NUTRIENT DYNAMICS IN THE RICE-BASED CROPPING SYSTEMS

BY

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THESIS

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DECLARATION

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

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CERTIFICATE

Certified that the thesis entitled "Nutrient dynamics in the rice-based cropping systems" is a record of research work done independently by [illegible] C. Sundaresan Nair 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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INTRODUCTION

Agriculture in India depends on varying soil types, water resources, temperature, sunshine and labour. The country has an area of 165 million hectares under cultivation, out of this about 30 per cent of the land is under irrigation.

The present cropping intensity is about 120 per cent. This can easily be stepped up to 200 and even 300 per cent if water is made available to irrigate the second or third crop when the monsoon ceases. The entire water reserve of about 100 mhm (million hectare meters) is expected to be harnessed in the next 12 to 15 years. At that time, the total irrigated area would be about 50 per cent of the then gross cultivated area of 210 million hectares.

The total agricultural production from the current gross cultivated area of 165 million hectare is around 150 million tons. This means an average yield of less than 1 ton ha^{-1}, while China's average is around 4 ton ha^{-1}. This means that we also have a very high potential. To attain this, we have necessarily to increase the cropping intensity. This can be done only by extending the results of a well planned programme of cropping systems research.

The objective of such a well planned system of cropping research will aim to increase the efficiency of use of a given quantity and quality of physical resources in crop production.

Kerala is one of the States where possibilities for horizontal expansion of agricultural area do not exist. At the same time, there exists a need for rapid increase in agricultural production. The resources of the State at present are being drained for importing food grains and food items from surplus States such as Punjab and Andhra Pradesh. To mitigate this situation, vertical growth in agriculture through intensive cropping is the only alternative. Looking at this complex situation of enhancing cropping intensity, one wonders at the successes achieved in recent years in Kerala both under upland and lowland situations.

In the uplands, a plethora of mixed and intercropping systems have been developed. The genius of the farmers of Kerala has been mainly responsible for the poly-crop system developed. Some of these systems have been sanctified by agricultural scientists as multi-tier systems or multi-storeyed cropping systems (Nelliat *et al.*, 1974).

Kerala's rice farming situations and systems, when examined against its physical resources viz. nature of the rice lands, water resources available, intensity of radiation in the major seasons namely virippu, mundakan and puncha, reveal that the state offers innumerable variability in these factors. The nature of the rice lands of the State lends themselves amenable to introduction of different crops such as pulses, sweet potato, vegetables, green manure crops etc. in the summer season, while they could be cultivated to rice in both the virippu and the mundakan seasons. Kerala's major rice tracts are situated in the flood plains of the rivers and various ribbon valleys running in east-west direction with several branches occasionally in the north-east direction as well. These lands have their central valley bottoms suitable for multiple cropping with rice-rice-rice. In fact, in many of these lands crops other than rice even in summer would be impossible. The fringes and boundaries of these ribbon valleys which are slightly elevated than the valley bottoms do not have enough water available for a rice crop in summer. These are the traditional rice fallows of Kerala in summer. But they have sufficient residual moisture for a summer pulse crop or a green manure can be grown. Thus, improving the intensity of cropping by working out different cropping sequences for the combination of various physical resources in Kerala's rice lands is very much possible. This excercise has to be followed up by proving the agronomic advantages to be derived out of the adoption of different sequences.

Further, intensive cropping enhances considerably the nutrient input requirements by several folds especially since all the crops in a multiple cropping sequence in lowlands or under a poly-crop system in uplands are likely to be high yielding and high nutrient exhaustive crop varieties. Such combinations of crop varieties would result in a rapid turn-over of plant nutrient in the soil plant system. In this context, the sustainability of high intensive cropping on a long term basis has also to be examined to arrive at suitable cropping sequences. Again growing of different crops in a sequence under high fertility conditions may create nutrient build-up or depletions with reference to particular nutrients. The magnitude of such accumulations and depletions depends on the nutrient involved, type of soil, nature and intensity of cropping and amount of fertilizer added. Thus, the dynamics of the nutrients in the soil and the cropping system requires to be studied in intensive cropping sequences. Fertility management in such situations becomes sustainable, if it would make the least demand on the soil. In this context, the nutrient balance sheet approach of Sadanandan and Mahapatra (1973) is probably the only recourse to such studies.

