with the tap root system of cowpea. The nutrient status of the soil after one and two year crop sequences (tables 62, 63, 64 and 65) also substantiates the above inference.

In the case of S_2 cropping system there is a saving of 25 per cent of P and K only. Inspite of growing a leguminous summer crop the kharif rice crop has responded to 100 per cent of fertilizer nitrogen indicating that there is no residual effect of nitrogen left in the soil for successive rice crop. This can be due to the fact that the bhusa of the crop was cut and removed without incorporating the same in the plot whereas in the case of P and K only 75 per cent of the recommended dose of fertilizer materials are only required and 25 per cent came from soil. Cowpea being a leguminous crop there should have been some accumulation of P due to the dissolution of the fixed P in the soil. In the case of potassium the fertilizer doses given for the crop of rice as well as for the crop of cowpea must not have been fully utilised there by leaving some residual effect reducing the fertilizer requirement to 75 per cent.

4.2.2.6. Uptake of nitrogen kg ha^{-1}

The result on the uptake of nitrogen by kharif crop 1983 and 1984 are presented in tables 9 a and 9 b respectively. The mean uptake of nitrogen over varying fertilizer levels in 1983 is 73.10 kg ha^{-1} and in 1984 73.04 kg ha^{-1}. The control plots recorded a nitrogen uptake of 57.85 kg ha^{-1} in 1983 as well as in 1984. The highest rate of nitrogen uptake of 81.10 kg ha^{-1} recorded under the treatment F_8 followed by F_9 and F_7 which were on par with F_8. In 1984 highest uptake of nitrogen of 81.10 kg ha^{-1} was recorded under the treatment F_8 followed by F_9 and F_7 which are on par with F_8. The above results indicate that total uptake of nitrogen is proportional to the quantity of nitrogen applied to the crop through fertilizers.

4.2.2.7. Uptake of phosphorus kg ha^{-1}

The result on the uptake of phosphorus in 1983 and 1984 are presented in tables 10 a and 10 b.

The mean uptake of phosphorus over varying fertilizer levels in 1983 was 11.57 kg ha^{-1} and 11.53 kg ha^{-1} in 1984. The control plots recorded an uptake of 8.70 kg ha^{-1} each and 1983 in 1984. The maximum uptake of phosphorus was recorded in treatment F_9 in 1983 followed by F_8 and F_7 which were on par with F_9. In 1984 also the highest uptake of phosphorus was recorded in treatment F_9 followed by F_8, F_7, F_6, and F_5 which were on par with F_9. The above results indicate that when nitrogen and phosphorus are supplied at increased rates there is a proportionate increase in the uptake of phosphorus. It is an established fact that the response of phosphorus is high when sufficient nitrogen also is supplied and vice versa, (Sinha, 1957; Mohankumar, 1967; Varma, 1971; Rastogi et al., 1981).

4.2.2.8. Uptake of potassium kg ha^{-1}

The results on the uptake of potassium in 1983 and 1984 are presented in table 11 a and 11 b respectively. The mean uptake over varying fertilizer levels in 1983 was 62.01 kg ha^{-1} and in 1984 it was 61.21 kg ha^{-1}. The control plots recorded an uptake of 47.95 kg ha^{-1} in 1983 and 49.70 kg ha^{-1} in 1984. The maximum uptake in 1983 was 68.50 kg ha^{-1} under F_8 followed by F_9 and F_7 which were on par with F_8. In 1984 it was 68.00 kg ha^{-1} under F_9 followed by F_8 which was on par with F_9. In general there was a progressive trend in uptake of element from F_1 to F_9 (Sharma and Rajendraprasad, 1980).

4.2.3. Rabi rice

4.2.3.1. Grain yield kg ha^{-1}

The result of grain yields of rabi rice 1983 and 1984 is presented in table 20.

The mean grain yield in 1983 was 2782 kg ha^{-1} and in 1984 it was 2766 kg ha^{-1}. In 1983 as well as in 1984 more residual effect was observed under kharif treatments F_9, F_8, F_7 and F_6. This clearly indicates that for the manifestation of residual effect of nutrients applied to the kharif crop to the succeeding rabi crop, balanced and higher rate of nutrients should be applied to the kharif crop. The reason for the F_6 treatment (with less than 50 per cent N than F_9 treatment) and F_8 treatment (with 25 per cent less of P and K than F_9 treatment) and F_7 treatment (with 50 per cent less P and K than F_9 treatment) behaving on par with F_9 treatment in a cowpea-rice-rice system, can be attributed to the biological nitrogen fixation by the cowpea crop and also due to extraction of P and K nutrients from the deeper layers of soil with tap root system of the cowpea crop.

4.2.3.2. Number of productive tillers M^2

The results recorded on the number of productive tillers during rabi 1983 and 1984 is presented in table 21.

Table 20. Rabi rice-yield of grain (kg ha^{-1}) cowpea-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	2467	2944	2705	2552	2991	2772
F_1	2490	2946	2718	2470	2967	2718
F_2	2469	3171	2820	2460	3206	2833
F_3	2555	3129	2842	2471	3112	2792
F_4	2551	3109	2810	2507	3136	2822
F_5	2549	3139	2844	2535	3130	2832
F_6	2555	3156	2855	2550	3155	2852
F_7	2551	3205	2878	2548	3195	2871
F_8	2525	3186	2855	2526	3181	2853
F_9	2545	3170	2857	2542	3166	2857
Mean	2521	3115	2818	2516	3124	2820
SEm	17.41			16.94		
CD(F)			36.44			35.46
CD (Fxm)	51.53			50.16		

Table 21. Rabi rice - No. of productive tillers m^{-2} at maturity cowpea-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	230.50	260.50	245.50	230.00	259.00	244.50
F_1	227.50	265.00	246.25	227.00	266.50	246.75
F_2	225.50	266.50	246.00	225.50	267.50	246.00
F_3	225.50	270.00	247.75	225.50	270.00	247.75
F_4	223.50	269.50	246.50	226.50	269.50	248.00
F_5	225.00	269.50	247.25	225.50	270.00	247.75
F_6	225.50	266.50	246.50	231.50	266.50	249.00
F_7	224.50	271.50	248.00	225.50	273.50	249.50
F_8	229.50	266.50	248.50	227.50	270.50	250.50
F_9	228.50	270.50	249.25	229.50	271.50	250.25
Mean	225.60	267.55	247.07	277.55	268.45	248.00
SEm	2.259			1.936		
CD (F)			4.729			4.729
CD (F x M)	6.687			6.687		

The mean number of productive tillers m^{-2} in 1983 was 247.07 and in 1984 it was 248.00. During 1983 treatments are not significant indicating that none of the fertilizer levels of kharif crop exhibited residual effect to the succeeding rabi crop. In 1984 fertilizer levels F_9 and F_8 are significant in exhibiting residual benefit to the succeeding rabi rice crop. During 1983 also the fertilizer levels F_9, F_8 and F_7 have produced higher number of productive tillers even though not statistically significant. The above results indicate that application of 100 per cent each of N, P and K and 100 per cent N and 75 per cent each of P and K applied to the kharif crop contribute residual effect for the production of productive tillers in the succeeding rabi crop.

4.2.3.3. Number of filled grains panicle^{-1}

The results on the number of filled grains produced panicle^{-1} during 1983 and 1984 are presented in table 22.

The mean number of filled grains panicle^{-1} recorded in 1983 was 60.67 and in 1984 it was 60.74. During 1983 the maximum number of filled grains panicle^{-1} was produced under the fertilizer level F_8 followed by F_9, F_7 and F_6 which were on par with F_8. During 1984 also the above trend was repeated. Thus the treatments F_8, F_9, F_7 and F_6

have consistently contributed residual effect to the succeeding rabi crop in producing higher number of filled grains panicle^{-1}. Since the cowpea is a tap rooted crop this must have foraged the P and K from the sub soil portions and made available to the succeeding kharif rice under treatments F_8 and F_7 thus enabling them act to on par with F_9.

4.2.3.4. 1000 grain weight (g).

The result of the 1000 grain weight during 1983 and 1984 on rabi rice is presented in table 23.

The mean 1000 grain weight in 1983 was 27.42 g and in 1984 it was 27.38 g. During 1983 and 1984 the highest residual effect is seen manifested under the fertilizer level F_9 followed by F_8 and F_7 which were on par with F_9. The probable reason for many of the treatments behaving on par with treatment F_9 (with full recommended NPK nutrients) under the cowpea-rice-rice system can be due to the biological nitrogen fixation of cowpea crop and exploitation of native P and K nutrients from the deeper layers of the soils with its deep tap root system. In general the same trend was exhibited in the case of grain yield also in S_2 system.

Table 22. Rabi rice - Number of filled grains panicle^{-1} Cowpea-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean (F)	MO	M1	Mean (F)
F0	56.85	63.25	60.05	57.40	63.60	60.50
F1	57.05	63.35	60.20	57.20	63.10	60.15
F2	57.60	63.25	60.42	57.50	63.65	60.57
F3	58.00	62.90	60.45	57.85	63.05	60.45
F4	56.75	64.10	60.52	57.10	64.20	60.65
F5	57.20	61.95	59.57	57.35	61.75	59.55
F6	58.20	63.90	61.05	58.20	64.15	61.17
F7	58.75	63.70	61.22	58.70	63.80	61.20
F8	59.65	63.90	61.77	59.40	64.00	61.30
F9	58.75	64.15	61.45	58.70	64.15	61.42
Mean	57.90	63.44	60.67	57.94	63.55	60.74
SEm	0.534			0.378		
CD (F)			1.118			0.792
CD (F x M)	1.581			1.121		

Table 23. Rabi rice-1000 grain weight (g) Cowpea-rice-rice system

Treatments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	26.40	28.50	27.45	26.35	28.45	27.40
F1	26.35	28.50	27.42	26.30	28.40	27.35
F2	26.50	28.45	27.47	26.50	28.50	27.50
F3	26.35	28.35	27.35	26.30	28.40	27.35
F4	26.50	28.50	27.50	26.35	28.45	27.40
F5	26.60	28.10	27.35	26.50	27.70	27.10
F6	26.25	28.00	27.12	26.35	27.85	27.10
F7	26.50	28.65	27.50	26.50	28.50	27.50
F8	26.65	28.40	27.52	26.50	28.50	27.50
F9	26.40	28.65	27.52	26.60	28.50	27.55
Mean	26.43	28.41	27.42	26.42	28.35	27.38
SEm	0.165			0.117		
CD (F)			0.347			0.246
CD (F x M)	0.491			0.348		

Table 24. Rabi rice-yield of straw (kg ha^{-1}) - cowpea-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean(F)	MO	M1	Mean(F)
F_0	2449	2671	2560	2445	2665	2555
F_1	2454	2675	2564	2455	2682	2568
F_2	2442	2602	2522	2447	2597	2522
F_3	2420	2590	2505	2427	2585	2506
F_4	2427	2643	2535	2433	2645	2539
F_5	2460	2684	2572	2464	2686	2575
F_6	2469	2664	2566	2475	2665	2570
F_7	2477	2688	2583	2469	2690	2579
F_8	2479	2716	2597	2478	2717	2598
F_9	2511	2715	2613	2522	2720	2621
Mean	2459	2685	2562	2461	2665	2511
SEm	8.82			7.25		
CD(F)			18.47			15.18
CD(FxM)	26.12			21.47		

4.2.3.5. Yield of straw kg ha^{-1}.

The result on yield of straw of rabi rice 1983 and 1984 is presented in table 24.

The mean values of straw yield over varying fertilizer levels were 2587 kg ha^{-1} in 1983 and 2588 kg ha^{-1} in 1984. It is seen from the table that the fertilizer levels F_9, F_8, F_6 and F_7 have exhibited higher residual effect for higher yield of straw consistently during 1983 and 1984. Like wise the low fertilizer levels of F_4, F_3 and F_2 have exhibited low residual effect for low yield of straw consistently during 1983 and 1984. The 100 per cent nitrogen levels of the treatments F_9, F_8 and F_7 must have contributed to high yield of straw and comparatively low nitrogen status of treatments F_4, F_3 and F_2 must have resulted in low yield of straw. It is a universally accepted fact that in rice, straw yield is directly proportional to the supply of nitrogen.(Rao and Ramanujam, 1971; Venkitesvarlu, 1978).

4.2.3.6. Uptake of nitrogen kg ha^{-1}

The result on uptake of nitrogen of rabi crop 1983 and 1984 is presented in table 25.

The mean uptake of nitrogen over varying fertilizer doses in 1983 was 65.15 kg ha^{-1} and 1984 it was 65.13

kg ha^{-1}. the highest rate of uptake of nitrogen was recorded under the treatment level F_8 during 1983 and 1984 and the treatment F_9, F_7, F_6 and F_5 are consistently on par. The lowest uptake of nitrogen noticed under treatments F_0 and F_1 in 1983 kept up the same trend in 1984 alos. In rice culture it is a common observation that higher the nitrogen supply higher will be the uptake also. This is applicable to kharif treatments F_8, F_9 and F_7 containing 100 per cent of recommended dose of nitrogen which contributed residual effect to the succeeding rabi crop. It is also a well known fact that nitrogen absorption is accelerated in the presence of potash / phosphorus. The capacity of the cowpea crop in a cowpea-rice-rice system in making available more N, P and K to treatments supplied with lower levels of nutrients have already been discussed else were.

4.2.3.7. Uptake of phosphorus kg ha^{-1}.

The result on the uptake of phosphorus by rabi rice in 1983 and 1984 is presented in table 26.

The mean uptake of P over varying fertility levels in 1983 was 10.42 kg ha^{-1} and in 1984 it was 10.49 kg ha^{-1}. During 1983 the highest uptake of P was recorded under the treatment F_9 followed by F_7 and F_8 which were on par with F_9. During 1984 the highest uptake of P was noticed under F_9

Table 25. Rabi rice-Uptake of N (kg ha^{-1}) Cowpea-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	52.75	76.05	64.40	52.90	76.05	64.47
F1	51.75	76.70	64.22	52.10	76.70	64.40
F2	52.95	77.30	65.12	53.15	77.00	65.07
F3	53.00	77.00	65.00	53.00	77.10	65.05
F4	53.70	76.00	64.85	53.80	75.95	64.87
F5	53.35	77.45	65.40	53.10	77.40	65.25
F6	54.30	76.65	65.47	53.90	76.70	65.30
F7	53.15	77.10	65.12	53.55	77.65	65.60
F8	53.65	78.00	65.82	53.75	77.90	65.82
F9	53.20	78.00	65.60	53.20	77.85	65.52
Mean	53.18	77.02	65.15	53.24	77.03	65.13
SEm	0.336			0.331		
CD (F)			0.705			0.692
CD (F x M)	0.997			0.978		

Table 26. Rabi rice - uptake of P (kg ha^{-1}) Cowpea-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean (F)	MO	M1	Mean (F)
F0	8.70	11.80	10.25	8.85	11.70	10.27
F1	8.70	11.70	10.20	8.70	12.30	10.50
F2	8.75	11.85	10.30	8.55	11.75	10.55
F3	8.65	11.65	10.15	9.25	11.75	10.27
F4	8.85	11.55	10.20	8.85	11.70	10.27
F5	8.70	11.85	10.27	8.75	12.30	10.52
F6	9.30	11.90	10.60	8.80	12.30	10.55
F7	9.25	12.30	10.77	8.85	12.35	10.60
F8	9.30	12.10	10.70	9.25	12.30	10.77
F9	9.55	12.15	10.85	9.30	12.25	10.77
Mean	8.97	11.88	10.42	8.91	12.07	10.49
SEm	7.754			7.837		
CD (F)			0.162			0.371
CD (F x M)	0.229			0.232		

followed by F_8, F_7 and F_6 which were on par with F_9. The higher rate of absorption of P consistently during 1983 and 1984 can be attributed to the supply of full dose of fertilizers (100 % each of N, P and K) to the kharif rice and its consequent residual effect to the succeeding rabi crop. Under fertilizer levels F_7 and F_8 also 100 per cent of nitrogen is supplied and in a cowpea-rice-rice system the reason for sufficient availability of P and K have been explained else where. Under a cowpea-rice-rice system N can be supplemented by the legume crop by atmosphuric fixation at absorpation P and K from deeper layers of soil.

4.2.3.8. Uptake of potassium kg ha^{-1}.

The result on the uptake of K by rabi rice in 1983 and 1984 is presented in table 27.

The mean uptake of K over varying fertility levels in 1983 was 56.26 kg ha^{-1} and in 1984 it was 56.27. In 1983 the highest uptake of K recorded under the treatment F_9 and F_4, F_6 and F_7 were on par. In 1984 the highest uptake was noticed under F_7, and F_9, F_6 and F_4 were on par. The higher uptake of K under treatment F_9 and F_6 can be due to the fact that these treatments are supplied with 100 per cent of the recommended doses of the nutrients. In the case of treatments F_7 and F_4 which have supplied 50 per cent of recommended dose of K and 75 per cent of N, the higher uptake can be attributed to the complementary effect of these elements in a legume-rice-rice system as explained else where.

In summing up it can be said that in the S_2 cropping system the maximum fertilizer dose required for the grain yield is F_8 where as in the case of number of productive tillers the response was upto F_9 and in the case of number of filled grains and 1000 grain weight the response was only upto F_6. This infers that the latter two characters have helped to attain a significant increase of grain yield at F_8 level eventhough the maximum response was upto F_6.

4.3. Ground nut-rice-rice system

4.3.1. Groundnut.

The result on the ground nut of 1983 and 1984 are presented in table 3 a and 3 b.

In 1983 the ground nut crop recorded an yield of 2129 kg ha^{-1} pods and in 1984 the yield recorded was 2253 kg ha^{-1} of dry pods. In 1983 a dry weight of 4911 kg ha^{-1} haulm was produced as against 5180 kg ha^{-1} dry haulm in 1984. The possible reason for the higher yield of pods and haulm in

Table 27. Rabi rice-Uptake of K (kg ha^{-1}) Cowpea-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	48.45	62.90	55.67	48.45	62.90	55.67
F_1	49.05	62.75	55.90	49.05	62.75	55.90
F_2	49.05	63.00	56.02	49.15	63.00	56.07
F_3	49.00	63.40	56.20	49.00	63.40	56.20
F_4	49.50	63.00	56.25	49.15	64.15	56.65
F_5	48.95	62.65	55.80	48.85	62.70	55.77
F_6	49.45	63.90	56.67	49.45	63.90	56.67
F_7	49.90	63.50	56.70	50.05	63.50	56.77
F_8	49.20	64.20	56.70	49.45	63.10	56.27
F_9	49.95	63.50	56.72	50.00	63.50	56.75
Mean	49.25	63.28	56.26	49.26	63.21	56.27
SEm	0.356			0.364		
CD (F)			0.746			0.762
CD (F x M)	1.055			1.078		

1984 over 1983 is due to the receipt of summer showers during the crop period which enabled better penetration of pegs and vegetative growth probably due to more absorption of major nutrients and calcium from the wet soil consequent on receipt of summer showers (table 3 b).

4.3.2. Kharif rice

4.3.2.1. Yield of grain kg ha^{-1}.

The result on the yield of grain recorded on kharif rice during 1983 and 1984 are presented in tables 4 a, and 4 b. Under S_3 system the mean yield under varying fertilizer levels in 1983 was 3390 kg ha^{-1} and 3435 kg ha^{-1} in 1984. The yield of grain in the control plots were 2700 kg ha^{-1} in 1983 and 2745 kg ha^{-1} in 1984.

In the S_3 system the treatment F_8 recorded the highest yield and F_9 was on par in first year. In second year also F_8 recorded highest yield and treatments F_9 and F_7 were on par. Thus there was an economy of 50 per cent P and K than recommended doses under S_3 system. Ground nut being a tap rooted legume it must have absorbed more P and K from the lower layers of soil and made available to the succeeding rice crop. This effect is more pronounced in the second year where in even the treatment F_7 with 100:50:50 per cent NPK was on par with F_9 having 100:100:100 per cent NPK indicating the beneficial effect of this legume crop in utilising more of native P and K. The above result is in agreement with the findings of Hartly and Reeping (1950), Seshadri (1954) Dalal and Nagi (1958), Magne (1960) Shivasankar et al. (1972) and Sardor (1975).

4.3.2.2. Number of productive tillers m^{-2}

The result on the number of productive tillers in kharif rice of 1983 and 1984 are presented in tables 5 a and 5 b.

The mean number of tillers over varying fertilizer dose in 1983 is 271.65 productive tillers m^{-2} and in 1984 it was 270.10 m^{-2}. The control plots recorded 224.50 productive tillers m^{-2} during both years. There is a progressive increase in the number of productive tillers with increase in fertilizer levels. The maximum number of tillers are recorded under the fertilizer level F_9 in both the years in which full recommended dose of nutrients are applied. In 1984 the treatments F_9 and F_8 were on par and were significantly superior to the rest. The 100 per cent of recommended dose of phosphorus contained in F_9 treatment must have aided to produce maximum number of productive tillers (Nair et al., 1972; Bhatacharya and Chatterji, 1978).

4.3.2.3. Number of filled grains panicle^{-1}

The result on the number of filled grains panicle^{-1} for kharif rice in 1983 and 1984 are presented in table 6 a and 6 b.

The mean number of filled grains recorded are 67.84 in 1983 and 67.81 in 1984. The control plots recorded 56.90 number of filled grains panicle^{-1} in both the years. The maximum number of filled grains produced were 72.55 (1983) and 72.45 (1984) under F_8 and F_9 were on par. This indicates that for the production of maximum number of filled grains 100 per cent N and 75 per cent each of P and K is sufficient compared to recommended dose under the groundnut-rice-rice system (Chandrasekharan, 1984; Sankaranarayana, 1985; Krishnakumar, 1986). This can be due to the ability of the groundnut crop to absorb sufficient P and K from the deeper layers of the soil and make available to the succeeding kharif rice crop.

4.3.2.4. 1000 grain weight (g)

The results recorded on 1000 grain weight in 1983 and 1984 are presented in table 7 a and 7 b. The mean 1000 grain weight over different fertilizer levels were 27.93 g in 1983 and 27.89 g in 1984. The control plots recorded 1000 grain weights of 26.80 g in 1983 and 27.05 in 1984. The highest grain weight of 28.80 g was recorded under F_8 in 1983 followed by F_7 and F_9 which were on par with F_8. In 1984 the highest grain weight of 28.70 g was under F_9 followed by F_8 and F_7 which were on par with F_9. The above results are indicative of the fact that for higher 1000 grain weight a fertilizer dose of 100 per cent N and 50 per cent each of P and K of recommended dose is sufficient under a groundnut-rice-rice system. The other fifty per cent of P and K must have been made available by the groundnut crop by dissolution of native phosphorus and absorption of K from deeper layers of soil with its tap root system.

4.3.2.5. Yield of straw kg ha^{-1}

The results recorded on yield of straw in 1983 and 1984 are presented in table 8a and 8 b respectively. The mean yield of straw over varying fertilizer levels recorded are 3530 kg ha^{-1} in 1983 and 3520 kg ha^{-1} in 1984. The control plots recorded 2897 kg ha^{-1} in 1983 and 2890 kg ha^{-1} in 1984. In 1983 the highest yield of 3835 kg ha^{-1} straw was recorded under treatments F_9. In 1984 the same trend was noted with the highest straw yield of 3827 kg ha^{-1}. Hence under this system there is no economy of fertilizer application to kharif crop of rice with regard to straw production. This can be due to the fact that crop residues of the summer crop of groundnut was fully removed from the plots for better economic use as fodder and as such no crop residues was left behind for the succeeding rice crop as supplementary source of plant nutrients in treatments supplied with lower rates of NPK.

4.3.2.6. Uptake of nitrogen kg ha^{-1}

The result on uptake of nitrogen in 1983 and 1984 are presented in table 9 a and 9 b respectively.

The mean nitrogen uptake over varying fertilizer levels in 1983 was 73.07 kg ha^{-1} and in 1984 it was 73.04 kg ha^{-1} and in 1984 it was 73.04 kg ha^{-1}. The control plots recorded 57.35 kg ha^{-1} in 1983 and 58.15 kg ha^{-1} in 1984. In 1983 the highest nitrogen uptake of 81.80 kg ha^{-1} was under the treatment F_9 followed by F_8 and F_7 which were on par with F_9. In 1984 the maximum uptake of 81.95 kg ha^{-1} was under the treatment F_8 followed by F_9 which was on par with F_8. Thus the above results indicate that maximum uptake of nitrogen takes place when higher doses of the nutrient element is applied to the crop through fertilizers.

4.3.2.7. Uptake of phosphorus kg ha^{-1}

The result on uptake of phosphorus recorded in 1983 and 1984 are presented in tables 10 a and 10 b respectively.

The mean uptake of phosphorus over varying fertilizer levels in 1983 was 11.46 kg ha^{-1} and 11.52 kg ha^{-1} in 1984. The control plots recorded 8.95 kg ha^{-1} in 1983 and 8.95 kg ha^{-1} in 1984. The maximum uptake of phosphorus was recorded in 1983 under treatment F_9 followed by F_8 which was on par (Mohankumar, 1967; Rastogi et al.1981). In general there was a progressive uptake of phosphorus from F_1 to F_9 indicating that with increased application of the element there is an increased uptake especially under treatments supplied with higher rate of nitrogen also. This clearly indicates that the uptake of phosphorus and nitrogen are complementary.

4.3.2.8. Uptake of potassium kg ha^{-1}

The result on the uptake of K in 1983 and 1984 are presented in table 11 a and 11 b respectively.

The mean uptake over varying fertilizer levels in 1983 was 61.62 kg ha^{-1} and 62.04 kg ha^{-1} in 1984. The control plots recorded 49.05 kg ha^{-1} in 83 and 47.95 kg ha^{-1} in 1984. In 1983 the maximum uptake of 68.25 kg ha^{-1} K was recorded in F_9 followed by F_8 and F_7 which were on par with F_9. In 1984 the maximum uptake of 68.40 kg ha^{-1} was recorded in F_8 followed by F_9 and F_7 which were also on par with F_8. In general there was a progressive increase in the uptake of K from F_1 to F_9 with the increase in fertilizer levels (Sharma and Rajendraprasad, 1980). The above results clearly shows that higher uptake of K is associated with higher rate of supply of K and nitrogen.

4.3.3. Rabi rice

4.3.3.1. Grain yield kg ha^{-1}

The result of grain yield in 1983 and 1984 are presented in table 28.

During both the years consistently higher yields are recorded under the treatments F_9, F_8 and F_7. The lowest yield is recorded in the F_0 treatment during both the years. The treatments which recorded the higher yields come under the nutrient combinations of 100:100:100 per cent, 100:75:75 per cent NPK and 100:50:50 per cent of recommended doses of NPK. The cropping system under discussion involves the cultivation of a legume ie. groundnut which is a tap rooted crop capable of absorbing P and K nutrient from the sub soil layers of the soil and biological fixation of atmospheric nitrogen. Thus the nitrogen fixed by the crop and the P and K extracted from the sub soil region can mutually benefit the nutrition of the crop on the one hand and the same can supplement the nutrients supplied to the crop under varying levels on the other hand. Hence the higher yield obtained under the above mentioned nutrient combination are quite justifiable which must have contributed to the residual effect of nutrients applied to the kharif crop far the succeeding rabi crop under this system of cropping.

4.3.3.2. Number of productive tillers m^{-2}

The result on the number of productive tillers m^{-2} in 1983 and 1984 is presented in table 29.

The mean number of productive tillers m^{-2} in 1983 was 253.35 and in 1984 it was 251.20. It is seen that during 1983 the fertilizer level F_9 recorded significantly higher number of productive tillers m^{-2}. In 1984 also F_9 recorded the highest number of productive tillers and F_8, F_7, F_4, F_5 and F_8 were on par. The above result indicate that for production of higher number of productive tillers fertilizer level F_7 (100:50:50 % of recommended dose) need be applied to the kharif rice crop for getting residual effect of the nutrients to the succeeding rabi crop under the groundnut-rice-rice system. In this case also inclusion of a tap rooted legume crop as summer crop must have influenced the other treatments in the production of higher number of

Table 28. Rabi rice-yield of grain (kg ha^{-1}) groundnut-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	2479	3129	2804	2475	3131	2803
F_1	2538	3117	2827	2515	3112	2813
F_2	2550	3149	2849	2531	3156	2844
F_3	2559	3076	2817	2556	3082	2819
F_4	2552	3112	2832	2538	3104	2821
F_5	2580	3040	2813	2501	3016	2808
F_6	2499	3191	2845	2500	3193	2846
F_7	2551	3192	2871	2530	3172	2851
F_8	2570	3195	2882	2572	3191	2881
F_9	2805	3249	2927	2588	3232	2910
Mean	2548	3145	2846	2540	3139	2839
SEm	30.01			18.92		
CD(F)			62.82			39.59
CD (Fxm)	88.85			55.99		

Table 29. Rabi rice - No. of productive tillers m^{-2} at maturity Groundnut-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	225.00	269.50	247.25	224.50	270.50	247.50
F_1	225.00	275.50	250.25	225.00	250.50	237.75
F_2	226.00	279.00	253.00	226.50	280.00	253.50
F_3	227.00	277.50	252.25	224.50	277.50	251.00
F_4	230.00	276.50	253.25	229.50	276.50	253.00
F_5	229.50	276.50	253.00	229.50	276.50	253.00
F_6	225.00	281.00	253.00	225.00	281.00	253.00
F_7	226.00	282.50	254.25	226.00	282.50	254.25
F_8	230.50	279.00	254.50	230.00	279.00	254.50
F_9	224.00	281.50	262.75	229.50	280.00	254.75
Mean	228.50	277.90	253.35	227.20	275.40	251.20
SEm	3.325			5.706		
CD (F)			6.960			11.944
CD (F x M)	9.843			16.691		

Table 30. Rabi rice - Number of filled grains panicle^{-1}
Groundnut-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean (F)	MO	M1	Mean (F)
F0	58.10	63.50	60.85	57.80	63.50	60.65
F1	58.30	63.05	60.67	57.90	64.00	60.95
F2	58.10	63.70	60.90	58.00	63.35	60.67
F3	59.00	64.10	61.55	57.10	64.05	60.57
F4	56.15	63.00	59.57	56.75	63.35	60.05
F5	57.80	63.00	60.40	57.50	63.00	60.25
F6	57.85	64.50	61.17	58.20	63.20	60.70
F7	59.00	64.10	61.55	58.45	63.90	61.17
F8	58.85	63.80	61.35	58.00	64.55	61.27
F9	58.90	64.20	61.55	59.00	64.20	61.60
Mean	57.98	63.66	60.82	57.87	63.71	60.79
SEm	0.577			0.374		
CD (F)			1.209			0.783
CD (F x M)	1.710			1.108		

productive tillers, more especially in 1984 when the climatic conditions were more favourable to the summer crops as can be seen from the weather data of 1984 (Appendix II b).

4.3.3.3. Number of filled grains panicle^{-1}

The result on the number of filled grains panicle^{-1} in 1983 and 1984 is presented in table 30.

The mean number of filled grains panicle^{-1} in 1983 was 60.82 and in 1984 it was 60.79. In 1983 and 1984 the treatment F_9 contributed maximum residual effect for the production of maximum number of filled grains panicle^{-1} followed by F_7 and F_8 in 1983 F_8 and F_7 in 1984 respectively. Groundnut being a nitrogen fixing and tap rooted legume must have supplemented N, P and K to various treatments and making them on par with treatments supplied with higher and balanced rate of nutrients.

4.3.3.4. 1000 grain weight g

The result of 1000 grain weight of rabi 1983 and 1984 is presented in table 31.

The mean value of 1000 grain weight in 1983 was 27.43 g and 1984 it was 27.42 g. In 1983 and 1984 the higher residual effect of kharif treatments on the succeeding rabi crop were under the treatments F_7, F_6, F_8 and F_9 with regard to 1000 grain weight. It may be seen that some of the treatments with seventy five per cent (F_6) and 50 per cent (F_3) of recommended nitrogen and 100 per cent each of recommended P and K have behaved on par with F_9 (100 per cent of recommended N,P and K). This can be due to the supplementation of nitrogen through biological nitrogen fixation under the groundnut-rice-rice system. F_7 treatment (100 % nitrogen and 50 % each P and K) also must have taken advantage of the P and K extraction capacity of the tap rooted legume from the deeper layers of the soil as discussed else where.

4.3.3.5. Straw yield kg ha^{-1}

The result on the straw yield on rabi rice in 1983 and 1984 is presented in table 32.

The mean yield .of straw in 1983 was 2617 kg ha^{-1} and in 1984 it was 2323 kg ha^{-1}. In 1983 and 1984 the higher straw yield was recorded under the treatments F_9 followed by F_8, F_7 and F_6. The lowest straw yield was recorded consistently in both years under the treatments F_1, F_2, F_3 and F_4. Thus it is evident that the residual effect of fertilizers applied to the kharif crop will be transmitted to the succeeding rabi crop only if balanced nutrients at

Table 31. Rabi rice-1000 grain weight (g) Groundnut-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean (F)	MO	M1	Mean (F)
F0	26.65	27.90	27.27	26.45	28.00	27.22
F1	26.30	27.25	27.27	26.40	28.30	27.35
F2	26.50	28.00	27.25	26.50	28.00	27.25
F3	26.40	28.50	27.45	26.45	28.50	27.47
F4	26.60	28.05	27.32	26.50	27.90	27.20
F5	26.50	28.15	27.32	26.55	28.05	27.30
F6	26.75	28.55	27.65	26.60	28.55	27.57
F7	26.55	28.80	27.67	26.50	28.85	27.67
F8	26.65	28.55	27.60	26.65	28.55	27.60
F9	26.65	28.50	27.57	26.60	28.60	27.60
Mean	26.55	28.32	27.43	26.52	28.33	27.42
SEm		0.133			0.126	
CD (F)			0.279			0.264
CD (F x M)		0.295			0.373	

Table 32. Rabi rice-yield of straw (kg ha^{-1}) - groundnut-rice-rice system

Treatments	1983			1984		
	M0	M1	Mean	M0	M1	Mean
F_0	2488	2678	2593	2517	2671	2594
F_1	2512	2674	2593	2531	2588	2609
F_2	2525	2689	2607	2550	2674	2612
F_3	2524	2685	2604	2489	2694	2591
F_4	2536	2657	2596	2535	2658	2596
F_5	2537	2741	2639	2525	2742	2633
F_6	2512	2759	2635	2550	2727	2638
F_7	2554	2670	2612	2560	2731	2645
F_8	2555	2725	2640	2625	2708	2666
F_9	2554	2732	2643	2543	2750	2646
Mean	2529	2703	2617	2542	2704	2623
SEm	12.34			11.86		
CD(F)			25.83			24.82
CD(FxM)	36.35			35.10		

recommended doses are applied to the kharif crop. The reason for some of the treatments such as F_7 (with 100 % N and 50 % each of P and K of recommended dose) and F_6 (with 75 % N and 100 % each of P and K of recommended dose) behaving on par with F_9 can be due to the biological nitrogen fixation by the groundnut crop and its capacity to extract the native P and K from the deeper layers of soil with its tap root system as discussed elsewhere.

4.3.3.6. Uptake of nitrogen (kg ha^{-1})

The result on uptake of nitrogen by rabi rice is presented in table 33.

The mean uptake of N over varying fertilizer doses in 1983 was 64.95 kg ha^{-1} and in 1984 it was 64.99 kg ha^{-1}. In both the years consistently the treatment F_9, F_8 and F_7 have shown higher absorption of nitrogen and the treatments F_1 and F_2 recorded the lower uptake of nitrogen. This clearly indicates that higher the quantity of nitrogen supplied to the kharif crop higher will be the uptake of nitrogen in the rabi crop also, indicating residual effect from kharif crop to succeeding rabi crop. Some of the treatments with lower levels of nitrogen content (F_6) and with lower level of P and K content (F_7) also are on par with

F_9. This can be due to the biological nitrogen fixation by the groundnut crop and its absorption of P and K from the deeper layers of soil by virtue of its tap root system.

4.3.3.7. Uptake of phosphorus kg ha^{-1}

The result on P uptake by rabi rice crops of 1983 and 1984 is presented in table 34.

The mean uptake of P over fertility level in 1983 was 10.50 kg ha^{-1} and in 1984 it was 10.45 kg ha^{-1}. During 1983 highest uptake of 10.72 kg P ha^{-1} was recorded under treatment F_9 followed by F_8, F_7 and F_6 which were on par with F_9. During 1984 the highest uptake of 10.82 kg P ha^{-1} was recorded in treatment F_9 followed by F_8, F_8 and F_4 which were on par with F_9. The reason of treatments supplied with low rate of nutrients behaving on par with treatments supplied with higher rate of nutrients with respect to uptake of P under groundnut-rice-rice system can be due to the capacity of the groundnut crop as already mentioned

4.3.3.8. Uptake of potassium kg ha^{-1}

The result on uptake of K in 1983 and 1984 are presented in Table 34.

Table 33. Rabi rice-Uptake of N (kg ha^{-1}) Groundnut-rice-rice system

Treatments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	52.50	77.50	65.00	53.35	77.70	65.02
F1	52.35	76.35	64.35	52.35	76.45	64.40
F2	51.80	76.50	64.15	52.00	76.40	64.20
F3	53.00	77.10	65.05	52.50	77.10	65.07
F4	53.80	76.20	65.00	53.85	76.20	65.02
F5	52.85	77.10	64.97	53.10	77.10	65.10
F6	53.35	76.75	65.05	53.30	76.70	65.02
F7	53.30	76.80	65.05	53.05	76.80	65.05
F8	52.90	78.00	65.45	53.00	77.95	65.47
F9	53.00	78.00	65.50	53.15	78.10	65.62
Mean	52.88	77.03	64.95	52.96	77.03	64.99
SEm	0.331			0.378		
CD (F)			0.694			0.791
CD (F x M)	0.982			1.119		

Table 34. Rabi rice - Uptake of P (kg ha^{-1}) - Groundnut-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	8.75	11.75	10.25	8.60	11.70	10.15
F_1	9.15	11.70	10.42	8.75	12.20	10.47
F_2	8.15	12.00	10.47	8.65	11.65	10.15
F_3	9.15	12.05	10.60	8.85	11.55	10.20
F_4	9.25	11.70	10.40	9.50	12.15	10.82
F_5	8.75	12.10	10.42	8.70	11.80	10.25
F_6	8.70	12.30	10.50	9.25	12.15	10.70
F_7	8.80	12.25	10.52	9.30	12.10	10.70
F_8	9.00	12.35	10.67	9.25	12.40	10.82
F_9	9.15	12.30	10.72	9.50	12.15	10.82
Mean	8.96	12.05	10.50	8.96	11.95	10.45
SEm	0.115			9.895		
CD (F)			0.241			0.207
CD (F x M)	0.341			0.293		

Table 35. Rabi rice - Uptake of K (kg ha^{-1}) Groundnut-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	49.50	63.15	56.32	49.50	63.05	56.27
F_1	47.90	63.05	55.47	47.90	63.05	55.47
F_2	48.90	63.30	56.10	48.90	63.30	56.10
F_3	49.05	63.15	56.10	49.05	63.10	56.07
F_4	49.05	63.50	56.27	49.10	63.45	56.27
F_5	48.85	63.65	56.20	49.00	63.75	56.37
F_6	49.30	63.65	56.47	49.25	63.00	56.37
F_7	49.20	64.00	56.60	49.20	64.15	55.67
F_8	49.45	64.20	56.82	49.55	64.20	56.87
F_9	49.45	64.20	56.62	49.55	63.70	56.62
Mean	49.07	63.53	56.30	49.10	63.52	56.31
SEm	0.501			0.470		
CD (F)			1.048			0.984
CD (F x M)	1.483			1.392		

The mean uptake of K under varying fertility levels in 1983 was 56.30 kg ha^{-1} and in 1984 it was 56.31 kg ha^{-1}. In 1983 the highest uptake of 53.82 kg ha^{-1} was recorded on treatment F_8 and all other treatments were on par except F_1. In 1984, also the highest uptake of 56.87 kg ha^{-1} was under the treatment F_8 and all other treatments were on par except F_1. Thus the pattern of uptake of K during both years are the same. The reasons for treatments with low amounts of K behaving on par with treatments supplied with high amount of K can be due to the complementary effect of nutrients as explained elsewhere and also due to release of native K from the soil under submerged condition. (Ponnamperuma, 1965; Barnes et al., 1986).

In the S_3 cropping system the maximum fertilizer dose required for the grain yield as well as for the yield attributes of filled grains and 1000 grain weight is F_8. For the production of maximum panicle as well as for attaining maximum yield full dose of recommended nutrients is required. Thus there is a good relation between the fertilizer levels required for the expression of the yield attributes and the grain yield. There is also a perfect relation existing between nutrient requirement for the maximum production of productive tillers and straw yield.

4.4. Bhendi-rice-rice system

4.4.1. Bhendi.

The yield of bhendi crops in 1983 and 1984 are presented in table 3 a and the uptake of nutrients by the crop in table 3 b. In 1983 an yield of 6400 kg ha^{-1} of fresh bhendi pods was harvested and in 1984 the corresponding yield was 5850 kg ha^{-1}. A quantity of 1014 kg ha^{-1} of haulms in 1983 and 9830 kg ha^{-1} in 1984 were recorded. There was some reduction in the yield of bhendi and haulms in 1984 compared to 1983. This may be due to the unpresedented heavy summer showers and loss of nutrients through drained water in 1984. Correspondingly there was a reduction in the uptake of NPK in 1984 (table 30).

4.4.2. Kharif rice

4.4.2.1. Yield of grain kg ha^{-1}

The results on the yield of grain on kharif rice of 1983 and 1984 are presented in tables 4a and 4b.

A grain yield of 3435 and 3394 kg ha^{-1} kg ha^{-1} was recorded over the varying fertilizer levels in 1983 and 1984 respectively. The control plots recorded a corresponding yield of 2545 kg ha^{-1} in 1983 and 2700 kg ha^{-1} in 1984. The treatment F_9 recorded highest yield and F_8 was on par in 1983, whereas in 1984, F_8 recorded the highest yield and it was on par with F_9. This is important because about 12 t ha^{-1} FYM was applied to the previous bhindi crop. The P and K supplemented from FYM must have made the F_7 treatment comparable with F_8 and F_9. Thus it is seen that only 75 per cent of P and K need be supplied through fertilizer for maximum grain yield under the bhindi-rice-rice system effecting an economy of 25 per cent of P and K for kharif rice crop.

According to Yawalker (1965) the nutrients utilised by the current crop from the applied FYM is only around 50 per cent. Therefore the balance amount of NPK must have been made available for the succeeding rice crop. In this case the residual effect of P and K is more pronounced and has resulted in a saving of 25 per cent of P and K. The above result is in agreement with the finding of Meelu and Rekhi (1981).

4.4.2.2. Number of productive tillers M^{2}

The number of productive tillers M^{2} in kharif rice of 1983 and 1984 are presented in table 5 a and 5 b.

The mean number of productive tillers over varying fertilizer levels in 1983 was 273.25 M^{2} and in 1984 it was 272.85 M^{2}. The control plots recorded 224.50 and 223.50 tillers M^{2} in 1983 and 1984 respectively. There was a progressive increase in the number of productive tillers from F_1 to F_9 in both years. The maximum number was produced under F_9 during both years. More number of productive tillers are produced only with application of full dose of N, P and K fertilizers. (Nair et al. 1972; Bhattacharya and Chatterjee, 1978).

4.4.2.3. Number of filled grains panicle^{-1}

The results on the number of filled grains panicle^{-1} in 1983 and 1984 are presented in tables 6 a and 6 b respectively.

The mean number of filled grains panicle^{-1} for varying fertilizer levels are 68.19 (1983) and 67.90 (1984). The control plots recorded 58.75 (1983) and 57.40 (1984). In 1983, the maximum number was recorded under treatment F_9 followed by F_8 and F_7 which were on par. In 1984, F_8 recorded the highest value followed by F_9 and F_7 which were on par with F_8. This indicates that 50 per cent of P and K is met from the cropping system. Bhendi is a crop which received FYM at 12 t ha^{-1} and this would have resulted in residual effect of supplementing 50 per cent of P and K to the kharif rice crop (Yawalker, 1965). Reference to table 3 b shows that total removal of nutrients by bhindi is comparatively lesser than cassava, and groundnut croping systems.

4.4.2.4. Weight of 1000 grains (g)

The data on 1000 grain weight in 1983 and 1984 are presented in tables 7a and 7b.

The mean 1000 grain weight in 1983 was 27.90 and in 1984 it was 27.79 with control plots recording 27.05 g (1983) and 26.80 g (1984). The highest 1000 grain weight of 28.70 g was recorded under F_9 followed by F_8 and F_7 in 1983 which were on par with F_9. In 1984, highest grain weight was recorded under F_8 followed by F_8 which was on par with F_9. Thus a fertilizer dose of 100:75:75 per cent of recommended dose is with an economy of 25 per cent of P and K. These nutrients must have been supplemented through the residual effect of FYM applied at 12 t ha^{-1} to the summer crop of bhindi.

4.4.2.5. Yield of straw kg ha^{-1}

The data on the yield of straw in 1983 and 1984 are presented in tables 8a and 8b respectively.