For Kerala's rice farming situations, there exists a need to intensively study the nutrient balance sheets and nutrient dynamics, when cropped with several sequences under high, medium and low fertility management conditions. An attempt has been made with this objective to study some of the sequences under different fertilizer management system in a continuous filed experiment. This study, thus, lays emphasis on the following aspects.

i. Locating the most suitable and efficient cropping sequence which produces the maximum yield per unit area per unit time with optimum utilisation of inputs and natural energy sources.

ii. Determining the effect of various crops of the cropping sequence on the fertility status of the soil.

iii. Determining the fate of the nutrients in the soil due to different crops.

iv. Finding out the uptake of major plant nutrient by different crops in the varying cropping patterns.

v. Working out the balance sheet of plant nutrient in various treatments and sequences.

vi. Working out the economics of various cropping sequences and treatments.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature pertaining to the present investigation "Nutrient dynamics in the rice based cropping systems" from the point of view of the effects of cropping systems on soil fertility, crop yields and economic feasibility is reviewed below.

I Plant nutrients in soil

(a) Nitrogen

Nitrogen occurs in many different forms in the soil. The inorganic nitrogen is present as ammonium, nitrate and nitrite forms. The amount present in these forms constitutes less than two per cent of the total nitrogen, the balance being in organic form.

Mitsui (1955) reported that on drying the soil prior to flooding, almost double the quantity of ammonia is released.

Sinha (1957) reported that the application of phosphorus improved the availability of nitrogen in soil, while K application showed a depressing effect on nitrogen supplying power of the soil.

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

Ponnamperuma (1964) reported that submerged soils vary widely in their capacity to produce ammonia. Soils rich in organic matter on submergence rapidly release ammonia which attains a concentration exeeeding 300 ppm NH_3-N within 30 days. Soils low in organic matter produce only smaller amounts of ammonia.

Ponnamperuma (1965) reported that NO_3 form is the most unstable and within a few days of submergence, the entire NO_3 is lost as elemental nitrogen by denitrification.

Kawaguchi and Kawachi (1966) opined that total nitrogen in Tropical rice soils was generally lower than temperate regions.

Battacharya (1971) observed an increase in the exchangeable NH_4-N in many soils on waterlogging. This was attributed to the expansion of the crystal lattice of clay minerals. as a result of which part of the fixed ammoniacal nitrogen is released.

Paul and Myers (1971) observed that clay content of soil had a considerable influence on the nitrogen uptake and yield.

Venkata Rao and Badiger (1971) reported that nitrogeneous fertilizers were almost completely utilised.

Appreciable increase in available nitrogen content in the soil could be expected due to the application of nitrogenous fertilizers.

Ponnamperuma (1975) reported that denitrification loss of nitrogen can be minimised by keeping the soil continuously flooded and this may be the reason for the submerged soils to be more fertile than upland soils.

Prasad abd Jha (1973) reported that due to continuous cropping there had been a significant loss of soil nitrogen and that the loss was more with high levels of nitrogen application.

Esakimuthu, and Krishnamoorthy, (1977) reported from pot culture experiments with rice that water soluble ammonium was high at planting and vegetative stages while exchangeable ammonium was high at vegetative stage.

Chandler (1979) reported that rice grows best in soils that are continuously submerged from the time to planting until crop maturity.

Mandal et al., (1982) reported that after five years of sequential cropping of jute-rice-wheat, about 18 per cent loss of N was seen in the control plots, followed by 15 per cent loss in 50 per cent NPK treated plots and 10 per cent loss in 100 per cent NPK treated plots.

Subbiah and Prasad Rao (1983) reported that the uptake of nitrogen by the rice crop slowly increased upto panicle initiation stage, with a steep increase upto blooming. It remained more or less constant at harvest.

Mohankumar and Singh (1984) reported that the apparent recovery of fertilizer nitrogen was comparatively higher in the intermittently flooded water regimes than in continuously flooded ones.

Pande et al., (1985), while studying the available nutrient status and pH of submerged rice soils at varying nutritional environments, reported that there was slight decrease in NH_4-N content of the soil as a result of rice cropping. Response to nitrogen application and increase in dry matter production was also noted with increase in nitrogen application.

Noshita and Hang (1986) reported the distribution of different forms of nitrogen in the desert soils at Nevada Test site and in the sub-surface found that the amount of total nitrogen was greater in surface layer and usually decreased very sharply with depth.

Sharma and Mishra (1988) reported that nitrogen application increased the amount of NH_4-N, whereas P and K had no effect. Application on nitrogen caused a slight decrease in available P content of soil as well P concentration in soil solution.

(b) <u>Phosphorus</u>

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.

Ponnamperuma (1955), in a study on the phosphorus transformations under submerged condition, observed an increase in available P and attributed this to hydrolysis of ferric and aluminium phosphates.

Chang and Jackson (1958) reported an increase in the phosphorus content under submerged conditions which may be due to the release of soluble P caused by reduction of occluded phosphate.

Shapiro (1958) reported that flooding increased the availability of soil P and paddy utilised P more efficiently under submerged conditions resulting in an increased uptake.

Basak *et al*., (1960) reported that increase in available P in waterlogged conditions was through the reduction of iron and aluminium phosphates.