The mean yield of straw over the varying fertilizer levels in 1983 was 3507 kg ha^{-1} and 3503 kg ha^{-1} in 1984, with control plots recording an yield of 2865 kg ha^{-1} in 1983 and 2852 kg ha^{-1} in 1984. In 1983, the maximum yield of 3795 kg ha^{-1} was recorded under F_9 and all other treatments were inferior. In 1984, also the same trend was followed. The above results indicate that for maximum straw yield under a bhendi-rice-rice system, the full recommended dose of fertilzier is necessary. (Rao and Ramanujam, 1971 and Venkiteswaralu, 1978). There was an increasing yield on all other treatments compared to the control plots in both years which can be due to the combined effect of fertilizer levels applied to the kharif crop as well as the residual effect of the farm yard manure applied to the previous bhendi crop at 12 t ha^{-1}.

4.4.2.6. Uptake of nitrogen kg ha^{-1}.

The uptake of nitrogen in 1983 and 1984 are presented in tables 9a and 9b respectively. The mean uptake of nitrogen over the varying fertilizer levels in 1983 was 73.19 kg ha^{-1} and in 1984, it was 73.08 kg ha^{-1}. The control plots recorded an uptake of 58.15 kg ha^{-1} in 1983 and 57.35 kg ha^{-1} in 1984. In 1983, the maximum absorption of 81.95 kg ha^{-1} was recorded in the treatment F_8 followed by F_9 which was on par with F_8. In 1984, the highest nitrogen uptake was recorded in treatment F_9 followed by F_8 and F_7 which was on par with F_9. It may also be noted that, the progressive uptake is proportional to the quantity of the element applied through fertilizers.

4.4.2.7. Uptake of phosphorus kg ha^{-1}

The result in 1983 and 1984 are presented in table 10a and 10b respectively.

The mean uptake of P was 11.43 kg ha^{-1} during both 1983 and 1984, with the control plots recording 8.70 kg ha^{-1} in both years. The maximum uptake of 12.65 kg in 1983 was recorded under treatment F_9 followed by F_8 which was on par with F_9. The same trend was exhibited in 1984 also. In general, there was a progressive uptake of phosphorus with the increase in fertilizer levels from F_1 to F_9.

4.4.2.8. Uptake of potassium kg ha^{-1}

The result of 1983 and 1984 is presented in tables 11a and 11b - S_4.

The uptake values in 1983 was 61.32 kg ha^{-1} and 61.60 kg ha^{-1} in 1984. The control plots recorded 49.70 kg ha^{-1} in 1983 and 49.05 kg ha^{-1} in 1984. In 1983, maximum uptake was recorded in F_9 followed by F_8 and F_7 which were on par with F_9. There was a progressive increase in the uptake in both years with increase in the nitrogen application (Sharma and Rajendra Prasad, 1980).

4.4.3. Rabi rice

4.4.3.1. Grain yield kg ha^{-1}

The result on the grain yield of rabi rice (1983 and 1984) is presented in table 36. A higher yield of 2881 kg ha^{-1} was recorded in 1983 under F_9 and other treatments except F_0, F_1 and F_2 are on par. In 1984 also the highest yield was recorded in treatment F_9 and in other treatments except F_0, F_1 and F_3 are on par. Thus it is seen that fertilizer doses applied to kharif crop up to F_4 level impart residual effect to the succeeding rabi crop with an economy of 25 per cent N and 50 per cent each of P and K. This can be attributed to the residual effect of FYM applied at 12 t ha^{-1} to the previous bhandi crop (Yawalker, 1965)

4.4.3.2. Number of productive tillers M^2

The result presented in Table 37, showed that in 1983 it was 250.22 M^2 and in 1984 it was 211.95 M^2

Table 36. Rabi rice-yield of grain (kg ha^{-1}) Bhendi-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	2498	3068	2783	2447	3017	2732
F_1	2508	3149	2828	2511	2937	2724
F_2	2612	2968	2790	2522	3035	2778
F_3	2505	3189	2847	2449	2972	2710
F_4	2573	3112	2842	2462	3067	2765
F_5	2507	3192	2850	2472	3055	2763
F_6	2530	3201	2866	2567	3099	2833
F_7	2504	3197	2851	2476	3096	2786
F_8	2547	3173	2873	2515	3045	2780
F_9	2555	3207	2881	2570	3034	2855
Mean	2536	3145	2840	2510	3036	2773
SEm	24.46			58.54		
CD(F)			51.21			122.52
CD (Fxm)	72.42			172.26		

Table 37. Rabi rice - No. of productive tillers (M^{-2})
Bhendi-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	223.50	265.50	244.50	224.00	266.50	245.25
F_1	224.00	267.00	245.50	224.00	267.00	245.50
F_2	226.50	270.00	248.25	224.50	270.00	247.25
F_3	223.50	270.50	247.00	223.50	270.50	247.00
F_4	230.00	275.00	252.50	228.50	273.50	251.00
F_5	225.50	275.50	250.25	226.50	275.00	250.50
F_6	226.50	275.50	251.00	227.50	275.50	251.25
F_7	227.50	279.50	253.50	226.50	279.00	252.75
F_8	231.50	280.50	255.50	231.50	280.50	255.50
F_9	227.50	281.00	254.25	226.50	280.50	253.50
Mean	226.50	273.50	250.22	226.10	273.80	249.95
SEm	2.195			1.832		
CD (F)			4.596			3.833
CD (F x M)	6.500			6.419		

Table 38. Rabi rice - Number of filled grains panicle^{-1} B@ndhi-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	56.35	63.95	60.15	56.85	64.20	60.52
F1	56.55	63.85	60.20	56.65	64.00	60.32
F2	57.35	62.10	59.72	57.40	62.10	59.75
F3	57.10	64.10	60.60	57.10	64.20	60.90
F4	58.00	63.90	60.95	57.80	63.80	60.80
F5	58.05	64.05	61.05	58.00	64.00	61.00
F6	57.85	63.95	60.90	57.90	63.70	60.80
F7	59.10	62.70	60.90	59.10	62.85	60.97
F8	58.70	64.00	61.35	59.00	63.70	61.35
F9	58.90	64.40	61.65	58.80	64.20	61.50
Mean	57.80	63.70	60.75	57.87	63.68	60.77
SEm	0.579			0.343		
CD (F)			1.121			0.718
CD (F x M)	1.714			1.016		

In both years the treatments F_8, F_9 and F_7 consistantly produced higher number of productive tillers and F_1 and F_0 produced least. The treatments which contributed maximum residual effect contain 100 per cent of N, P and K of the recommended nutrients and it can be inferred that higher number of productive tillers are produced only when balanced nutrients are supplied at higher rates. The residual effect of the farm yard manure applied to the summer bhendi crop at 12 t ha^{-1} must have helped to supplement the 25 and 50 per cent deficit of P and K nutrients in the F_8 and F_7 treatments.

4.4.3.3. Number of filled grains $panicle^{-1}$

The result in 1983 and 1984 are presented in table 38. The figures in 1983 was 60.75 and in 1984 it was 60.77. In both years the treatment F_9 contributed maximum residual effect for the production of filled grains $panicle^{-1}$ followed by F_8, F_5 and F_7 which were on par with F_9. Physiologically grain filling is a function of nitrogen and potassium combination by way of transporting photosynthates from the source to the sink.

4.4.3.4. 1000 grain weight (g)

The result on 1000 grain weight (g) in 1983 and 1984 is presented in table 39. The mean weight of 1000 grains over varying fertilizer levels in 1983 was 27.28 g and in 1984 it was 27.15 g. In 1983 the effect of treatments on 1000 grain weight was not significant. However the treatments F_7, F_9, F_8 recorded more 1000 grain weight than other treatments. In 1984, the highest 1000 grain weight was recorded in F_9 followed by F_8, F_6 and F_7. Since the 1000 grain weight within a variety is governed primarily by genetic factors the role of nutrients in influencing the same is only secondary. However, the above result indicates that balanced nutrients at recommended levels may enhance the 1000 grain weight to limited extend.

4.4.3.5. Yield of straw kg ha^{-1}

The result on the yield of straw in 1983 and 1984 is presented in table 40. The mean yield of straw in 1983 was 2578 kg ha^{-1} and in 1984 it was 2580 kg ha^{-1}. In 1983 the treatments F_9 recorded the highest yield of straw followed by F_8 and F_7 which were on par. In 1984, the treatment F_9 recorded the highest straw yield followed by F_8, F_7 and F_6 which were on par with F_9. Consistant results in the yield of straw kg ha^{-1} were recorded in 1983 and 1984 probably because of the residual effect of the farm yard manure applied at 12 t ha^{-1} to the bhindi crop and at 5 t ha^{-1} for the successive rice crops in bhendi-rice-rice system. However, the results are clearly indicative of the fact that

Table 39. Rabi rice - 1000 grain weight (g) Bhendi-rice-rice system

Treat- ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	26.45	27.90	27.17	26.35	27.45	26.90
F1	26.50	27.85	27.17	26.25	27.50	26.87
F2	26.45	28.40	27.42	26.30	27.90	27.10
F3	26.30	28.10	27.20	26.35	27.50	26.92
F4	26.50	28.00	27.25	26.30	28.10	27.20
F5	26.35	27.80	27.07	26.30	28.05	27.17
F6	26.60	27.75	27.17	26.70	27.80	27.25
F7	26.70	28.30	27.50	26.25	28.30	27.27
F8	26.35	28.50	27.42	26.25	28.35	27.30
F9	26.65	28.25	27.45	26.45	27.40	27.55
Mean	26.48	28.08	27.28	26.35	27.96	27.15
SEm	0.302			0.126		
CD (F)			0.632			0.264
CD (F x M)	0.895			0.373		

Table 40. Rabi rice-yield of straw (kg ha^{-1}) - Bh@ndi-rice-rice system

Treat- ments	1983			1984		
	M0	M1	Mean(F)	M0	M1	Mean(F)
F_0	2505	2634	2569	2502	2641	2571
F_1	2448	2679	2563	2467	2559	2513
F_2	2460	2650	2555	2554	2672	2563
F_3	2476	2655	2565	2458	2665	2561
F_4	2452	2661	2556	2484	2650	2567
F_5	2512	2655	2583	2510	2649	2579
F_6	2525	2671	2598	2539	2648	2593
F_7	2498	2642	2570	2529	2689	2608
F_8	2542	2679	2610	2559	2684	2521
F_9	2551	2683	2617	2556	2687	2622
Mean	2496	2661	2578	2506	2654	2580
SEm	10.38			23.01		
CD(F)			21.7			48.17
CD(FxM)	30.73			68.12		

for the contribution of residual effect by kharif crop to the succeeding rabi crop the kharif crop should be supplied with balanced nutrients at the recommended doses.

4.4.3.6. Uptake of nitrogen kg ha^{-1}

The table 41 shows the uptake of nitrogen in 1983 and 1984. The mean uptake values in 1983 was 65.34 kg ha^{-1} and in 1984 it was 65.02 kg ha^{-1}. The highest uptake of nitrogen was recorded under treatment F_9 in 1983. In 1984, the highest uptake of nitrogen was recorded under F_8. In 1983, rabi crop had the benefit of receiving FYM for the bhendi crop and rice crop only once whereas the 1984 rabi rice was benefited by the additional application of the FYM in the second sequence also. Thus there was a residual as well as cumulative effect exhibited resulting a saving of P and K for rabi crop.

4.4.3.7. Uptake of phosphorus kg ha^{-1}

The result in 1983 and 1984 are presented in table 42. The mean uptake of phosphorus in 1983 and 1984 was 10.44 kg ha^{-1}. The highest uptake of phosphorus in 1983 as well as in 1984 was recorded under treatment F_9 followed by F_7, F_8 and F_6 which were on par with F_9. The higher uptake of phosphorus in treatments supplied with higher rate of the

Table 41. Rabi rice - Uptake of N (kg ha^{-1}) Bhendi-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean (F)	MO	M1	Mean (F)
F0	53.80	76.80	65.30	52.85	76.50	64.67
F1	53.65	76.20	64.92	52.70	76.50	64.60
F2	52.70	77.25	64.97	53.50	76.60	65.05
F3	52.90	77.10	65.00	52.70	77.30	65.00
F4	53.80	77.00	65.40	52.40	77.15	64.77
F5	53.35	77.30	65.32	53.10	76.70	64.90
F6	54.05	77.00	65.52	53.00	77.10	65.05
F7	53.05	77.85	65.45	53.45	77.45	65.45
F8	53.90	77.50	54.25	52.00	77.00	65.45
F9	53.55	78.10	65.82	52.95	77.20	65.07
Mean	53.47	77.21	65.34	53.09	76.95	65.02
SEm	0.297			0.293		
CD (F)			0.622			0.615
CD (F x M)	0.880			0.869		

nutrient is a normal phenomenon. The deficit of 25 to 50 per cent of various nutrients existed in some of the treatment combinations must have been supplemented by the residual effect of NPK through the application of 12 t ha^{-1} of farm yard manure applied to the summer bhindi crop in the bhindi-rice-rice system.

4.4.3.8. Uptake of potassium kg ha^{-1}

The result is presented in table 43.

The mean uptake of potassium over varying fertilizer levels in 1983 was 56.32 kg ha^{-1} and in 1984 it was 55.98 kg ha^{-1}. The effects of treatments on the uptake of potassium were not significant in both the years under study. This can be due to the residual effect of the FYM applied to the summer bhindi crops and also due to the residual effect of farm yard manure applied to the rice crops on succeeding seasons. This can be also due to the release of soil potassium under submerged condition (Ponnamperuma, 1965; Barnes et al. 1986).

In the S_4 system involving bhindi as summer crop, the fertilizer dose required for maximum grain yield was only F_7 with 100 per cent N and 50 per cent each of recommended P and K where as for the maximum production of productive tiller the full quantities of recommended NPK nutrients were

Table 42. Rabi rice - Uptake of P (kg ha^{-1}) - Bhendi-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	8.70	11.50	10.10	8.65	11.50	10.07
F_1	8.55	11.75	10.15	8.55	11.75	10.15
F_2	8.75	11.90	10.32	8.75	11.90	10.32
F_3	8.65	12.05	10.35	8.65	12.05	10.35
F_4	8.75	11.90	10.32	8.75	11.90	10.32
F_5	8.70	11.75	10.25	8.75	11.75	10.25
F_6	9.25	12.10	10.67	9.25	12.10	10.67
F_7	9.25	12.30	10.77	9.25	12.30	10.77
F_8	9.15	12.30	10.72	9.15	12.30	10.72
F_9	9.30	12.25	10.77	9.30	12.25	10.77
Mean	8.90	11.98	10.44	8.90	11.98	10.44
SEm	9.103			0.177		
CD (F)			0.269			0.371
CD (F x M)	0.269			0.524		

Table 43. Rabi rice - Uptake of K (kg ha^{-1}) Bhendi-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	48.90	63.15	56.02	48.80	62.65	55.72
F_1	49.50	62.95	56.22	48.65	62.80	55.72
F_2	49.35	62.75	56.05	48.50	63.10	55.80
F_3	49.05	63.25	56.15	48.65	63.55	56.10
F_4	49.00	63.10	56.05	48.50	63.60	56.05
F_5	48.75	64.50	56.22	48.60	63.05	55.82
F_6	48.80	64.30	56.55	48.25	63.15	55.70
F_7	49.00	63.90	56.45	48.70	63.80	56.25
F_8	49.45	63.70	56.67	48.40	64.15	56.27
F_9	49.70	63.45	56.57	48.75	64.10	56.42
Mean	49.15	63.50	56.32	48.58	63.39	55.98
SEm	0.399			0.532		
CD (F)			0.837			0.737
fD (F x M)	1.183			1.043		

required. For the maximum expression of other yield attributes of filled grains and 1000 grain weight nutrient doses of F_7 and F_8 levels were required respectively. For the maximum production of straw also full recommended doses of nutrients were required thus maintaining a perfect relation with the number of productive tillers.

4.5. Rice-rice-rice system

4.5.1. Summer rice.

The yield and the uptake of nutrients by the summer rice crops are presented in table 3a and 3b respectively.

In 1983, a grain yield of 3210 kg ha^{-1} and in 1984 a grain yield of 3020 kg ha^{-1} was recorded. The straw yield of the corresponding years were 3250 kg ha^{-1} and 3065 kg ha^{-1}. The reduction in yield in 1984 can be due to monoculture of rice continuously for 4 seasons. Another reason could be attributed to the depletion of soil nutrients due to the no manure plots of the previous rabi rice amounting to 50 per cent of the area under summer rice crop.

The summer rice crop had an uptake of 65.36 kg N ha^{-1}, 10.93 kg P_2O_5 ha^{-1} and 68.30 kg K_2O ha^{-1} in 1983 and 60.64 kg N ha^{-1}, 10.42 kg P_2O_5 ha^{-1} and 64.46 kg K_2O ha^{-1} in 1984.

4.5.2. Kharif rice

4.5.2.1. Yield of grain kg ha^{-1}

The results are presented in table 4 a & b respectively. In S_5 system in 1983 the mean yield was 3217 kg ha^{-1} and in 1984 it was 3225 kg ha^{-1}. The control plots had a grain yield of 2500 kg ha^{-1} in 1983 and 2532 kg ha^{-1} in 1984.

In rice-rice-rice cropping system treatments F_9 recorded highest yield and F_8 were on par during both the years. This shows that there is a saving of 25 per cent of recommended P and K for kharif rice yield. It is already established that application of P is not required for every season and skipping the phosphorus on alternate seasons is recommended for Kerala (Anon, 1986). In the case of potassium there is considerable addition of K through the stubbles. It is estimated that the uptake of K is in the order of 48 to 67 kg ha^{-1}. At least one third of this quantity would have been left in the soil as crop residue. This would have resulted in saving of 25 per cent of K. More over, the previous three rice crops had received 5000 kg ha^{-1} each of farm yard manure. There would have been some residual effect of P and K on this account. The availability of exchangeable potassium under submerged conditions in acidic latasolic soil as recorded by Ponnamperuma (1965) holds good in this context.

4.5.2.2. Number of productive tillers M^{-2}

The results are presented in tables 5a and 5b for 1983 and 1984 respectively.

The mean number of productive tillers produced in 1983 was 273.40 M^{-2}, and in 1984 it was 272.80 M^{-2}. The control plots recorded 226.00 tillers in 1983 and 226.50 tillers in 1984. There was a progressive increase in the number of productive tillers from F1 to F_9 in both years. In 1983 F_9 and F_8 were on par. In 1984, F_8 produced maximum number of tillers and F_9 was on par. This indicates that in a rice-rice-rice cropping system full recommended dose of fertilizers may not be required for maximum production of productive tillers. There can be an economy of 25 per cent of P and K as in F_8. This may be due to the residual effect of farm yard manure applied to the previous rice crop of a short duration and the entire quantity of FYM would not have been utilized by the rice crop. Yawalker (1965) opined that nutrients in the FYM will be exhausted at the rate of 50 per cent only by the current crop and balance will be available as residual and cumulative effect to succeeding crops.

4.5.2.3. Number of filled grains panicle^{-1}

The results are presented in tables 6 a and 6 b respectively for two years.

The mean number was 65.64 grains panicle^{-1} in 1983 and 65.62 in 1984. The control plots recorded 56.80 number of filled grains panicle^{-1} during both the years. In 1983 F_9 recorded the maximum number followed by F_8 and F_7 which were on par with F_9. In 1984 F_9 alone was significant. This indicates that full quantity of recommended NPK is required for the expression of this yield attributes under the rice-rice-rice system. The above result is in agreement with the finding reported by Racho and De Detta (1968).

4.5.2.4. 1000 grain weight (g)

The result of 1983 and 1984 are presented in tables 7a and 7b respectively.

The mean 1000 grain weight in 1983 was 27.84 g and in 1984 it was 27.63 g. The control plots recorded value of 26.55 g (1983) and 26.65 g (1984). In 1983 and 1984 highest 1000 grain weight of 28.75 g was recorded under F_9 followed by F_8 which was on par with F_9. The above result shows that for getting higher 1000 grain weight in a rice-rice system a fertilizer dose equivalent to F_8 treatment i.e., 100: 75 : 75 per cent of recommended NPK dose, is sufficient with an economy of 25 per cent each of the recommended dose of P and K.

4.5.2.5. Yield of straw kg ha^{-1}

The result in 1983 and 1984 are presented in tables 8 a and 8 b respectively.

The mean yield of straw in 1983 was 3417 kg ha^{-1} and 3716 kg ha^{-1} in 1984. The control plot recorded an yield of 2705 kg ha^{-1} in 1983 and 2730 kg ha^{-1} in 1984. In 1983 the highest yield of 3670 kg ha^{-1} of straw was recorded under treatment F_9 followed by F_8 which was on par with F_9. In 1984 also, same result was obtained. The above result shows that for maximum straw under monoculture of rice a fertilizer level of 100 % nitrogen and 75 % each of P and K of recommended dose is sufficient with an economy of 25 per cent of P and K (Rao and Ramanujam 1971, Venketesvarlu 1978).

4.5.2.6. Uptake of nitrogen kg ha^{-1}

The results on the uptake of nitrogen in 1983 and 1984 is presented in tables 9a and 9b respectively.

The mean uptake presented in tables 9 a and 9 b shows that in 1983 it is 66.25 kg ha^{-1} and 69.28 kg ha^{-1} in 1984. The control plots recorded 53.95 kg ha^{-1} in 1983 and 55.35 kg ha^{-1} in 1984. The maximum uptake of 75.00 kg ha^{-1} was noticed in treatment F_9 followed by F_8 which was on par with F_9 in 1983. In 1984 also the treatment F_9 had maximum uptake of 76.20 kg ha^{-1} followed by F_8 which was also on par. The above results clearly shows that the uptake of nitrogen by kharif rice crop is proportional to the nitrogen supplied to the crop in combination with P and K to the level of at least 75 per cent of the recommended doses. F_7 is significanlty inferior to F_8 and F_9. The reason for lower uptake of nitrogen in F_7 is due to less quantity of P and K applied through fertilizer in a this treatment.

4.5.2.7. Uptake of phosphorus kg ha^{-1}

The results of in 1983 and 1984 are presented in tables 10a and 10b respectively.

The mean uptake over varying fertilizer levels in 1983 was 11.03 kg ha^{-1} and 11.10 kg ha^{-1} in 1984. The control plots have recorded an uptake of 8.50 kg ha^{-1} each in 1983 and 1984. The maximum uptake of 12.25 kg ha^{-1} phosphorus in 1983 was recorded under the treatment F_9 followed by F_8 which was on par with F_9. During 1984 the same trend was exhibited. F_9 recorded the maximum uptake of phosphorus followed by F_8 and F_7 which were on par with F_9. In general, there was a progressive increase in the uptake of phosphorus with increase in nutrient supply. Mohanakumar (1967) and Rastogi (1981) also obtained similar results.

4.5.2.8. Uptake of potassium kg ha^{-1}

The uptake of potassium in 1983 and 1984 are presented in tables 11a and 11b respectively.

The mean uptake over varying fertilizer levels in 1983 was 59.52 kg ha^{-1} and in 1984 it was 60.06 kg ha^{-1}. The control plots recorded an uptake of 48.10 kg ha^{-1} in 1983 and 48.10 kg ha^{-1} in 1984. In 1983, maximum uptake of 67.00 kg ha^{-1} was recorded in treatment F_9 followed by F_8 which was on par with F_9 and in 1984 it was 68.40 kg ha^{-1} in F_9 followed by F_8 and F_7. There was a progressive increase in the uptake of potassium in both the years in treatments F1 to F_9. The higher uptake of potassium is associated with higher supply of the nutrients to the crop through fertilizers (Sharma and Rajendra Prasad, 1980).

4.5.3. <u>Rabi rice</u>

4.5.3.1. Yield of grain kg ha^{-1}

The result of the grain yield of rabi rice (1983 and 1984) is presented in table 44. The mean yield in 1983 was 2831 kg ha^{-1} and in 1984 it was 2777 kg ha^{-1}.

In 1983 as well as in 1984 the treatment F_9 have given significantly higher yield and during both the years treatments F_0, F1, F_2 and F_4 were significantly inferior.

Table 44. Rabi rabi-yield of grain (kg ha^{-1}) Rice-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	2543	2940	2741	2547	2957	2752
F_1	2573	3035	2804	2454	2954	2704
F_2	2481	3206	2843	2443	3106	2774
F_3	2510	3166	2838	2441	3161	2801
F_4	2525	3046	2785	2442	3101	2771
F_5	2534	3114	2824	2532	2915	2723
F_6	2518	3191	2854	2572	3004	2788
F_7	2518	3191	2854	2534	3018	2776
F_8	2526	3221	2873	2529	3090	2809
F_9	2522	3236	2879	2547	3205	2876
Mean	2522	3140	2831	2504	3051	2777
SEm	37.47			22.06		
CD(F)			78.44			46.18
CD (Fxm)	40.93			65.30		

Table 45. Rabi rice - No. of productive tillers m^{2}
Rice-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	225.00	269.50	247.25	222.00	271.50	246.75
F_1	223.00	271.50	247.25	222.50	273.00	247.50
F_2	225.00	272.50	248.75	224.00	272.50	248.25
F_3	225.00	269.50	247.25	225.00	271.50	248.00
F_4	226.00	270.50	248.25	224.50	271.00	247.75
F_5	223.50	273.00	248.25	222.00	273.00	247.50
F_6	224.50	275.00	249.75	224.00	276.50	250.50
F_7	226.50	278.00	252.25	225.00	280.00	252.50
F_8	230.50	281.00	255.75	229.00	281.00	255.00
F_9	229.50	279.00	.254.25	228.00	279.50	253.75
Mean	225.85	273.90	249.87	224.60	274.40	249.53
SEm	3.297			2.168		
CD (F)			6.902			4.539
CD (F x M)	9.761			6.4198		

The above result clearly indicate that even though some of the fertilizer doses of higher magnitude applied to the kharif rice exhibit slight residual effect distinctly higher residual effect is manifested by the full recommended doses of fertilizer applied to the kharif crop in the succeeding rabi rice under the fallow-rice-rice system. This may be due to the release of nutrients from the stubbles that must have been produced to a large extent due to the balanced as well as enhanced nutrient supply to the kharif crop by way of full dose of recommended fertilizers.

4.5.3.2. Number of productive tillers m^{-2}

The result on the number of productive tillers is presented in table 45. The mean number of productive tillers over varying fertilizer levels in 1983 was 249.87 m^{-2} and 249.53 m^{-2} in 1984.

The highest number of productive tillers in 1983 was 255.75 m^{-2} in treatment F_8 followed by F_9, F_7 and F_6 and in 1984 it was 255.00 m^{-2} in F_8 followed by F_9, F_7 and F_6. The lesser number of productive tillers were produced in treatments with lower nutrient level. The above result indicates that higher number of productive tillers are produced only if balanced nutrition at higher levels are applied to the previous crop. Nutritiion combinations as given in treatments F_6, F_7 and F_8 has given comparable results as that of F_9. This must be due to the supplementation of the N, P and K to the extent of 25 tp 50 per cent through the FYM applied to the previous rice crop as well as from the decomposition at the stubbles of previous kharif crop.

4.5.3.3. Number of filled grains panicle^{-1}

The result on the number of filled grains panicle^{-1} in 1983 and 1984 is presented in table 46. The mean number of filled grains in 1983 was 60.97 and in 1984 it was 60.83. The highest number in 1983 was in F_9 followed by F_8, F_5 and F_3 which were on par. In 1984 the highest number of filled grains panicle^{-1} was in F_5 followed by F_8, F_9 and F_7. It is to be specially mentioned that the treatment F_5 containing 75 per cent of N, P and K of the recommended fertilizer dose which have contributed residual effect in producing maximum number of filled grains per panicle in 1984 was on par with F_9 and F_8. This can be due to the residual nutrients made available through decomposition of the stubbles of the summer rice crop under rice-rice-rice system. It can be also due to the residual effect of FYM applied at 5 t ha^{-1} to the previous two rice crops under the system.

Table 46. Rabi rice - Number of filled grains $panicle^{-1}$
Rice-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	57.00	62.20	59.60	57.05	63.10	60.07
F1	57.35	64.65	61.00	57.00	64.40	60.70
F2	57.55	63.85	60.70	56.95	64.00	60.47
F3	57.90	64.60	61.25	57.50	64.10	60.80
F4	56.95	64.00	60.47	57.10	63.85	60.47
F5	58.75	64.05	61.40	58.80	65.00	61.90
F6	57.75	63.85	60.80	57.65	63.10	60.37
F7	58.25	64.15	61.20	58.10	64.00	61.05
F8	59.05	63.95	61.50	58.80	63.80	61.30
F9	59.60	64.15	61.87	58.35	64.05	61.20
Mean	58.01	63.94	60.97	57.73	63.94	60.83
SEm	0.613			0.333		
CD (F)			1.284			0.697
CD (F x M)	1.816			0.986		

Table 47. Rabi rice - 1000 grain weight (g) Rice-rice-rice system

Treatments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	26.35	27.45	26.90	26.25	27.70	26.97
F1	26.45	28.00	27.22	26.50	28.00	27.25
F2	26.40	27.40	26.90	26.40	28.10	27.25
F3	26.40	27.90	27.15	26.55	28.10	27.32
F4	26.25	28.30	27.27	26.50	28.00	27.25
F5	26.40	28.10	27.25	26.50	28.50	27.50
F6	26.25	28.30	27.27	26.35	28.05	27.20
F7	26.50	28.15	27.15	26.45	28.40	27.42
F8	26.50	28.60	27.55	26.50	28.50	27.50
F9	26.35	28.30	27.32	26.55	28.50	27.52
Mean	26.38	28.05	27.21	26.45	28.13	27.29
SEm	0.169			0.274		
CD (F)			0.354			0.573
CD (F x M)	0.500			0.811		

Table 48. Rabi rice-yield of straw (kg ha^{-1}) Rice-rice-rice system

Treatments	1983			1984		
	MO	M1	Mean(F)	MO	M1	Mean(F)
F_0	2430	2573	2501	2430	2567	2498
F_1	2469	2545	2507	2473	2546	2509
F_2	2461	2568	2514	2468	2575	2522
F_3	2490	2661	2575	2489	2661	2575
F_4	2525	2655	2590	2530	2656	2593
F_5	2474	2664	2569	2479	2662	2570
F_6	2527	2632	2579	2550	2617	2584
F_7	2514	2667	2590	2534	2635	2584
F_8	2543	2660	2601	2519	2677	2598
F_9	2542	2687	2614	2540	2687	2613
Mean	2497	2631	2564	2501	2628	2564
SEm	9.42			14.94		
CD(F)			19.72			31.21
CD(FxM)	27.89			44.13		

4.5.3.4. 1000 grain weight (g)

The result on 1000 grain weight of rabi crop in 1983 and 1984 are presented in table 47.

The mean weight of 1000 grains over varying fertilizer levels in 1983 was 27.21 g and in 1984 it was 27.29 g. The maximum weight of 1000 grains in 1983 was recorded under treatment F_8 followed by F_7, F_9, F_5 and F_6. It was not however not significant in 1984. Since 1000 grain weight is not generally influenced by nutrition the impact must be still lower due to residual effect.

4.5.3.5. Yield of straw in kg ha^{-1}

The result on yield of straw in 1983 and 1984 are presented in table 48. The mean yield of straw over varying fertilizer levels in 1983 was 2564 kg ha^{-1} and in 1984 it was 2564 kg ha^{-1}. In 1983 the highest straw yield was obtained in treatment F_9 followed by F_8, F_7 and F_4 and in 1984 the highest yield of straw was recorded in treatment F_9 followed by F_8, F_4, F_7 and F_6.

The above results are indicative of the fact that for the residual effect of the kharif crop to the succeeding rabi crop the kharif crop should be supplied with balanced nutrients at the recommended doses itself.

4.5.3.6. Uptake of nitrogen kg ha^{-1}

The result on the uptake of nitrogen in 1983 and 1984 are presented in table 49. The mean uptake of nitrogen in 1983 over varying fertilizer levels was 65.15 kg ha^{-1} and in 1984 it was 65.21 kg ha^{-1}. In 1983 the highest uptake of nitrogen was recorded under the treatment F_8 (100 : 75 : 75 % of NPK) followed by F_9 and F_7 which were on par with F_8. In 1984 the highest nitrogen uptake was under F_9 followed by F_8 and F_7 which were on par with F_9. Thus it is seen that higher uptake of nitrogen is in treatments supplied with higher doses of nitrogen thus indicative of residual effect of nitrogen applied to kharif crop to the succeeding rabi crop.

4.5.3.7. Uptake of phosphorus kg ha^{-1}

The result on uptake of phosphorus in 1983 and 1984 s presented in table 50. The mean uptake of phosphorus over varying fertilzer levels in 1983 was 10.32 kg ha^{-1} and in 1984 it was 10.27 kg ha^{-1}. In 1983 highest uptake of phosphorus was recorded in treatment F_9 followed by F_8, F_7 and F_5 which were on par with F_9. In 1984 the highest uptake was recorded in treatment F_9 followed by F_7, F_6, F_5 and F_8 which were on par with F_9.

Table 49. Rabi rice - Uptake of N (kg ha^{-1}) Rice-rice-rice system

Treatments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	52.65	77.40	65.02	53.05	76.60	64.82
F1	52.90	76.90	64.90	52.70	77.25	64.97
F2	53.45	77.35	65.40	53.50	76.80	65.15
F3	52.80	77.20	65.00	53.40	76.65	65.02
F4	53.50	76.60	65.05	53.20	77.00	65.10
F5	53.00	77.10	65.05	53.55	77.40	65.47
F6	52.70	76.50	64.60	53.70	76.15	64.92
F7	53.50	77.30	65.40	53.55	77.40	65.45
F8	54.20	77.00	65.60	53.95	77.00	65.45
F9	53.40	77.50	65.45	53.90	77.50	65.70
Mean	53.21	77.08	65.15	53.45	76.97	65.21
SEm		0.276			0.244	
CD (F)			0.578			0.511
CD (F x M)		0.818			0.722	

Table 50. Rabi rice - Uptake of P (kg ha^{-1}) Rice-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	8.75	11.80	10.27	8.75	11.80	10.27
F_1	8.65	11.95	10.30	8.55	11.95	10.25
F_2	8.55	11.75	10.15	8.55	11.75	10.15
F_3	8.75	11.80	10.27	8.75	11.80	10.27
F_4	8.65	11.80	10.22	8.65	11.75	10.20
F_5	8.75	12.10	10.45	8.55	12.30	10.42
F_6	8.55	11.95	10.25	8.75	12.10	10.42
F_7	8.70	12.20	10.45	8.70	12.20	10.45
F_8	8.65	12.30	10.47	8.65	11.95	10.30
F_9	8.65	12.30	10.47	8.65	12.30	10.47
Mean	8.66	11.99	10.32	8.65	11.90	10.27
SEm	9.598			9.195		
CD (F)			0.200			0.192
CD (F x M)	0.284			0.272		

Table 51. Rabi rice - Uptake of K (kg ha^{-1}) Rice-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	48.80	62.60	55.70	48.75	63.15	55.95
F_1	48.55	62.95	55.75	49.03	63.25	56.15
F_2	48.75	63.20	55.97	48.75	63.90	56.32
F_3	48.60	63.05	55.82	49.25	64.45	56.35
F_4	49.30	63.75	56.52	49.35	62.75	56.05
F_5	48.40	63.70	55.70	48.75	63.90	56.32
F_6	48.75	62.90	55.82	49.70	63.45	56.57
F_7	48.40	63.95	55.97	48.60	64.15	56.37
F_8	48.50	64.05	56.27	48.10	64.65	56.37
F_9	48.60	63.60	59.10	49.45	63.70	56.57
Mean	48.66	63.35	56.00	48.97	63.73	56.35
SEm	0.351			0.369		
CD (F)			0.735			0.773
CD (F x M)	1.040			1.094		

The above result clearly indicates that the uptake of P is noticed in treatments supplied with higher rate of N, P and K nutrients under the rice-rice-rice cropping system.

4.5.3.8. Uptake of potassium kg ha^{-1}

The result on the uptake of potassium in 1983 and 1984 is presented in table 51. The uptake of potassium in 1983 was 56.00 kg ha^{-1} and in 1984 it was 56.35 kg ha^{-1}. In 1983 the highest uptake of potassium was noticed in the treatment F_9 (100 : 100 : 100 % NPK) and all other treatments were inferior. In 1984 the uptake of potassium due to treatment variations are not significant. The lack of significant effect can be due to the residual effect of the farm yard manure applied to all the rice crops at 5 t ha^{-1} and aslo due to the residual effect of stubbles incorporated in the plot under the rice-rice-rice system. This can be also due to the release of exchangeable K uder submerged condition under this system with mono-culture of rice (Ponnamperuma, 1965; Barnes et al., 1986).

In S_5 system of cropping for the maximum grain yield F_7 level of nutrients was sufficient where as for the maximum production of productive tillers and 1000 grain weight F_8 level of nutrients was required. For the maximum number of filled grains also F_7 level of nutrients was sufficient. For the maximum production of straw also F_8 level of nutrients was sufficient.

4.6. Fallow-rice-rice system

4.6.1. Kharif rice

4.6.1.1. Yield of grain kg ha^{-1}

The result on the grain yield of kharif rice in 1983 and 1984 are presented in tables 4a and 4b. The mean yield in 1983 is 3101 kg ha^{-1} and 3098 kg ha^{-1} in 1984. The control plots have recorded grain yield of 2510 kg ha^{-1} in 1983 as well as in 1984.

In this system (S_6) there is a progressive increase in grain yield commensurate with the fertilizer doses (Singh and Ramamoorthy, 1974). During both years the treatment F_9 recorded the maximum yield followed by F_8, F_7 and F_6 which are significantly different among themselves. All other treatments such as F_5, F_4, F_3 were inferior. There was proportionate reduction when the level of N and K was reduced in F_8 and F_7. The reduction of 25 per cent N in F_6 was more deleterious since it has given lowest yield when compared to the other treatments mentioned above. This is in contrast with kharif rice yield in the F_5 system. The reasons for the difference in performance is attributed to the lack of beneficial effect associated with growing rice crop such as incorporation of FYM as well as stubbles of the summer rice crop.

4.6.1.2. Number of productive tillers m^{-2}

The result on the number of productive tillers produced by kharif rice in 1983 and 1984 are presented in tables 5a and 5b. The mean number of productive tillers m^{-2} recorded over varying fertilizer levels in 1983 was 266.50 and in 1984 it was 266.90 tillers m^{-2} The control plots recorded 220.00 tillers m^{-2} in 1983 and 221.50 tillers m^{-2} in 1984. maximum number of tillers are produced under the F9 level of fertilizers in both years. The 100 per cent fertilizer levels given in this treatment must be the major factor for the superiority. Any reduction in the recommended dose is detrimental especially in the absence of 'no crop' in the summer season.

4.6.1.3. Number of filled grains panicle^{-1}

The result on the number of filled grains panicle^{-1} in 1983 and 1984 are presented in tables 6 a and 6 b respectively.

The mean number of filled grains panicle^{-1} over varying fertilizer levels was 65.52 in 1983 and 65.04 in

1984. The control plots recorded 56.70 in 1983 and 56.85 in 1984. In 1983 F_7 recorded the maximum number of filled grains panicle^{-1} followed by F_9 and F_8 which were on par with F_7. In 1984 the treatment F_8 ranked first followed by F_9 wihch was on par with F_8. The above result indicates that for the maximum number of filled grains panicle^{-1}, full dose of N and at last and 75 per cent each of p and K is essential in fallow-rice-rice system.

4.6.1.4. 1000 grain weight g

The results recorded on 1000 grain weight in 1983 and 1984 are presented in tables 7 a and 7b respectively.

The mean 1000 grain weight over varying fertilizer levels in 1983 was 27.66 g and 27.91 g in 1984. The control plots have recorded a 1000 grain weight of 26.75 g (1983) and 26.65 g (1984). In 1983 the highest 1000 grain weight of 28.30 g was recorded under F_9 followed by F_7 and F_8 which were on par with F_9. In 1984 F_9 recorded the highest 1000 grain weight of 28.60 g followed by F_6, F_8 and F_7 which were on par with F_9. This indicates that under fallow-rice-rice cropping system at least nutrients is given in treatment F_7 is to be applied (100 per cent N and 50 per cent each of recommended P and K).

4.6.1.5. Yield of straw kg ha^{-1}

The result on the yield of straw in 1983 and 1984 are presented in tables 8a and 8b respectively. The mean yield of straw over varying fertilizer levels in 1983 was 3344 kg ha^{-1} and 3342 kg ha^{-1} in 1984. The control plots recorded an yield of 2695 kg ha^{-1} in 1983 and 2720 kg ha^{-1} in 1984. The maximum straw yield of 3555 kg ha^{-1} was recorded under the treatment F_9 in 1983 followed by F_8 which was on par with F_9. All other treatments were inferior. In 1984 also same tend was recorded. The above results indicate that for maximum straw yield under fallow-rice-rice system at least a fertilizer application as given in F_8 level i.e., 100 per cent N and 75 per cent each of P and K of recommended dose is absolutely required.

4.6.1.6. Uptake of nitrogen kg ha^{-1}

The result on the uptake of nitrogen in 1983 and 1984 are presented in tables 9a and 9b respectively. The mean uptake over varying fertilizer levels in 1983 was 69.28 kg ha^{-1} and 66.27 kg ha^{-1} in 1984. The control plots recorded an uptake of 55.45 kg ha^{-1} in 1983 and 53.95 kg ha^{-1} in 1984. The maximum uptake of 76.70 kg ha^{-1} was recorded under treatment F_8 followed by F_9 which was on par with F_8. In 1984 F_9 recorded the maximum uptake followed by F_8 which was on par with F_9. The above results shows that uptake of nitrogen is in general proportional to the supply of the nutrients to the crop in combination with at least 75 per cent of P and K at the recommended doses. F_7 have given a significantly lower N uptake inspite of recommended dose of N. This combination has received only 50 per cent of recommended P and K. It is to be inferred that in the absence of adequate quantities of P and K the N uptake has come down. This points to the necessary of balanced fertilizer application.

4.6.1.7. Phosphorus uptake kg ha^{-1}

The result on phosphorus uptake in 1983 and 1984 are presented in tables 10a and 10b respectively. The mean uptake over varying fertilizer levels in 1983 was 10.95 kg ha^{-1} and 10.94 kg ha^{-1} in 1984. The control plots recorded an uptake of 8.60 kg ha^{-1} each in 1983 and 1984. In 1983 maximum uptake of 11.95 kg ha^{-1} was recorded under the treatment F_9 followed by F_8 which is on par with F_9. In 1984 the maximum uptake of 11.90 kg ha^{-1} was under F_9 followed by F_8 and F_7 which were on par with F_9. The above results indicate that increased uptake of phosphorus is associated with increased supply of N, P and K (Rastogi _et al._, 1981).

4.6.1.8. Uptake of potash kg ha^{-1}

The result on the uptake of potassium in 1983 and 1984 are presented in tables 11a and 11b. The mean uptake of potassium over various fertilizer levels in 1983 was 61.11 kg ha^{-1} and 61.31 kg ha^{-1} in 1984. The control plots recorded 48.25 kg ha^{-1} in 1983 and 48.50 kg ha^{-1} in 1984. In 1983 maximum uptake of 67.00 kg ha^{-1} was recorded in F_9 followed by F_8 which was on par with F_9. In 1984 the maximum uptake of 68.45 kg ha^{-1} was in F_9 followed by F_8 and F_7 which were on par with F_9. In general there was a progressive increase in the uptake of potassium from treatments F_1 to F_9 indicating that the rate of uptake of potassium is associated with higher rate of application of nutrients such as N, P and K (Sharma and Rajendra Prasad, 1980).

4.6.2. Rabi rice

4.6.2.1. Yield of grain kg ha^{-1}

The result of the grain yield of the rabi rice (1983 and 1984) is presented in table 52. The mean yield of grain in 1983 as well as in 1984 was 2833 kg ha^{-1}. The highest yield of 2879 kg ha^{-1} was recorded under F_9 in 1983 and all other treatments except F_4 and F_0 were on par. In 1984 the highest yield of 2829 kg ha^{-1} was recorded under F_9 and all other treatments were inferior to it. The above results indicate that as the system progresses fertilizer doses applied to the kharif crop at F_9 level (100 per cent of recommended fertilizer dose) alone manifest residual effect to the succeeding rabi crop under the fallow-rice-rice cropping system. This can be due to the non inheritence of soil nutrients from the fallow to the succeeding rice crops.

4.6.2.2. Number of productive tillers m^{-2}

The result on the number of productive tillers m^{-2} in 1983 and 1984 is presented in table 53. The mean number in 1983 is 250.32 (m^{-2}) and in 1984 it is 250.12 m^{-2}

The highest number of productive tillers m^{-2} was produced under the treatment F_9 in both 1983 and 1984 followed by F_8 and F_7. The lowest number of productive tillers were produced in treatments F_0 and F_1. The above result clearly indicate that for getting higher number of productive tillers nutrients at recommended levels should be applied to the rice crop. In this case the residual effect of the higher levels of fertilizers applied under treatments F_9, F_8 and F_7 to the kharif crop might have resulted in some residual effect for producing higher number of productive tillers in the succeeding rabi crop.