David (1964) reported that unless a soil is deficient in P, yield response to P fertilizers in field experiments could not be obtained.

Patrick and Mahapatra (1968) reported that insoluble iron phosphates that were not readily available to plants in well drained soils undergo transformation to a more soluble ferrous form in waterlogged conditions and act as a good source of P to low land rice.

Mahapatra and Patrick (1969) reported that Al-P and Fe-P generally increased and reductant - P decreased as a result of waterlogging. Ca-P was relatively unchanged. The extractable phosphorus also increased due to waterlogging.

Cholitkul and Tyner (1971) reported that Fe-P and reductant soluble - P were the most abundant inorganic P fractions comprising about 19-35 per cent of total P. Al-P and Ca-P comprised about 4-5 per cent respectively. Al-P was the major plant source and Fe-P was found to be the next available form.

Khanna and Mahajan (1971) reported that more than half of the phosphate added in acid soil was converted to Al-P, 47-73 per cent at pH 4.7 and 35-36 per cent at pH 6.6 followed by Fe-P with 18-44 per cent at pH 4.0 and 17.34 per cent at pH 6.6.

Srivasthava and Pathak (1971) reported, in their study of UP soils, that the added P in the soil kept at field capacity moisture for three days can almost completely be recovered as saloid-P, Al-P and Ca-P. Recovery in the form of reductant P and occluded P was very little. When the soil was fractionated 100 days after P application, it was observed that as time elapsed, the saloid-P and Al-P changed gradually to Fe-P, which was the least soluble among the different fractions.

Kar (1973), in his study on the availability of iron and aluminium phosphates in acid soils, has reported that P release increased with increase in soil phosphorus status.

Bedrna (1974) reported that in acid soils, 90 per cent of the applied phosphate was transformed into aluminium phosphate and iron phosphate.

Thakkur <u>et al</u>., (1975) observed that Fe-P fraction formed the major portion of the inorganic P fraction. Al-P, Fe-P and Ca-P fractions increased at both at flowering and harvesting stages of rice in all the treated plots. Maximum transformation of applied P into Al-P, Fe-P and Ca-P was observed in plots receiving the highest dose of P. There was no appreciable increase in the reductant soluble P fraction even where the highest dose of P was applied.

Singh and Singh (1976) reported that the increase in Al-P at initial stages of waterlogging may be due to the transformation of Ca-P to this form because of the reduced condition. The decreased Al-P at the second and third stage during waterlogging may be due to the transformation of Al-P to Fe-P because of the lower solubility product of iron phosphate.

Mandal and Khan (1977) showed that 60 to 70 per cent of the applied P was found to remain in soils in fixed forms as Fe-P and Al-P even after the harvest of rice plants.

Singhania and Goswami (1978) reported that the P applied to rice increased the Al-P and Fe-P fractions in laterite soils.

Sharma and Tripathi (1984) showed that Bray's method extracts P mainly from Al-P followed by Fe-P fractions.

Raduvanshi *et al.*, (1985) reported that of the fertilizer P left in the soil after the harvest of crops, was found transformed into Al-P (32.7%), Fe-P (10.9%), Ca-P (50%) and reductant P (55%).

Mahimairaja and Mayalagu (1985) reported that prolonged submergence caused an increase in the availability of Fe in soil, practically benefitting the rice crop. This suggest the necessity to apply Fe (20 kg ha^{-1}) along with P (60 kg ha^{-1}) to get higher yields along with N and K.

Sharma and Mishra (1985) reported that when soils are submerged, the available P content of soil increased rapidly during the first 10 days, followed by a gradual increase attaining a maximum value by 30-40 days and then decreased slowly.

Dillen and Dave (1986) reported that with increasing levels of P application, the concentration of saloid P and Al-P in soil increased significantly. The effect was more marked during the initial stages of incubation upto seven days. Both saloid-P and Al-P recorded higher values under field capacity condition as compared to flooding. The content of Ca-P continued to be higher in soil at field capacity than at flooding after seven days of incubation.

Sarkar *et al.*, (1986) reported that due to submergence, phosphate potentials decreased with consequent increase in soil pH and in hydroxide potentials of Al^{3+} and Fe^{3+}.

Yaduvanshi *et al.*, (1985) reported that the major portion of the added P, unutilised by the wheat crop, gets converted into Al-P (41 per cent), followed by Fe-P (23.1 per cent). The transformation into Ca-P was of lower magnitude (16.3 per cent). With liming, a marked decline in the conversion to Al-P and Fe-P was noticed. In the lack of addition of fertilizer P, depletion in Fe-P and Al-P occurred in the soil. Al-P and Fe-P were related with available-P in soil.