Table 52. Rabi rice-yield of grain (kg ha^{-1}) Fallow-rice-rice system

Treat-ments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	2502	3089	2795	2510	3105	2807
F_1	2508	3141	2824	2512	3095	2803
F_2	2468	3099	2783	2470	3100	2785
F_3	2493	3192	2842	2522	3160	2841
F_4	2536	3068	2802	2540	3069	2804
F_5	2528	2166	2847	2497	3200	2848
F_6	2552	3154	2853	2566	3165	2865
F_7	2501	3175	2838	2515	3160	2837
F_8	2516	3189	2852	2487	3195	2841
F_9	2593	3207	2900	2600	3210	2905
Mean	2519	3148	2833	2522	3145	2833
SEm	18.69			16.72		
CD(F)			39.12			34.99
CD (Fxm)	55.33			49.49		

Table 53. Rabi rice - No. of productive tillers M^{-2}
Fallow-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	225.50	263.50	244.50	224.00	265.50	244.75
F_1	225.00	265.00	245.00	226.00	265.00	245.00
F_2	229.00	268.50	248.75	228.00	269.50	248.75
F_3	228.00	268.50	248.35	228.00	271.00	249.50
F_4	230.00	271.50	250.75	230.00	272.50	251.25
F_5	228.00	271.00	249.50	228.50	273.50	251.00
F_6	230.50	275.00	252.75	225.50	275.50	250.50
F_7	229.50	278.50	254.00	225.50	279.00	252.25
F_8	228.00	279.00	253.50	226.00	279.00	252.50
F_9	231.00	281.50	256.25	229.00	281.50	255.25
Mean	228.45	272.20	250.32	227.05	273.20	250.12
SEm	3.310			2.514		
CD (F)			6.929			5.262
CD (F x M)	9.799			7.442		

Table 54. Rabi rice - Number of filled grains panicle^{-1}
Fallow-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	57.25	63.25	60.25	57.10	63.50	60.30
F1	57.85	63.05	60.45	57.80	63.45	60.62
F2	59.00	62.35	60.67	58.60	62.10	60.35
F3	57.30	64.00	60.65	57.05	64.00	60.52
F4	57.45	63.60	60.52	58.05	63.65	60.85
F5	57.20	64.35	60.77	57.50	64.30	60.90
F6	58.80	63.00	60.90	58.50	63.00	60.75
F7	58.05	64.00	61.02	57.90	63.95	60.92
F8	59.00	64.20	61.60	58.80	64.10	61.45
F9	58.45	63.75	61.10	58.60	63.90	61.25
Mean	58.03	63.55	60.79	57.99	63.59	60.79
SEm	0.372			0.280		
CD (F)			0.779			0.586
CD (F x M)	1.101			0.829		

4.6.2.3. Number of filled grains panicle^{-1}

The result on the number of filled grains panicle^{-1} on 1983 and 1984 are presented on table 54.

The number both in 1983 and 1984 was 60.79 grains panicle^{-1}. In both years the treatments F_8, F_9 and F_7 exhibited same residual effect in producing the highest number of filled grams panicle^{-1}. In F_7 and F_8 even though only lesser quantities of P and K are givn in the kharif season some of the soil P must have been made available by flooding and K in the presence of higher quantities of N (Ponnamperuma, 1965; Barnes, 1986).

4.6.2.4. 1000 grain weight (g)

The result on the 1000 grain weight recorded in 1983 and 1984 is presented in table 55. The mean weight of 1000 grains recorded over varying fertilizer levels in 1983 was 27.14 g and in 1984 was 27.24 g. The highest 1000 grain weight recorded in 1983 was in the treatment F_9 followed by F_8 and F_6 which were on par with F_9. In 1984 the highest 1000 grain weight was recorded in F_8 followed by F_9 and F_6 which were on par with F_8. Treatments F_6 (75 : 100 : 100 per cent of recommended NPK dose) have behaved on par with F_9 with full recommended dose of N, P and K. F_7 is found t be significantly inferior to the above mentioned treatments in both the years. This shows that P and K is absolutely essential for grain filling and increasing the 1000 grain weight. This is all the more clear where, in F_6 when P and K was given at 100 per cent become on par with F_8 and F_9.

4.6.2.5. Yield of straw in (kg ha^{-1})

The result on the yield of straw in 1983 and 1984 are presented in table 56.

The mean yield of straw over varying fertilizer levels in 1983 was 2553 kg ha^{-1} and in 1984 it was 2566 kg ha^{-1}. The highest straw yield recorded in 1983 was under the treatment F_8 followed by F_9 and F_7 which were on par with F_8. Straw yield is mainly a function of nitrogen and hence in all those treatments which received fertilizer N in kharif exhibited residual effect in rabi. Also the 50 per cent deficit of P and K in F_7 must have been made good by release from soil as explained earlier.

4.6.2.6. Uptake of nitrogen (kg ha^{-1})

The result on the uptake of nitrogen in 1983 and 1984 is presented in table 57. The mean uptake of nitrogen over varying fertilizer levels in 1983 was 65.04 kg ha^{-1} and

Table 55. Rabi rice-1000 grain weight (g) Fallow-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean (F)	M0	M1	Mean (F)
F0	26.35	27.50	20.92	26.35	27.70	27.02
F1	26.60	27.55	27.07	26.60	27.75	27.17
F2	26.25	27.50	26.87	26.60	28.25	27.42
F3	26.30	27.90	27.10	26.40	27.90	27.15
F4	26.25	28.05	27.15	26.70	28.30	27.50
F5	26.25	27.70	26.97	26.40	28.30	27.35
F6	26.55	28.10	27.32	26.40	28.00	27.20
F7	26.40	28.05	27.22	26.40	27.45	26.92
F8	26.50	28.10	27.30	26.45	28.00	27.22
F9	26.55	28.50	27.52	26.55	28.35	27.45
Mean	26.40	27.89	27.14	26.48	28.00	27.24
SEm	0.180			0.192		
CD (F)			0.378			0.403
CD (F x M)	0.535			0.569		

Table 56. Rabi rice-yield of straw (kg ha^{-1}) fallow-rice-rice system

Treat-ments	1983			1984		
	M0	M1	Mean(F)	M0	M1	Mean(F)
F_0	2462	2674	2568	2461	2679	2570
F_1	2441	2688	2564	2458	2703	2580
F_2	2425	2691	2558	2434	2688	2561
F_3	2472	2664	2568	2464	2670	2568
F_4	2456	2673	2565	2442	2694	2568
F_5	2457	2716	2586	2463	2721	2592
F_6	2449	2696	2573	2467	2712	2589
F_7	2460	2711	2586	2474	2731	2602
F_8	2470	2734	2602	2577	2667	2622
F_9	2508	2674	2591	2505	2683	2594
Mean	2497	2631	2564	2501	2628	2566
SEm	7.34			21.78		
CD(F)			15.36			45.38
CD(FxM)	21.72			64.48		

Table 57. Rabi rice-Uptake of N (kg ha^{-1}) Fallow-rice-rice system

Treat-ments	1983			1984		
	MO	M1	Mean (F)	MO	M1	Mean (F)
F0	53.25	76.70	64.97	53.50	76.65	65.07
F1	52.85	76.50	64.67	53.90	77.10	65.00
F2	53.45	77.15	64.80	53.00	77.10	65.05
F3	52.70	77.30	65.00	52.45	77.40	64.92
F4	52.75	76.70	64.72	53.50	77.35	65.42
F5	53.05	76.85	64.95	53.85	76.90	65.37
F6	53.40	76.65	65.02	52.80	76.95	64.87
F7	53.50	76.80	65.15	53.40	77.50	65.45
F8	53.55	77.40	65.47	53.00	77.90	65.45
F9	53.20	78.10	65.65	53.55	78.10	65.82
Mean	53.07	77.01	65.04	53.19	77.29	65.24
SEm	0.278			0.280		
CD (F)			0.583			0.586
CD (F x M)	0.825			0.829		

Table 58. Rabi rice - Uptake of P (kg ha^{-1}) Fallow-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	8.55	11.75	10.15	8.75	11.70	10.22
F_1	8.75	12.25	10.50	8.75	12.30	10.52
F_2	8.60	12.20	10.40	8.65	12.30	10.47
F_3	8.75	11.85	10.30	8.75	11.85	10.30
F_4	8.65	12.00	10.32	8.65	12.00	10.32
F_5	9.25	12.00	10.62	9.25	12.00	10.62
F_6	9.10	12.10	10.60	9.10	12.10	10.60
F_7	9.05	12.25	10.65	9.25	12.25	10.75
F_8	9.25	12.30	10.77	9.35	12.30	10.82
F_9	9.05	12.30	10.67	9.05	12.30	10.67
Mean	8.90	12.10	10.50	8.95	12.11	10.53
SEm	0.108			9.940		
CD (F)			0.226			0.208
CD (F x M)	0.320			0.294		

in 1984 it was 65.24 kg ha^{-1}. The highest uptake of nitrogen in 1983 as well as in 1984 was recorded in the treatment F_9 followed by F_8 and F_7 which were on par with F_9. This indicates that higher N given to the soil higher uptake. The availability of the P and K from the soil in treatments F_7 and F_8 along with the added P and K also must have contributed in ensuring sufficient uptake of nitrogen.

4.6.2.7. Uptake of phosphorus (kg ha^{-1})

The result on the uptake of phosphorus in 1983 and 1984 is presented in table 58. The mean uptake of phosphorus over varying fertilizer levels in 1983 was 10.50 kg ha^{-1} and in 1984 it was 10.53 kg ha^{-1}. The highest uptake of phosphorus in 1983 was recorded in treatment F_8, followed by F_9 and F_7, which were on par with F_8. In 1984 the highest uptake was recorded in treatment F_8, followed by F_7 and F_9 which also were on par with F_8. Treatments receiving 100, 75 and even 50 per cent of the recommended P gave equal P uptake. The balance quantity of P in F_8 and F_7 must have come from the soil especially in the presence of higher level of N (Sreenivasalu Reddy, 1988).

4.6.2.8. Uptake of potash (kg ha^{-1})

The result on the uptake of potassium in 1983 and 1984 is presented in table 59. The mean uptake of potassium over varying fertilizer levels in 1983 was 56.31 kg ha^{-1} and in 1984 it was 56.24 kg ha^{-1}. The highest uptake of potassium in 1983 was in treatment F_8 followed by F_6, F_9 and F_7 which were on par with F_8. In 1984 also the highest uptake was recorded in F_8 followed by F_7, F_9 and F_8. K uptake also more or less follows the trend as that of P uptake. 100 per cent recommended dose of K in kharif has definitely produced a clear residual effect due to the known reasons. Even in treatments which received 75 and 50 per cent of the recommended K could come upto the level of 100 per cent probably due tp release of K from the stubbles of the kharif crop.

In S_6 system in both kharif and rabi for the maximum grain yield full recommended dose of nutrients are required. For yield attributes such as productive tillers, filled grains $panicle^{-1}$ and 1000 grain weight also recommended quantities are reuired. However in treatments which received 75 and 50 per cent of the recommended P and K also become equal in producing the above characters probably because of the release of these nutrients from the soil concurrently as well as cummulatively. The residual effect in rabi also is exhibited more or less onthe same pattern.

Table 59. Rabi rice-Uptake of K (kg ha^{-1}) Fallow-rice-rice system

Treatments	1983			1984		
	M_0	M_1	Mean (F)	M_0	M_1	Mean (F)
F_0	48.25	63.10	55.67	48.50	63.20	55.85
F_1	48.70	63.80	56.25	48.75	63.20	55.97
F_2	48.70	63.05	55.87	48.40	63.90	56.10
F_3	48.75	63.65	56.20	48.95	63.10	56.02
F_4	48.75	64.00	56.37	49.50	62.95	56.22
F_5	48.85	64.05	56.45	48.40	63.70	56.05
F_6	48.65	64.50	56.57	49.00	63.90	56.45
F_7	49.00	63.90	56.45	48.80	64.30	56.55
F_8	49.25	64.25	56.75	48.75	64.70	56.72
F_9	48.90	64.10	56.50	49.30	63.70	56.50
Mean	48.78	63.84	56.31	48.83	63.65	56.24
SEm	0.264			0.306		
CD (F)			0.515			0.642
CD (F x M)	0.728			0.908		

4.7. Nutrient status of the soil after one and two years of crop sequences

4.7.1. Nitrogen

The nitrogen status of the soil after one year crop sequence (table 60) was not significant due to various cropping systems over various fertility levels. However, there is a trend of M_1 plots having higher N status than M_0 plots which is quite natural. After two year crop sequences (table 61) the plots under S_2M_1 have given maximum N status. All the M_1 treatments are on par regarding N status only, which exhibit residual effect. There is no difference in N status among different cropping systems after two year crop sequence. This can be due to the loss of N on volatalisation under the dry condition that prevailed prior to harvest of the crops.

4.7.2. Phosphorus

The status of phosphorus after one and two year crop sequences (Tables 62 and 63) were not significant over varying fertilizer levels as well as cropping systems. This can be due to the fixation of phosphorus in to iron and aluminum phosphate under the acidic nature of the experiment site (pH 5.3) with high content of iron and aluminum.

Table 60. Available nitrogen status of soil after one year crop sequence (kg ha^{-1})

Fertility levels	Cropping systems						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	207.27	207.75	206.73	206.85	206.19	205.51	206.76
M_1	215.83	214.37	215.17	214.76	214.43	215.03	215.03
Mean	211.40	211.80	210.50	211.00	210.44	209.90	

Fertility levels of Rabi crops	Fertility levels of kharif rice										
	F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Mean
M_0	206.87	206.64	206.82	205.93	206.81	206.89	206.62	206.18	207.22	207.20	206.76
M_1	214.52	214.63	214.61	214.89	214.95	214.68	215.07	215.64	216.24	215.06	215.03
Mean	210.69	210.63	210.71	210.41	210.88	210.78	210.84	210.91	211.73	211.13	

SE/ Plot 0.941 CD (S x M) = 0.503 CD (F x M) = 0.681

Table 61. Available nitrogen status of soil after two year crop sequence (kg ha^{-1})

Fertility levels of Rabi rice	Cropping system						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	207.69	207.57	211.61	206.84	206.35	205.53	207.59
M_1	216.22	216.23	215.05	215.64	215.63	215.23	215.66
Mean	211.90	211.90	213.30	211.20	210.90	210.30	

Fertility levels of Rabi crops	Fertility levels of kharif rice										
	F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Mean
M_0	206.44	206.85	206.77	206.72	207.02	206.85	206.84	206.15	215.52	207.11	207.59
M_1	214.92	214.98	215.55	215.74	215.68	215.42	215.62	216.06	216.79	215.85	215.66
Mean	210.67	210.77	210.17	211.23	211.14	211.23	211.11	211.11	216.15	211.47	

SE/ Plot 4.5166 CD (S x M) = 4.04 CD (F x M) = 5.22

Fig.6. Nitrogen status of soil after first and second year crop sequences in different cropping systems

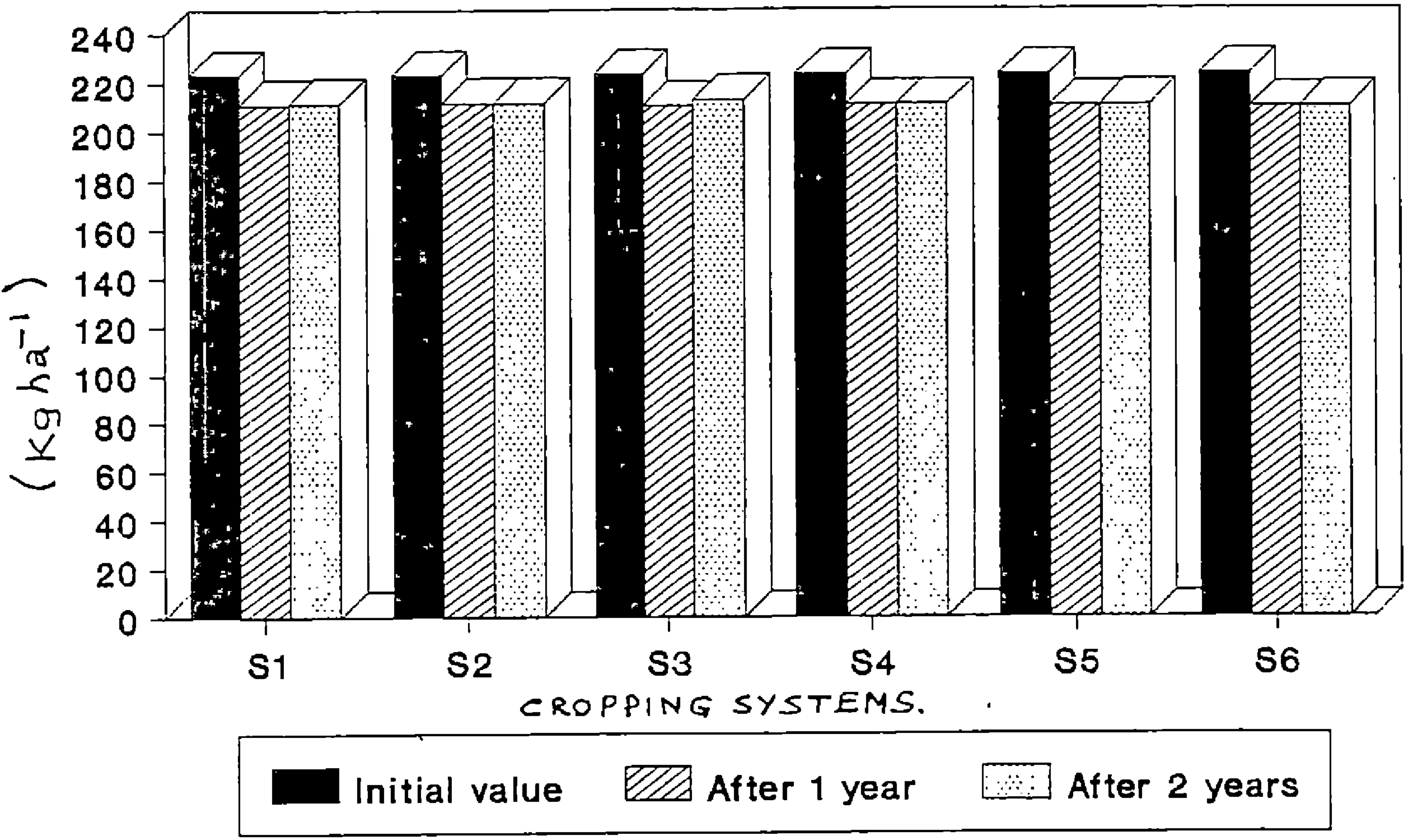


Table 62. Available phosphorus status of soil after one year crop sequence (kg ha^{-1})

Fertility levels	Cropping system						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	14.73	14.76	14.91	14.60	14.70	14.57	14.71
M_1	14.77	14.92	14.80	14.70	14.70	14.62	14.75
Mean	14.75	14.84	14.85	14.65	14.70	14.60	

Fertility levels of Rabi crops	Fertility levels of kharif rice										
	F_0	F_1	F_2	F_3	F_4	F_5	F_8	F_7	F_8	F_9	Mean
M_0	14.41	14.67	14.70	14.68	14.85	14.60	14.87	14.77	14.77	14.80	14.71
M_1	14.61	14.69	14.69	14.82	14.84	14.63	14.86	14.80	14.73	14.84	14.75
Mean	14.51	14.68	14.69	14.75	14.84	14.61	14.86	14.78	14.75	14.82	

SE/ Plot 0.1432

Table 63. Available phosphorus status of soil after two year crop sequence (kg ha^{-1})

Fertility levels	Cropping systems						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	14.86	14.92	14.95	14.66	14.73	14.73	14.81
M_1	14.02	14.03	14.92	14.66	14.80	14.80	14.85
Mean	14.80	14.90	14.60	14.70	14.70		

Fertility levels of Rabi crops	Fertility levels of kharif rice										
	F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Mean
M_0	14.54	14.85	14.77	14.81	14.81	14.82	14.95	14.81	14.81	14.92	14.81
M_1	14.67	14.83	14.77	14.82	14.84	14.75	14.96	14.94	14.95	15.00	14.85
Mean	14.61	14.84	14.27	14.81	14.82	14.78	14.95	14.87	14.88	14.96	

SE/ Plot 0.1175

Fig.7. Phosphorus status of soil after first and second year crop sequences in different cropping systems

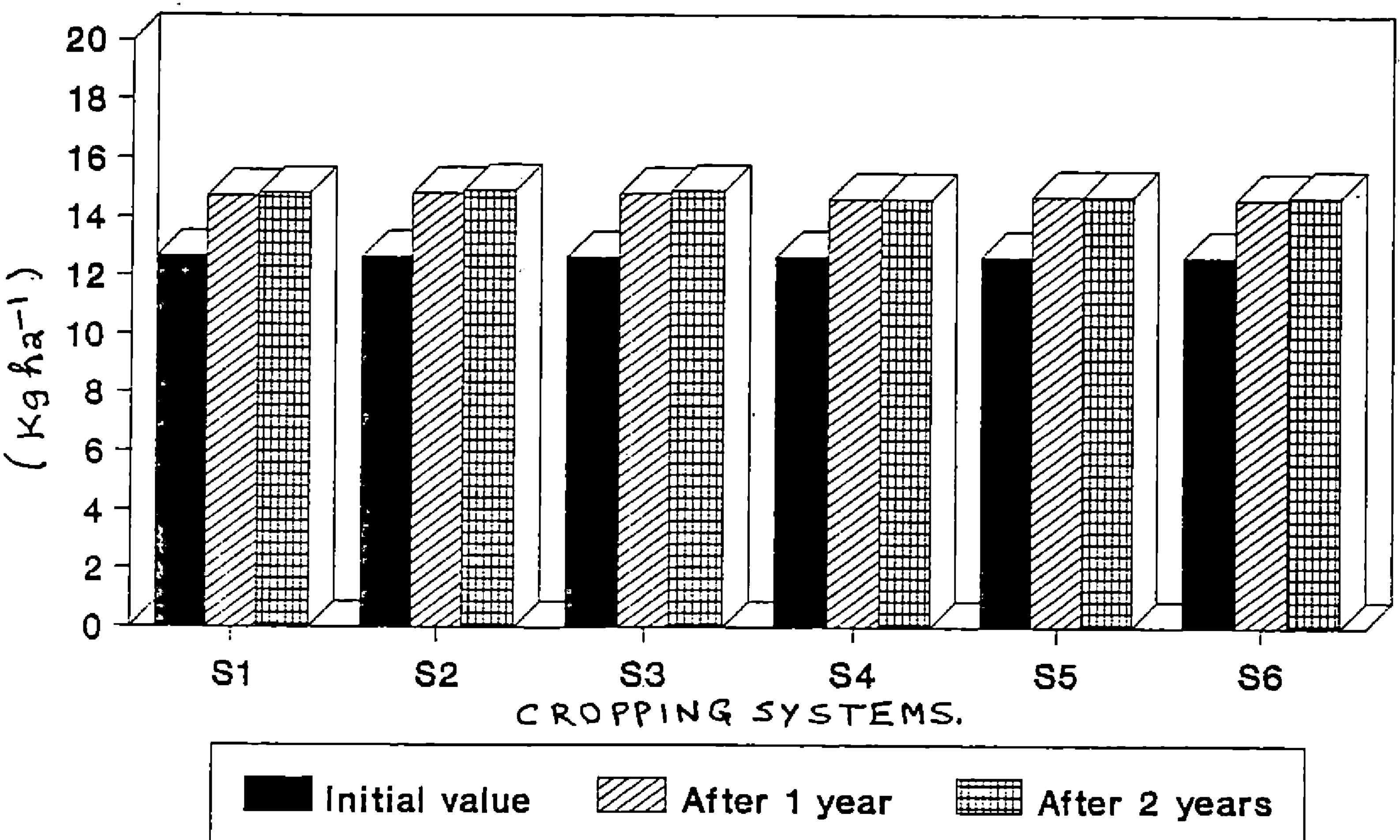


Table 64. Available potassium status of soil after one year crop sequence (kg ha^{-1})

Fertility levels	Cropping systems						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	166.79	165.94	164.97	165.17	165.70	164.48	165.51
M_1	171.41	179.04	179.07	179.13	179.55	179.59	177.92
Mean	68.90	172.40	172.00	172.10	172.60	172.00	

Fertility levels of Rabi crops	Fertility levels of kharif rice										
	F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Mean
M_0	167.15	165.79	164.50	166.44	165.22	165.51	165.55	164.59	164.94	165.34	165.51
M_1	179.69	179.38	179.38	179.04	179.01	165.51	178.77	166.20	179.20	179.19	177.92
Mean	173.42	172.62	171.97	172.74	172.12	172.19	172.16	165.39	172.27	172.26	

SE/ Plot 7.250 CD (S x M) = 6.48 CD (F x M) = 8.37

Table 65. Available potassium status of soil after two year crop sequence (kg ha^{-1})

Fertility levels	Cropping systems S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	162.19	161.85	161.51	161.87	161.75	161.69	161.81
M_1	172.50	171.45	172.61	172.04	172.20	173.20	172.33
Mean	167.35	166.65	167.06	166.96	166.97	167.45	

Fertility levels of Rabi crops	Fertility levels of kharif rice F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Mean
M_0	161.76	161.57	161.81	161.90	161.96	162.27	162.05	161.60	161.31	161.87	161.81
M_1	172.49	172.75	172.47	172.57	171.86	172.12	172.06	172.40	172.72	171.92	172.33
Mean	167.12	167.16	167.14	167.24	166.91	167.19	167.06	167.00	167.01	166.89	

SE/ Plot 0.778 CD (S x M) = 0.696 CD (F x M) = 0.898

Fig.8. Potassium status of soil after first and second year crop sequences in different cropping systems

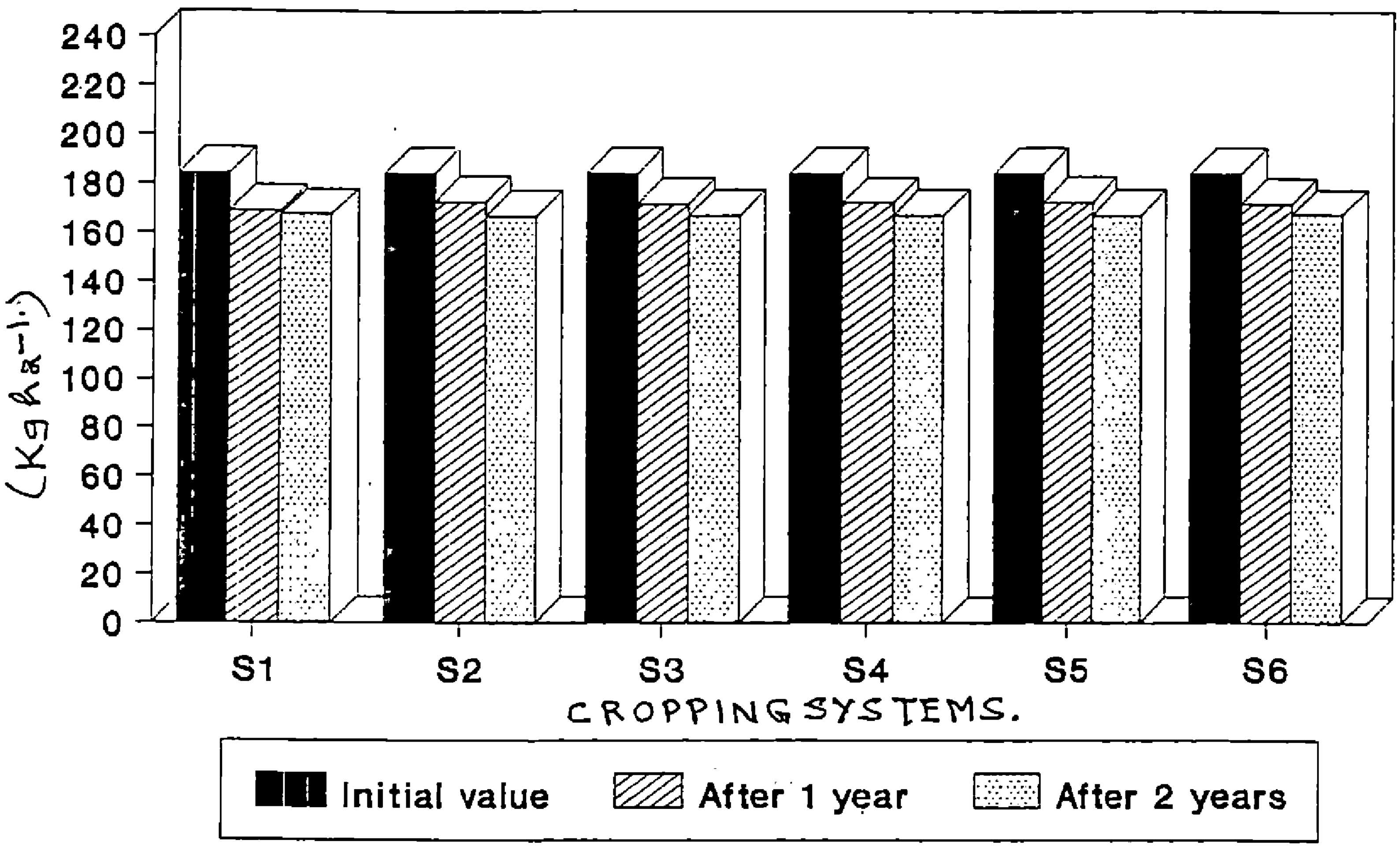


Table 66. Organic carbon (percentage) of the soil after one year crop sequence (kg ha^{-1})

Fertility levels	Cropping systems						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	1.287	1.289	1.289	1.293	1.283	1.278	1.287
M_1	1.288	1.288	1.290	1.292	1.282	1.282	1.287
Mean	1.287	1.288	1.289	1.292	1.282	1.280	

Fertility levels of Rabi crops	Fertility levels of kharif rice										
	F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Mean
M_0	1.287	1.285	1.287	1.288	1.283	1.286	1.290	1.285	1.285	1.286	1.287
M_1	1.284	1.290	1.286	1.287	1.282	1.287	1.290	1.291	1.284	1.292	1.287
Mean	1.285	1.287	1.288	1.287	1.285	1.285	1.288	1.290	1.284	1.286	

SE/ Plot 0.0053

Table 67. Organic carbon (percentage) of the soil after two year crop sequence (kg ha^{-1})

Fertility levels	Cropping system S_1	S_2	S_3	S_4	S_5	S_6	Mean
M_0	1.286	1.290	1.288	1.294	1.280	1.277	1.286
M_1	1.287	1.287	1.290	1.290	1.282	1.282	1.286
Mean	1.286	1.288	1.289	1.292	1.281	1.279	

Fertility levels of Rabi crops	Fertility levels of kharif rice F_0	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	Mean
M_0	1.283	1.285	1.289	1.288	1.286	1.283	1.288	1.288	1.283	1.286	1.286
M_1	1.285	1.286	1.285	1.287	1.285	1.285	1.288	1.289	1.284	1.290	1.286
Mean	1.284	1.285	1.287	1.287	1.285	1.288	1.288	1.288	1.283	1.288	

SE/ Plot 0.0066

4.7.3. Potash

After one year (Table 64) maximum value of potash status was obtained in S_6M_1. All other combinations of SxM_1 are on par with S_6M_1 and S_1M_1 being significantly inferior. Also S_xM_0 combinations are also significantly inferior. This can be due to the high foraging of the K by the cassava crop under the S_1 system and loss of K due to leaching. After two year sequence (table 65) plots under all M_1 treatments have high K status. This can be due to the controlled water management during the rabi season without any rains in the later stage of the crop, there by avoiding loss of potash by leaching.

4.8. Organic carbon

None of the effects and interactions are found to be significant with regard to the organic carbon status of the soil after first and second years of crop sequences (tables 66 and 67). This can be due to the removal of crop residues in all the cropping systems without adding the same back to the soil since they could be more economically utilised otherwise. The high mean temperature that prevailed during summer months also might have caused some reduction of the organic carbon content as reported by Das *et al*. (1992) and Anilkumar and Sivakumar (1993).

4.9. Balance sheet of plant nutrients (NPK) under different cropping systems at the end of the field experiment

The balance sheet of major plant nutrients at the end of the field experiment under various cropping systems were worked out on the method followed by Nambiar and Ghosh (1984) in the All India Coordinated Research Project on long term fertilizer experiments (ICAR) and is presented in table 68. The data shows that among the cropping systems S_1, S_2, S_4, S_5 and S_6 are having a positive balance of nitrogen and S_3 is having a negative balance of nitrogen. In the case of phosphorus all the systems have a positive nutrient balance. With regard to K all cropping systems have a negative balance except S_3 system involving groundnut as summer crop. This can be due to the absorption of K from deeper layers of the soil and also due to litter fall. Under the S_3 system of cropping eventhough it shows a negative balance of nitrogen the soil test value shows a positive value. This can be due to the biological nitrogen fixation of the groundnut crop.

Nutrient balances arrived at after deducting the uptake of the nutrient from the quantity applied under various cropping systems (both organic manures and inorganic fertilizers) over two years does not show any relationship with the final soil test values after two year crop sequences. But however the final soil test values after two year crop sequences show an approximation in status with the

Table 68. Balance sheet of plant nutrients (NPK) under different cropping systems at the end of the field experiment (kg ha^{-1})

pping tems	Nutrients applied			Nutrient uptake			Nutrient balance			Change in soil test values after 2 years		
	N	P	K	N	P	K	N	P	K	N	P	K
1	640	415	370	475	71	448	+165	+344	-78	215	15	172
2	480	300	280	432	65	334	+48	+235	-54	217	15	172
3	476	402	378	337	73	349	-61	+329	+29	216	15	172
4	636	328	328	406	68	348	+230	+260	-20	216	15	171
5	620	340	310	432	70	395	+188	+270	-85	217	15	171
6	440	240	220	306	48	263	+134	+192	-43	215	15	174

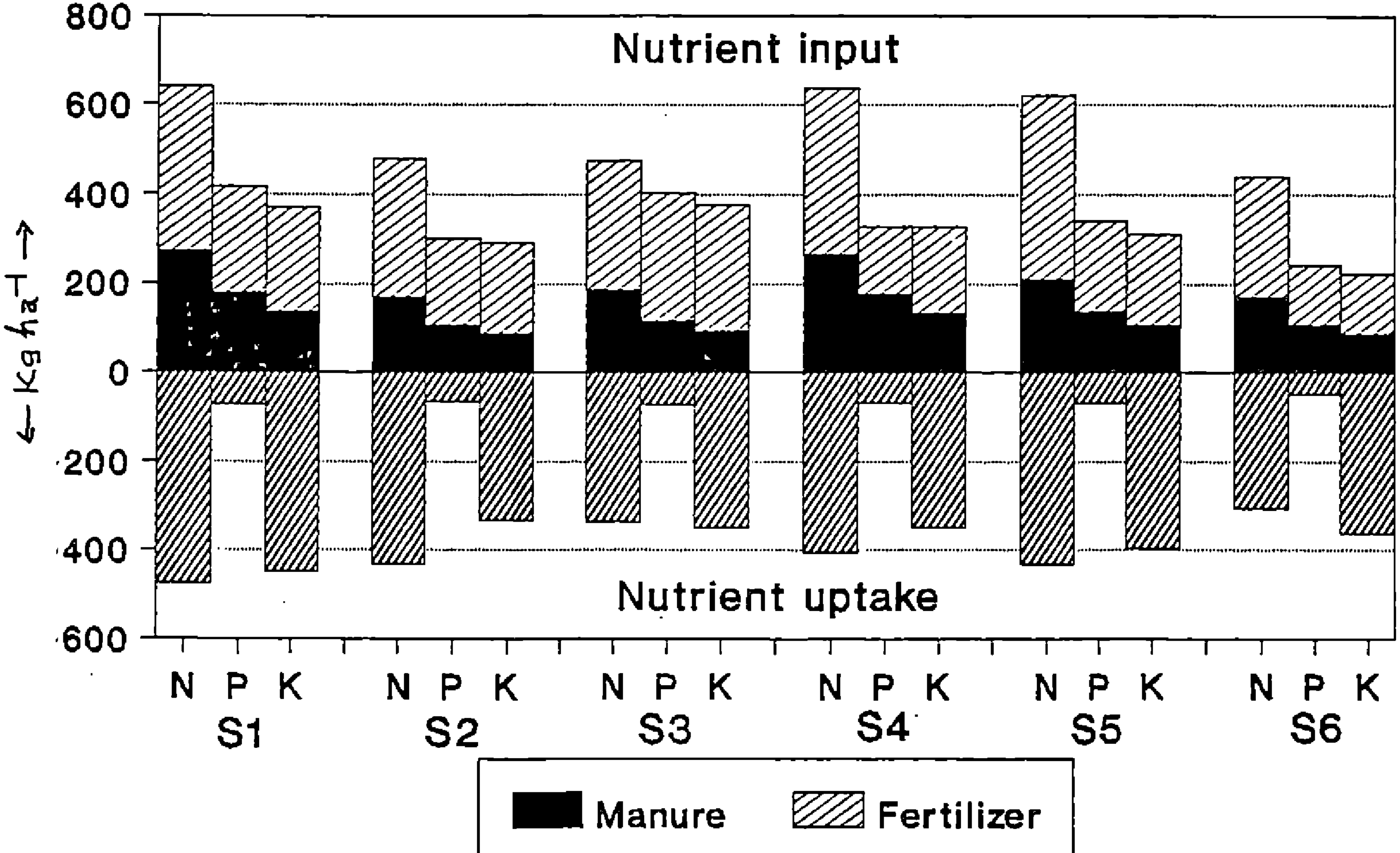
l test value at the beginning of the experiment

Available N 223.40 kg ha^{-1}

Available P 12.67 kg ha^{-1}

Available K 184.25 kg ha^{-1}

Fig.9. Nutrient input and uptake in different croppping systems over two years (kg ha^{-1})



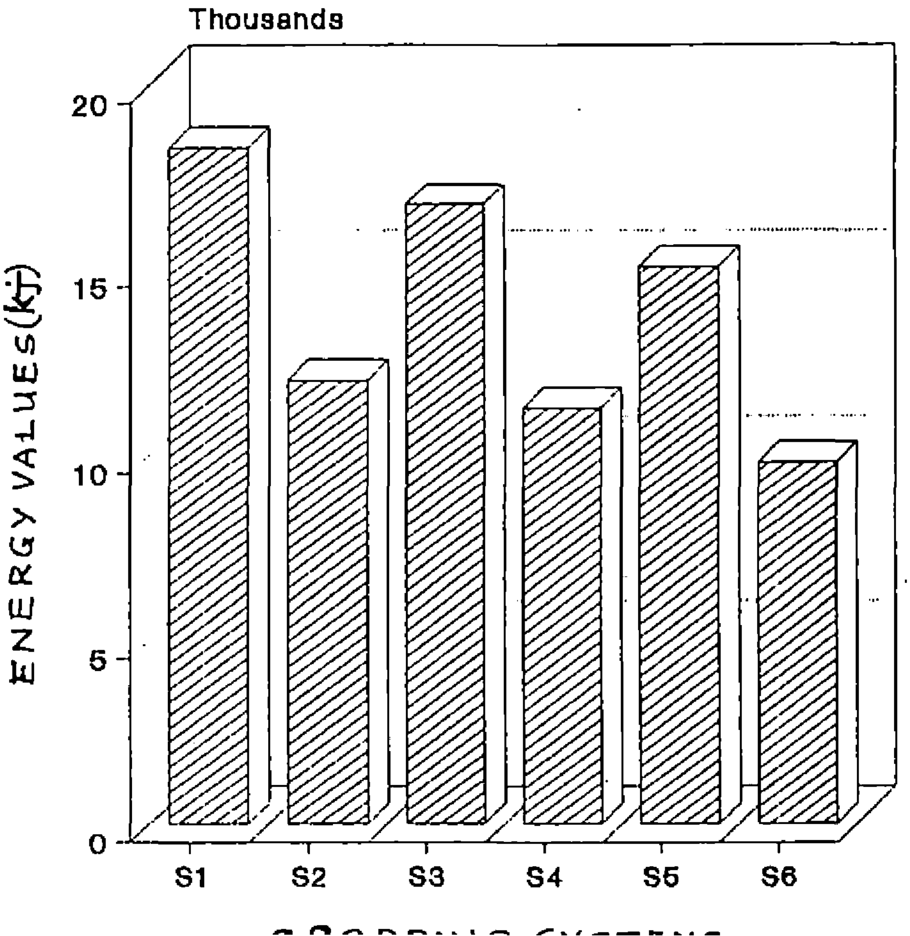
original soil test data before the starting of the experiment with a slight increase in the phosphorus status. The available P content of the soil after two year cropping as depicted in table 71 indicates that it is much lesser than the balance obtained in the table. This can be due to the fact that the experimental site is of lateritic in origin with high status of iron and alluminium. Thus there is every possibility of the major portion of the applied P getting fixed up as iron and alluminium phosphates under the acidic condition of the soil at pH 5.3. The slight decrease in the potassium and nitrogen status can be due to the soluble and leachable nature of the potash and nitrogen as plant nutrient in the soil, especially under heavy rainfall of the experimental site (Appendix I).

4.10. Energy equivalents of edible produces in different cropping systems (table 69)

In the study of the rice based cropping systems it is a common practice to evaluate the different cropping systems in terms of rice equivalents based on the market value of the different produces obtained in the cropping systems (Karwara et al. 1987). Since the price of an agricultural produce is determined by factors beyond the control of the farmer, in the present study the various

Cropping system	Summer 1983 (kJ)	Kharif 1983 (kJ)	Rabi 1983 (kJ)	Summer 1984 (kJ)	Kharif 1984 (kJ)	Rabi 1984 (kJ)	Total (kJ)
S_1	5251	2775	2293	3611	2801	2280	18306
S_2	0810	2823	2323	926	2824	2325	12031
S_3	3049	2798	2347	3401	2832	2340	16767
S_4	0535	2832	2342	0489	2798	2826	11282
S_5	2646	2652	2334	2490	2659	2289	15070
S_6		2556	2336		2554	2336	9782

Fig.10. Energy values of edible produces from different cropping systems over two years (kJ)



cropping systems are evaluated in terms of energy values of the edible produces obtained under various cropping systems (Gopalan *et al*. 1984).

The energy values of edible produces obtained from different cropping systems are presented in table 69 in terms of kiloJoules (kJ). When the cropping systems for two years are considered the S_1 system involving cassava as summer crop ranks first with the production of a total energy of 18303 (kJ). The second and third rank is for the S_3 and S_5 systems involving the groundnut and rice as summer crops respectively. The least quantum of energy is produced by S_6 system involving summer fallow. From the economic point of view even though the cropping system S_4 involving bhendi as summer crop ranked first with respect to energy production it ranked only fifth since the bhendi pods contain negligible quantities of carbohydrates and fat. The cropping systems S_1 (cassava) and S_3 (groundnut) which rank first and second in energy values contain largely carbohydrate and fat as their major ingredients in the human consumable parts.

4.11. Total dry matter production from different cropping systems kg ha^{-1}

The total dry matter harvested from all the crops under each system in both years were added and the sum is referred to as biological production potential and is presented in table 70.

The highest dry matter production of 43534 kg ha^{-1} was obtained from the S_1 system involving cassava as the summer crop and the second highest dry matter production was obtained from S_3 system with groundnut during the summer season. The S_5 system involving summer rice crop and S_4 system involving bhendi as summer crop and S_2 system involving cowpea as summer crop ranked third, fourth and fifth respectively. The least dry matter production was from S_6 system involving summer rice fallow. The S_1 system ranked first because the cassava as the summer crop produced higher tonnage of tuber within a period of 5 months. Cassava is universally known as a crop with high photosynthetic ability and production of storage materials within its tubers. The rate of utilisation of solar energy also is of the higher order compared to other C_3 plants. The summer crop involved in S_3 cropping system is groundnut with its high leaf area index and producing high tonnage of bhusa. The biological nitrogen fixation capacity of this legume with added ability of absorbing native P and K with its deep tap root system from the deeper layers of soil must have helped this cropping system to rank second. The S_6 system ranked sixth because this system involves only kharif and rabi crops of rice with

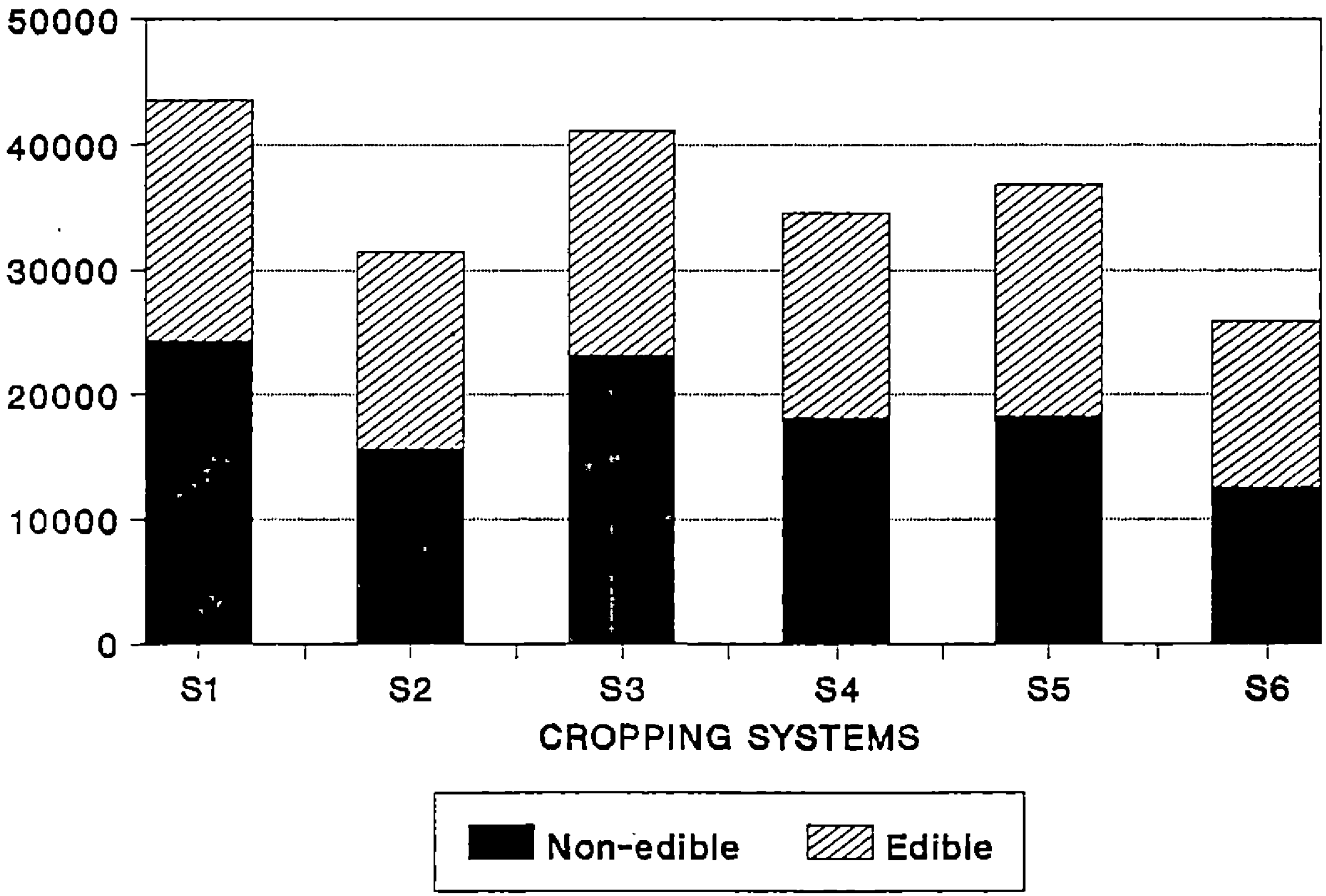
Table 70. Dry matter production under various cropping systems kg ha^{-1}

ropping ystem	Produce	1983 Summer	1983 Kharif	1983 Rabi	1984 Summer	1984 Kharif	1984 Rabi	Total of 1984 & '84	Total	$DMP\ day^{-1}$
S_1	Tuber/grain	3499	3662	3063	2406	3667	3035	19332	43534	111
	Stem/straw	5924	3717	2686	5469	3722	2684	24202		
S_2	Grain/grain	1060	3675	3115	1220	3670	3124	15864	31484	98
	Bhusa/straw	*1260	3825	2665	**1380	3825	2665	15620		
S_3	Pods/grain	2129	3637	3145	2253	3677	3139	17980	41140	119
	Bhusa/straw	X 4911	3835	2703	XX 5180	3827	2704	23160		
S_4	Pods/grain	1680	3682	3145	1240	3637	3036	16420	34514	96
	Bhusa/straw	2685	3795	2661	2653	3800	2500	18094		
S_5	Grain	2810	3482	3140	2640	3482	3051	18605	36811	104
	Straw	2872	3670	2626	2750	3660	2628	18206		
S_6	Grain	——	3550	3148	——	3535	3145	13378	25871	102
	Straw	——	3555	2692	——	3552	2694	12493		

* 4500 kg Fresh weight. ** 4600 kg. Fresh weight.

X 12800 kg Fresh weight XX 13500 kg Fresh weight.

Fig.11. Dry matter production under various cropping systems over two years



no crops during summer seasons. Thus it can be seen that the variation in dry matter production among the various cropping systems is due to the influence of different summer crops associated with the different cropping systems and not due to the variation in the performance of the rice crops.

Another phenomena noticeable from the table is that during kharif season more dry matter is accumulated in the rice straw rather than in the grain and during rabi season more dry matter is accumulated in the grain rather than in the rice straw. Yet another phenomena noticeable in the table is, per hectare production of grain and straw is more in a two crop sequence of rice rather than in a three crop sequence. Many factors are ascribed to be responsible for this situation, the most important being the poor physical condition of soil due to continuous water logging. Even though three crop sequence of rice is producing more DMP, in the long run it is likely to be counter productive.

4.12. Economics of cropping systems

4.12.1. Kharif rice crop

Table 71 a, b, c, d, e and f presents the net profit and benefit cost ratio of kharif rice crop under

Table 71. Net return and B/C ratio of fertilizer treatments to kharif rice under different cropping systems (mean of 1983 and 1984)

Fertilizer treatment	Additional Yield over control kg ha^{-1} Grain	Straw	Cost of extra produce over control (Rs)	Addl. expenditure over control (Rs)	Profit (Rs)	B/C ratio
1	2		3	4	5	6
(a) Cassave-rice-rice system						
F_0	0	-	-	-	-	-
F_1	662	582	1906	357	1549	5.34
F_2	702	652	2066	392	1674	4.57
F_3	767	647	2181	477	1704	4.57
F_4	872	910	2654	475	2179	5.59
F_5	902	940	2744	535	2209	5.13
F_6	985	930	2900	595	2305	4.87
F_7	1002	990	2194	593	2401	5.05
F_8	1035	987	3057	653	2404	4.68
F_9	1102	1012	3216	713	2503	4.51
(b) Cowpea-rice-rice system						
F_0	0	-	-	-	-	-
F_1	585	540	1710	357	1353	4.79
F_2	698	695	2091	392	1699	5.33
F_3	725	745	2195	477	1718	4.60
F_4	833	737	2403	475	1928	5.06
F_5	903	845	2651	535	2116	4.96
F_6	985	850	2820	591	2229	4.74
F_7	1010	867	2887	593	2294	4.87
F_8	1018	1007	3043	653	2390	4.66
F_9	1023	1040	3056	713	2373	4.33

Table 71 (Contd....)

1	2		3	4	5	6
			(c) Groundnut-rice-rice system			
F_0	0	-	-	-	-	-
F_1	507	453	1449	357	1092	4.09
F_2	592	500	1684	392	1292	4.30
F_3	587	610	1784	477	1307	3.74
F_4	725	650	2100	475	1425	4.42
F_5	800	725	2325	535	1790	4.35
F_6	907	737	2551	595	1956	4.29
F_7	910	842	2662	593	2069	4.49
F_8	937	862	2736	653	2083	4.19
F_9	932	937	2801	713	2088	3.93
			(d) Bhendi-rice-rice system			
F_0	0	-	-	-	-	-
F_1	545	513	1603	357	1246	4.49
F_2	652	623	1927	392	1535	4.92
F_3	672	592	1936	477	1459	4.06
F_4	775	680	2230	475	1755	4.67
F_5	827	723	3777	535	1842	4.44
F_6	827	720	2267	595	1672	3.87
F_7	835	845	2515	593	1922	4.23
F_8	867	865	2599	653	1946	3.89
F_9	937	948	2822	713	2109	3.96

Contd....

Table 71 (Contd....)

1	2		3	4	5	6
			(e) Rice-rice-riice system			
F_0	0	-	-	-	-	-
F_1	318	602	1238	357	881	3.47
F_2	590	565	1745	392	1353	4.45
F_3	700	722	2122	477	1645	4.45
F_4	740	730	2210	475	1735	4.65
F_5	855	775	2485	535	1950	4.64
F_6	913	752	2578	595	1983	4.33
F_7	928	880	2736	593	2143	4.61
F_8	938	905	2781	635	2128	4.26
F_9	950	930	2830	715	2117	3.97
			(f) Fallow-rice-rice system			
F_0	0	-	-	-	-	-
F_1	162	592	916	357	559	2.57
F_2	377	552	1196	392	804	3.055
F_3	455	5542	1452	477	975	3.04
F_4	655	672	1982	475	1507	4.17
F_5	720	720	2160	535	1625	4.04
F_6	747	740	2234	594	1639	3.75
F_7	840	782	2462	593	1869	4.15
F_8	942	822	2706	653	2053	4.14
F_9	1025	832	2882	713	2169	4.04

Grain at Rs 2 kg^{-1} Straw at Rs 1 kg^{-1}

various treatments in different cropping systems. The table 68 g shows the overall B/C ratio of the best economic doses under each system.

Table 71.g. Comparison of B/C ratios of kharif rice treatments in different cropping systems

Cropping System	Treatment	Cost of excess produce over control (Rs)	Extra expenditure over control (Rs)	B/C ratio
Cassava S_1	F_4	2654	475	5.59
Cowpea S_2	F_2	2091	392	5.33
Groundnut S_3	F_7	2662	593	4.49
Bhindi S_4	F_2	1927	392	4.92
Rice S_5	F_4	2210	475	4.65
fallow S_6	F_4	982	475	4.17

Under S_1 system F_4 has given the maximum benefit cost ratio. In spite of the fact that cassava is a fairly exhaustive crop the next kharif crop required only 75 per cent of N and 50 per cent each of P and K. It may be mentioned that this is not the maximum responsive dose, but the most economic dose beyond which the benefit accrued from the produce is not proportionate to the expenditure involved. However, in the case of P, 50 per cent is sufficient because

Fig.12. Highest net returns and B/C ratios of kharif rice under different cropping systems

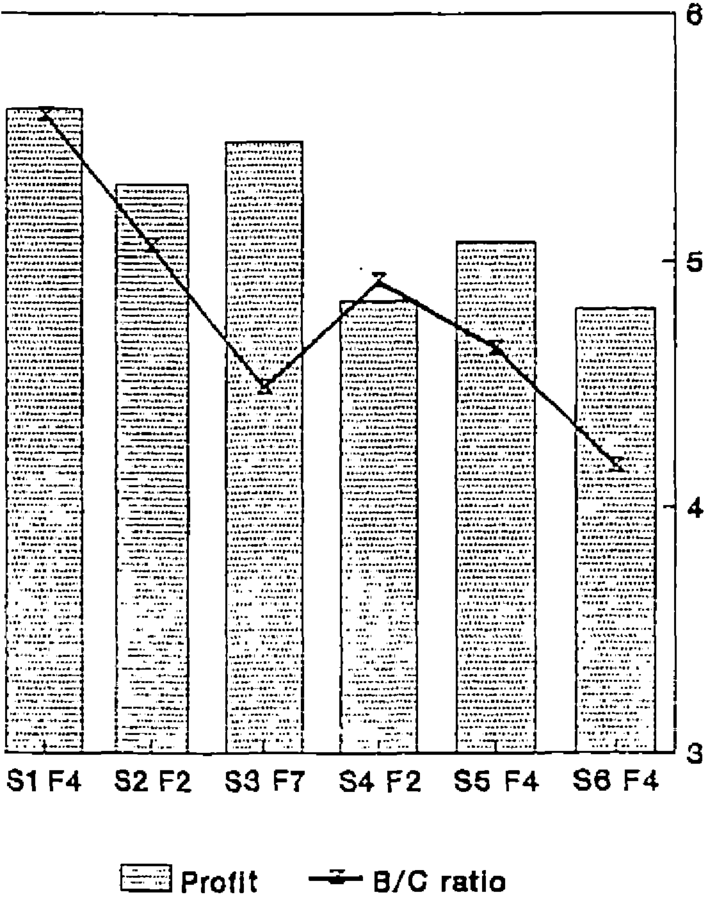
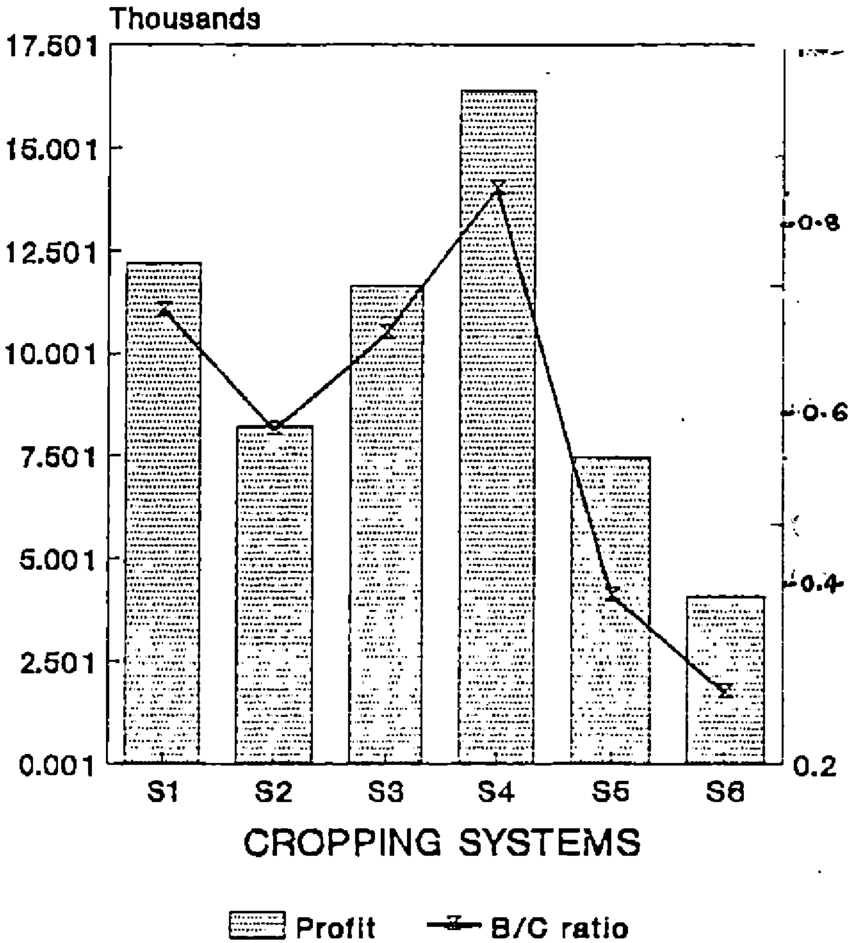


Fig. 14. Net returns and B/C ratios of different cropping systems



of the availability of the rest 50 per cent from the soil under rice crop. The reason for the 50 per cent potash being optimum is probably due to the residual effect of 12 t ha^{-1} of FYM given to the cassava crop.

In S_2 system F_2 has given the maximum benefit cost ratio. When cowpea is grown in the summer season some amount of N is invariably left in the soil for the succeeding crop. Hence, 50 per cent of N must be the economic optimum. Cowpea being a heavy feeder of P and K must have necessitated the application of 75 per cent dose. Ground nut crop in the S_3 system has given a comparatively poor benefit cost ratio among the systems. Inspite of groundnut being a leguminous crop, the succeeding rice crop must get 100 per cent recommended dose. Reasons have, already discussed elsewhere. The high cost involved is due to the highest dose of N required.

In S_4 system F_2 has given the highest benefit cost ratio. Bhindi have been given an organic manure of 12 t ha^{-1}. This has probably reduced the cost of fertilizers required (50:75:75 %) for producing the most economic returns. Incidentally this is the least costly fertilizer dose among the cropping systems.

In S_5 system the 75:50:50 is found to be most economic, probably because of the saving in 50 per cent each of P and K and 25 per cent of N. Five tonnes of FYM added to the previous summer crop must had some impact.

In the fallow-rice-rice system the benefit cost ratio is the least (4.17). Incidentally the increase in grain yield over control is least. This has not received any fertilizer during the previous season and hence 75 per cent of N has to be given to yield the highest benefit cost ratio in the system.

In general it can be said that rice is a crop in which the law of diminishing returns operate at a very early phase. Beyond a certain level of production further unit increase will be attained only by incurring more expenditure per unit increase in production thereafter. The only way to overcome this diffect is to grow some other crop in the summer fallow which enables the succeeding rice crop to record maximum benefit cost return. In this study the Cassava-rice-rice system seems to be the best which has recorded a benefit cost ratio of 5.99 when compared to a fallow-rice-rice system recording 4.17

4.12.3. Economics of different systems

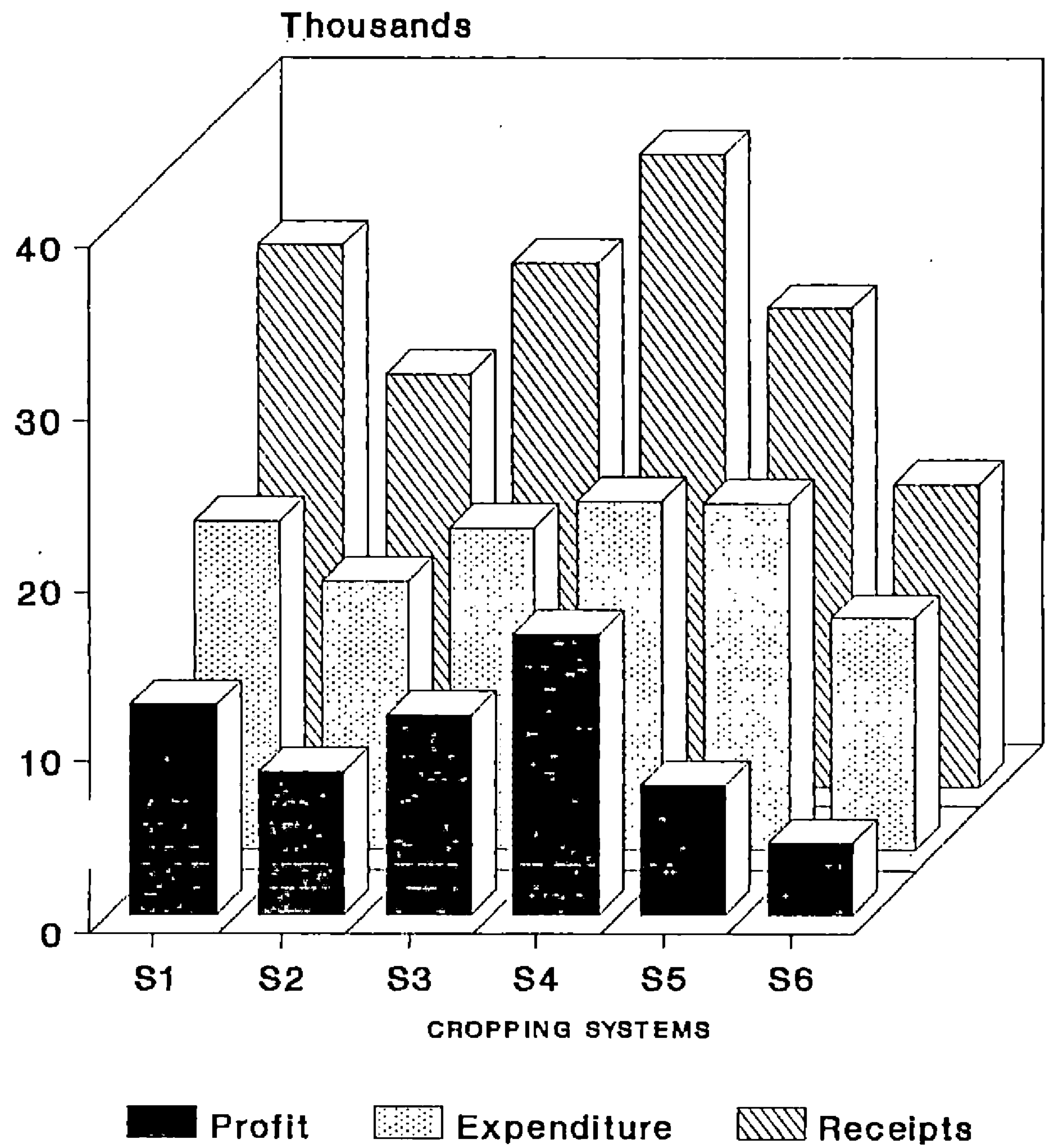
The average net return from each cropping system in terms of ruppee value is presented in Table 72. The values are taken from the plots receiving recommended fertilizer doses for an effective comparison. A perusal of the table indicates that maximum return of Rs. 16413 ha^{-1} was obtained from the cropping system S_4 involving bhindi as summer crop. This is due to the high market price of bhindi fruits as a vegetable during summer months. The second highest net return of Rs. 12239 ha^{-1} was from S_1 system involving cassava as summer crop. The cassava produced highest tonnage among the summer crops and this has recorded the second highest mean income on account of this factor. Next in order comes S_3 system involving groundnut as the summer crop with a net return of Rs. 11650 ha^{-1}. This is due to the high cost of groundnut pods which is used as an oil seed. The fourth rank goes to cowpea the grain of which is having a higher price than cereal crop.

The rice-rice-rice system costs least among the summer crops grown. The cost of the rice is the lowest in the market and hence this has proved to be the least profitable crop from the economic point of view.

Table No. 72. Net returns and B/C ratio of cropping systems over two years (Rs. ha^{-1})

		1983				1984					
		Summer crops (Rs.)	Kharif rice (Rs.)	Rabi rice (Rs.)	Total (Rs.)	Summer crops (Rs.)	Kharif rice (Rs.)	Rabi rice (Rs.)	Total (Rs.)	Mean Total (Rs.)	B/C ratio
1	Expenditure	5650	6880	7000	19330	5650	6880	7000	19330	19330	
	Reciepts	15500	10206	8152	33858	11125	10213	8121	29459	31669	0.63
	Net return	9850	3526	1152	14528	5475	3533	1121	9929	12239	
2	Expenditure	2143	6680	7000	15823	2143	6680	7000	15823	15823	
	Reciepts	5200	10374	8198	23772	5800	10367	8203	24370	24071	0.52
	Net return	3057	3694	1198	7949	3657	3687	1203	8547	8248	
3	Expenditure	5250	6680	7000	18930	5250	6680	7000	18930	18930	
	Reciepts	11400	10318	8310	30028	12440	10390	8301	31131	30580	0.61
	Net return	6150	3638	1310	11098	7190	3710	1301	12201	11650	
4	Expenditure	6810	6680	7000	20490	6810	6680	7000	20490	20490	
	Reciepts	19200	10377	8261	37838	17550	10291	8126	35967	36903	0.80
	Net return	12390	3697	1261	17348	10740	3611	1126	15477	16413	
5	Expenditure	6700	6680	7000	20380	6700	6680	7000	20380	20380	
	Reciepts	9650	9851	8224	27725	9465	9866	8694	28025	27875	0.36
	Net return	2950	3171	1224	7345	2765	2986	1694	7445	7495	
6	Expenditure	—	6680	7000	13680	—	6680	7000	13680	13680	
	Reciepts	—	9544	8244	17788	—	9538	8252	17790	17789	0.30
	Net return	—	2864	1244	4108	—	2858	1252	4110	4109	

Fig.13. Economics of cropping systems (mean of 1983 and 1984)



The above discussion indicates that the choice of the summer crop decides economic returns in a cropping system. A vegetable crop like bhindi or a tuber crop like cassava seems to be more profitable than growing rice in summer season.

Table 73. Employment generation under different cropping systems

Cropping system	Particulars of labour engaged			Total man days
	Bullock pair	Man	Woman	
S_1	14	125	255	394
S_2	16	87	249	352
S_3	19	104.5	278	401.5
S_4	14	109	318	441
S_5	6	123	324	453
S_6	4	82	216	302

because of excess labour required for dibbling seed, application of fertilizers and harvest of bhindi estimate in Kerala 60 per cent of the expenditure is involved for the labour cost for a rice crop. (Sreedharan, 1983).

Thus the crop chosen for the summer season decides the labour requirement of the cropping system which decides the economics of the cropping system itself.

Thus from the investigation it can be seen that a crop of bhendi is most profitable followed by cassava, groundnut, cowpea and rice in summer season in the double crop wet rice fields of Kerala.

However this result is applicable only to central Kerala where the rainfall is of unimodal pattern. It is better to conduct the investigation in all the agroclimatic situations of Kerala so as to develop location specific technology.

SUMMARY

SUMMARY

A field experiment on rice based cropping system was laid out at the Regional Agricultural Research Station, Pattambi starting from summer season of 1983 for a period of two years in the same site with the objectives of identifying the most economic crop combination for the double crop wet rice fields of Kerala, to assess the changes in soil fertility conditions on account of the different crop combinations and to find out the residual effect of summer crops on the succeeding rice crops. The experiment was laid out in a split-split plot design, replicated twice, with five different summer crops such as short duration cassava, cowpea, groundnut, bhendi and rice and a fallow, alloted to the main plots. During kharif season these main plots were divided into ten sub plots imposing different combinations of recommended N, P and K fertilizers with an absolute control. During rabi season, these sub plots were again divided into two sub-sub plots, one without any fertilizer application ~~application~~ and the other with of recommended fertilizer doses. The results of the investigations are summarised below:

In cassava-rice-rice system fertilizer dose of 100 : 75 : 75 per cent NPK gave grain yield of 3600 kg ha^{-1} which was on par with that of the 100 per cent recommended dose.

resulting in a saving of 25 per cent P and K for kharif rice. For maximum production of straw at (kg ha^{-1}) 100:50:50 per cent of recommended dose of NPK fertilizers was sufficient with a saving of 50 per cent of P and K for kharif crop.

Maximum productivity of 18530 kg ha^{-1} per year (11812 kg tuber + 3605 kg ha^{-1} of grain of kharif rice + 3113 kg ha^{-1} of grain of rabi rice) was obtained under this system.

Maximum dry matter production of 21717 kg ha^{-1} per year and maximum energy production of 9103 kj ha^{-1} was obtained under this system.

With regard to economy this system ranked second with a net return of Rs. 12,239/- ha^{-1} while the maximum economy was recorded under bhendi system.

The plot which received full quantity of recommended dose of NPK in Kharif season gave maximum grain yield of 2883 kg ha^{-1} in rabi season thus exhibiting residual effect.

In the cowpea-rice-rice system for significantly higher grain yield of 3665 kg ha^{-1} in kharif season there was a saving of 25 per cent of recommended dose of P and K.

For significantly higher straw yield of 3792 kg ha^{-1}, 100:75:75 per cent of recommended fertilizer dose was sufficient for kharif rice, resulting in a saving of 25 per cent of P and K.

In rabi crop for obtaining higher yield and yield attributes due to residual effect of nutrients applied to kharif plots, there was a saving of 25 per cent of N, P and K under the cowpea-rice-rice cropping system.

In groundnut-rice-rice system for maximum grain yield of 3625 kg ha^{-1} in kharif rice, there was a saving of 25 per cent of recommended dose of P and K.

For maximum production of straw of 3831 kg ha^{-1} full recommended dose of fertilizers was essential under this system.

In the groundnut-rice-rice system residual effect under treatments supplied with 25 to 50 per cent less of P and K to the kharif crop is transmitted to the succeeding rabi crop for maximisation of yield and some of the yield attributes.

This system of cropping ranked second in the production of dry matter content and energy production of edible produces. The first rank was held by the cassava-rice-rice system.

From the economic point of view this system ranked third in order. The first and second places were held by bhendi and cassava systems respectively.

In the bhendi-rice-rice system for maximum grain yield of kharif rice, a fertilizer dose of 100 : 50 : 50 per cent of recommended dose is found to be sufficient resulting in a saving of 50 per cent of P and K.

For getting maximum straw yield full recommended dose of fertilizers was essential under this cropping system.

Under this cropping system residual effect of fertilizers applied to the kharif crop at middle dose of recommended nutrients are seen transmitted to the rabi rice for higher production of yield and yield attributes.

For higher straw yield of rabi rice also the treatments with middle doses of nutrients applied to kharif rice crop is imparting residual effect.

From the economic point of view this system, ranked first fetching highest net return of Rs. 16413/- per hectare per year.

Under the rice-rice-rice system the fertilizer dose of 100 : 25 : 25 per cent of N, P and K gave grain yield on par with that of full recommended doses in kharif rice resulting in a saving of 25 per cent each of P and K.

Under this cropping system for maximum production of straw full recommended dose of fertilizers are essential.

The manifestation of residual effect of nutrients is seen associated with application of balanced and higher rates of nutrients to the kharif crop for better expression of yield and yield attributes in the succeeding rabi rice, under this cropping system. This holds good for the maximum production of straw yield also in the rabi-rice.

The cropping system with rice as summer crop is the least economic system.

Rice-rice-rice system of cropping has the maximum employment generation potential than other cropping systems studied.

For the production of dry matter and energy of edible produce this system ranked third next to cassava and groundnut respectively.

Under the fallow-rice-rice system for getting maximum grain yield of kharif rice full recommended dose of fertilizer is essential.

For the production of straw in kharif rice, 100:75:75 per cent of the recommended fertilizer dose of NPK gave straw yield on par with that of 100 per cent recommended dose resulting in a saving 25 per cent of P and K.

Residual effect of fertilizer on rabi rice is imparted only if balanced nutrients at higher rates are applied to the kharif crop as is observed from the grain yield and other yield attributes. The above findings holds good for higher production of straw also in rabi crop.

The nitrogen status of the soil after one and two year crop sequences are not significant due to various cropping systems. The same trend is observed with regard to phosphorus status also. Regarding potassium status also there was no significant variation after one and two year crop sequences due to various cropping systems. Cassava system recorded the minimum potash status after one year crop sequence. However there is a decreasing trend in the potassium status of the soil after two year crop sequences under all the cropping systems studied.

Regarding the nitrogen status of the soil after one and two year crop sequences there is an increased status in the manured plots than the unmanured plots. With regard to phosphorus status this variation is not observed after one and two year crop sequences. In the case of potassium status there is an increased status in the manured plots than the unmanured plots.

None of the cropping systems nor the fertilizer doses are found to be effective in increasing the organic carbon status of the soil after one and two year crop sequences.

A vegetable crop like bhendi or a tuber crop like cassava seems to be more profitable than growing rice in summer season in the wet rice fields of Kerala.

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* - Originals not seen

APPENDICES

Appendix-I.

Normal mean monthly meteorological data at R.A.R.S., Pattambi.
(Average of 1973 to 1982)

Month	Rainfall (mm)	Temperature °C Max.	Min.	No. of rainy days	Relative Humidity F.N.	A.N.	evaporation (mm)
January	0.5	33.2	19.7	0.2	79.3	35.9	6.3
February	2.8	34.9	20.9	0.5	84.5	35.9	6.6
March	16.3	36.6	23.2	1.2	87.5	39.4	7.1
April	89.5	35.4	24.4	5.0	89.7	51.5	6.5
May	170.5	33.3	24.2	8.5	92.3	60.6	5.5
June	577.0	30.2	22.8	20.7	95.5	76.8	4.5
July	677.0	28.4	22.5	24.2	96.3	81.7	3.6
August	424.0	29.1	22.7	29.2	95.8	79.8	3.7
September	208.0	30.6	23.0	12.2	95.0	69.9	4.5
October	265.0	31.4	23.9	11.2	95.0	68.3	3.8
November	262.0	31.9	22.3	10.5	92.5	61.1	4.4
December	3.2	32.9	21.0	0.5	83.7	48.6	5.3

Appendix, II(a).

R.A.R.S., Pattambi-meteorological data for the year 1983

Month	Rainfall (mm)	Temperature °C Max.	Min.	No. of rainy days	Relative Humidity F.N.	A.N.	evaporation (mm)
January	Nil	34.4	20.9		75.4	36.6	219.8
February	Nil	35.6	21.8		88.5	39.75	172.2
March	Nil	36.8	23.7		89.75	40.5	204.4
April	Nil	36.9	24.9		84.60	44.76	250.6
May	127.9	35.2	25.7	5	86.50	55.0	177.1
June	210.3	31.7	54.5	20	92.38	74.35	102.9
July	701.9	29.8	23.5	31	96.64	79.82	39.2
August	448.1	29.3	23.9	30	98.0	82.50	60.2
September	536.3	29.3	23.3	26	98.13	81.08	93.1
October	223.2	31.5	23.2	17	96.68	67.86	133.7
November	33.2	32.5	21.4	3	90.25	55.25	100.1
December	43.5	32.6	23.1	7	84.75	55.50	129.5

Appendix, II(b).

R.A.R.S., Pattambi-meteorological data for the year 1984-85.

Month	Rainfall (mm)	Temperature °C Max.	Temperature °C Min.	No. of rainy days	Relative Humidity F.N.	Relative Humidity A.N.	evaporation (mm)
January	14.0	33.4	22.0	1	79.8	44.6	182.1
February	14.8	35.1	24.3	3	81.0	41.75	151.9
March	16.0	35.9	23.7	4	91.98	47.23	144.9
April	80.0	34.9	24.8	9	91.80	59.0	147.0
May	263.3	34.9	25.1	11	91.75	59.50	123.2
June	549.6	34.9	22.9	28	93.5	87.25	37.8
July	724.8	28.6	22.9	31	89.4	77.6	49.0
August	180.4	28.7	23.2	19	94.5	74.0	74.9
September	65.4	30.4	23.2	9	94.25	69.0	94.5
October	292.0	29.9	21.9	15	92.25	69.25	74.2
November	61.2	32.5	22.6	4	90.75	55.25	106.4
December	17.6	32.5	19.7	1	87.6	49.66	133.0
1985							
January	56.2	33.1	21.8	3	84.4	54.0	180.6
February	Nil	34.9	21.6		92.25	47.79	97.6

Appendix III

Basic data used for calculating the cost of cultivation of crops and working out the net return in ruppee ha^{-1}.

Cost of labour

1. Hire charge of tractor - Rs. 60/- hr^{-1}
2. Animal pairs @ Rs. 50/- day
3. Man labourer @ Rs. 25/- day
4. Women labourer @ Rs. 18/- day

Cost of manures and fer

1. Cost of FYM @ Rs. 150 t^{-1}
2. Cost of nitrogen as urea Rs. 5.25 kg^{-1}.
3. Cost of phosphorus as musoorie rock phosphate Rs.3.10 Kg^{-1}
4. Cost of potassium as muriate of potash Rs. 2.25 Kg^{-1}
5. Cost of lime as slaked lime Rs 0.75 Kg^{-1}
6. Cost of dolomite Rs. 0.60 kg^{-1}

Contd.....

Cost of seeds and seed material

1. Cost of paddy seed Rs. 3 Kg^{-1}
2. Cost of cassava stems Rs10 for 100 numbers
3. Cost of cowpea seeds Rs. 8 Kg^{-1}
4. Cost of groundnut kernel Rs. 8 Kg^{-1}
5. Cost of bhindi seeds Rs. 75 Kg^{-1}

Cost of economic produces of crops

1. Cost of paddy Rs. 2 Kg^{-1}
2. Cost of straw Re 1 Kg^{-1}
3. Cost of cassava tuber Rs. 1 Kg^{-1}
4. Cost of stem Rs. 10 for 100 numbers
5. Cost of cowpea grain Rs. 4 Kg^{-1}
6. Cost of green bhusa Rs. 0.20 Kg^{-1}
7. Cost of groundnut pods Rs. 4 Kg^{-1}
8. green bhusa Rs. 0.20 Kg^{-1}
9. Cost of bhindi fruits Rs. 3 Kg^{-1}

Appendix IV A

Cost of cultivation of Cassava in one hectare (Summer rice fallows - irrigated crop) cv. Malavella. (5MD)

Perticulars of operations	Animal Pair @ Rs.50	Men @ Rs.25	Women Rs.18	Amount Rs Ps
1. Plouging the field (two rounds)	10	-	-	500.00
2. Transporting and appliying FYM @ 12.5 t/ha	-	-	10	250.00
3. Forming ridges and furrows	-	10	-	250.00
4. Cost of 12.5 t FYM @ Rs.150 t^{-1}		-	-	1875.00
5. Cost of fertilizers (50:50:50 NPK)		-	-	530.00
6. Cost of 3000 Tapioca stems (6-10 cuttings) @ Rs. 10/100 stems		-	-	300.00
7. Cutting setts and planting	-	2	5	140.00
8. Gap filling as and when necessary	-	1	-	25.00
9. Inter culturing and weeding and top dressing with N&K fertilizers	-	12	16	760.00
10. Irrigation at fortnightly intervals, guiding water etc.	-	10	-	250.00
11. Cost of diesel/electricity and rent of pump	-	-	-	350.00
11a. Plant protection (Lumpsum)	-	1	-	100.00
12. Harvesting the crop, separating tubers transporting to yard and stacking the stems	-	7	8	320.00
Total	10	43	39	5650.00

Appendix IV B

Cost of cultivation of one hectare cowpea in summer rice fallow (cv: Krishnamony)

Particulars of operations	Animal Pair @ Rs.50	Men @ Rs.25	Women Rs.18	Amount Rs Ps
1. Ploughing the field 2 times with bullock pairs @ Rs. 50/- pair	10	-	-	500.00
2. Cost of 20 Kg. seeds at Rs. 8/kg				160.00
3. Cost of fertilizers and Lime (Vide basic data appended)				502.00
4. Application of fertilizers and broadcasting the seed	-	1	-	25.00
5. Covering the seed by ploughting and opening drainage channels	2	1	-	125.00
6. Weeding and earthing up once	-	-	12	216.00
7. Irrigation twice-guiding water	-	2	-	60.00
8. Cost of diesal/electricity Lumpsum of Rs. 75 and rental charges of Motor and Pumpset	-	-	-	75.00
9. Plant protection operation (Lumpsum Rs. 80)	-	1		80.00
10. Picking pods - two times	-	-	11	200.00
11. Drying pods and threshing and cleaning.	-	-	3	75.00
12. Cutting and removing Bhusa (5 t/ha)	-	-	7	125.00
Total	12	5	33	2143.00

Appendix IV C

Cost of cultivation of one hectare of groundnut cv: TMV-2 in summer rice fallows (Irrigated crop)

Perticulars of operations	Animal Pair @ Rs.50	Men @ Rs.25	Women Rs.18	Amount Rs Ps
1. Ploughing the field 2 times with bullock pairs	10	-	-	500.00
2. Cost of 75 Kg Kernals @ Rs. 8/Kg	-	-	-	600.00
3. Application of fertil;izer	-	0.5	-	15.00
4. Dibbling te seeds behind country plough	-	-	8	400.00
5. Cost of fertilizers (10:75:75 NPK)	-	-	-	453.75
6. Cost of lime 1500 kg @ 0.75 Kg^{-1}		-	-	1125.00
7. Forming beds and channels for irrigation	-	4	-	120.00
8. Irrigation 15 times-guiding water	-	15	-	375.00
9. Electricity cost of diesel and rent of pumb (lumpsum)	-	-	-	150.00
10. Applying lime and earthing up	-	-	20	360.00
11. Plant protection operation (lumpsum) Rs. 225/-	-	2	-	275.00
12. Harvesting the crop and transporting to yard	-	-	15	375.00
13. Separating the pods and stacking te haulm	-	-	15	375.00
14. Drying the pods and storing in gunny bags	-	1	4	130.00
Total	15	22.5	62	5253.00

(Rounded to 5250/-)

Appendix IV D

Cost of cultivation of one hectare of bhindi in summer rice fallows (Irrigated crop cv. Pusasawami)

Particulars of operations	Animal Pair @ Rs.50	Men @ Rs.25	Women Rs.18	Amount Rs Ps
1. Ploughing the field 2 times	10	-	-	500.00
2. Transpprting and applying fram yard manure 12 t ha^{-1}	-	-	10	180.00
3. Cost of 12 t FYM @ Rs. 150 t^{-1}				1800.00
4. Forming beds and furrows and dibbling seeds	-	10	8	304.00
5. Cost of 10 Kg seeds @ Rs. 75/Kg	-	-	-	750.00
6. Cost of fertilizers (50:8:30 NPK)	-	-	-	350.00
7. Labour charges for application of fertilizers	-	2		50.00
8. Irrigation once in a week	-	15	-	375.00
9. Cost of diesel/electricity and rent of pumb	-	-	-	400.00
10. Plant protection operations (Lumpsum)	-	-	-	500.00
11. Harvest of fruits once in 4 days and storing in guny bags (10 harvests)	-	-	84	1500.00
Total	10	27	102	6811.00

(Rounded to Rs. 6810/-)

Appendix IV E

Cost of cultivation of rainfed transplanted rice one hectare - rabi season - with supplementary irrigation (Central Kerala)

Perticulars of operations (1)	Animal Pair @ Rs.50 (2)	Men @ Rs.25 (3)	Women Rs.18 (4)	Amount Rs Ps (5)
Preparatory cultivation				
Ploughing the fiel (puddling) and levelling with tractor (12 hrs @ Rs 60 hr^{-1})	-	-	-	720.00
Trimming and plastering bunds	-	-	10	300.00
Total	-	-	10	1020.00
Seeds and sowing				
Cost of 70 Kg seeds @ Rs. 3/Kg^{-1}	-	-	-	210.00
Ploughing thrice and levelling	2	-	-	100.00
Forming beds, sowing seeds and pp operations including chemicals	-	2	-	100.00
Uprooting seedlings	-	-	6	150.00
Transporting and spreading seedlings	-	2	-	50.00
Transplanting the seedling	-	-	30	540.00
Total	2	4	37	1108.00
After cultivation				
Hand weeding (twice)	-	-	30	540.00
Spraying thrice @ Rs.30/man	-	6	-	180.00
Cost of plant Protection Chemicals (Lumpsum)				700.00
Cost of diesel/ electriciy and rent of motor and pumpset. (Lumpsom)				550.00

(1)	(2)	(3)	(4)	(5)
Guiding water and irrigation management	-	5	-	125.00
	-	11	30	2095.00
<u>Harvest</u>				
Harvesting the crop transporting	-	5	25	575.00
Threshing and cleaning	-	5	5	215.00
Drying and Processing paddy and drying of straw	-	2	5	140.00
Total	-	12	35	930.00
Cost at 5 t FYM @ Rs. 150/L				750.00
Application charges of FYM	-	-	5	90.00
Cost of 250 kg of lime @ 0.75 kg^{-1}		-	-	187.00
Application of lime	-	-	1	18.00
Total	-	-	6	1045.50
Total cultivation charges without adding fertilizers	2	39	108	6198.00
Cost of fertilizers (90:45:45 NPK ha^{-1}) as urea, Musoorie rock phosphate and murite of potash (Vide Basic data sheet)	-	-	-	715.00
cost of transporting and application of fertilizers	-	2	-	100.00
Total	-	2	-	815.00
Grand Total	2	41	108	7013.00
		Rounded to		7000.00

RICE BASED CROPPING SYSTEM ANALYSIS IN KERALA

By

M. R. CHIDANANDA PILLAI

ABSTRACT OF THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE
DOCTOR OF PHYLOSOPHY
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

ABSTRACT

With the objectives of identifying the most economic crop combination for the double crop wet rice fields of Kerala and to assess soil fertility changes due to rice based cropping systems and also to find out the residual effects of the summer crops on the succeeding rice crops an investigation was conducted at the R.A.R.S. Pattambi in a split-split plot design, for a period of two years. The salient findings of the investigation are as follows.

In the Cassava-rice-rice system 25 per cent saving was recorded for P and K for maximum grain yield of kharif rice than the recommended doses. A saving Of 50 per cent each of P and K was recorded for the maximum straw yield than the recommended doses.

In cowpea-rice-rice system for maximum grain yield of kharif rice there was a saving of 25 per cent of P and K than recommended doses. The same trend followed for the maximum yield of straw also.

In groundnut-rice-rice system, for maximum grain yield of kharif rice there was a saving of 25 per cent of P and K than recommended doses. For the production of maximum straw yield full dose of recommended nutrients were required.

In bhendi-rice-rice system for maximum grain yield of kharif rice there was a saving of 50 per cent of P and K than recommended doses. For the production of maximum straw yield full dose of recommended nutrients were essential.

In rice-rice-rice system for maximum grain yield a saving of 25 per cent of P and K was recorded than recommended doses. For the production of maximum straw yield full dose of recommended nutrients were required.

In fallow-rice-rice system for maximum grain yield full dose of recommended nutrients were essential, whereas for the production of maximum straw yield a saving of 25 per cent of P and K than the full dose was recorded.

In cassava, rice and fallow systems for the manifestation of residual effect to the rabi rice, balanced nutrients at high doses are to be applied to the preceding kharif crop where as in the cowpea, groundnut and bhindi systems, residual effects of nutrients are seen manifested to the rabi rice crop even when the kharif rice crop is applied with medium doses of nutrients.

There was a trend of slight decrease in the organic carbon content of the soil under all the cropping systems. The status of available nitrogen and potash after one and two year crop sequences also followed the above trend. Regarding the status of phosphorus in the soil, there was a slight increase after one and two year crop sequences.

Cassava system produced maximum yield in terms of energy value followed by groundnut. From the economic point of view bhendi system gave the maximum net return. Maximum dry matter production (biomass production potential) was recorded in the cassava system followed by groundnut system.

A vegetable crop like bhendi or a tuber crop like cassava seems to be more profitable than growing rice in summer season in the double crop wet rice fields of Kerala, rice being least economic.

Among the cropping systems rice-rice-rice system generates maximum employment opportunities for the farm labourers with maximum job opportunities for women labourers as well.