Prasad *et al.* (1986) reported that lowland soils contained higher amounts of all the inorganic fractions of P than those of upland soils. Among the different inorganic fractions, the average relative abundance was in the order Red-P > Fe-P > Al-P > Ca-P.

Sudhir *et al.* (1987), from their studies on long term fertilizer experiments on mollisols, reported that NPK fertilizers increased the soloid-P, Al-P and Fe-P, reductant soluble-P and available P status of soil. Fe-P showed the highest increase.

(c) Potassium

The growing crops require adequate potassium supply. The potassium concentration in soil solution is in equilibrium with the potash reserve of the soil.

Ponnamperuma (1965) reported that submerging the soil enhances the release of exchangeable potassium in the soil. He also reported that increase in exchangeable 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.

Wu (1960) reported that the rate of replacement of non-exchangeable to exchangeable potassium is more rapid under submerged conditions than under upland conditions.

Mahapatra and Rajendra Prasad (1970) reported that an exchangeable potassium content of about 0.2 me/100g of soil is satisfactory for rice.

IRRI (1963) report shows that displacement of potassium from the clay complex greatly increases the concentration of potassium in soil solution.

Verma and Verma (1969) reported a positive correlation between available potassium and organic carbon in alluvial soils.

Thomas (1964) showed that in the top layers of forest soils of Kerala, the potash content varied from 0.18 to 0.37 per cent.

Mehrotra and Crulalae singn (1970), while studying the surface soils of Himachal Pradesh, reported that approximately 61.95, 31.06, 0.19. 0.6 and 0.1 per cent of the total potassium were present on HCl soluble potassmum, fixed potassium, respectively were noticed in these soils.

Rajakannu *et al.*, (1970) reported 1.67, 0.53 and 0.46 m/100g of available potassium in black, red and alluvial soils, respectively.

Islam and Bolton (1970) reported that most of the non-exchangeable potassium was removed from unlimed soils between PH 5.5 to 7.

Primavesi and Primavesi (1971) reported that dry soil on submergence increases potassium levels in soil solution.

Avokyan (1972) reported that the effectiveness of potassium fertilizers was related more to the saturation of the exchange complex with potassium and to the ionic activities of aqueous extracts prepared with or without saturation with CO_2 and to the potential capacity of soil with respect to potassium.

Tilali *et al.* (1974) reported that application of K fertilizers influences the available and non-exchangeable potassium content of soils.

Sreedevi and Aiyer (1974) reported comparatively high values of total, exchangeable, difficulty exchangeable and HCl soluble potassium in Kari, Karapadam and Kayal soils of Kuttanad.

Ram and Singh (1975) found that available potassium was positively and significantly correlated with pH.

Martine and Suarez (1977) reported that potassium fertilisation increased the exchangeable potassium fixed and decreased the non-exchangeable potassium released.

Esakimuthu et al., (1977) reported that water-soluble potassium was highest during flowering stage, while exchangeable potassium was high during transplanting stage. Non-exchangeable potassium was found to be high during post harvest stage.

Ramanathar (1978) reported that nitric acid extractable K was closely related to plant uptake.

Ramanathan and Subbain (1978) reported the influence of nitrogen and phosphorus on potassium application and potassium uptake was distinctly pronounced at the tillering stage of ragi.

Lichrer (1979) reported that the potassium content in the dry matter of grass sword was dependent on the amount of available potassium in soil.

Subbarao and Ghosh (1983) reported that under continuous cropping, available potassium showed a significant positive relationship with yield.

Kapur, et al., (1984), while studying the potassium response of maize and wheat, reported that the crop response to applied potassium will be more in soils low in available potassium.

Ganeshamoorthy and Biswas (1985) reported that continuous cropping did not affect the exchangeable K content of soil.

Singh et al., (1985) reported that soils of Haryana contain 1.02 to 0.02 per cent total K, 916 to 4638 ppm HCl soluble K, 131 to 675 ppm nitric acid soluble K (Neutral normal Ammonium acetate extractable K), 16 to 197 ppm and 2.38 ppm water soluble K.

Singh et al., (1986), while studying the K transformations, reported that a large portion of applied K was transformed to non-exchangeable form, followed by exchangeable and water-soluble forms.

Sahu and Gupta (1987), while studying fixation of K in some alluvial soils under alternate wetting and drying conditions by applying potassium at different levels, found that 31 to 65 per cent of the added K was fixed. Fixation increased with increasing levels of K application.

Gajbhiye (1988) reported that both Inceptisols and Entisols appeared nearly identical in the distribution of K in various forms, but there existed considerable variation at series level which may be considered in the management of K fertility problems when taxonomic information is used for profitable agriculture.

II Soil pH

The soil pH is one of the important soil properties that controls the soil fertility. The pH of submerged soil has a marked influence on its capacity to supply nutrients through its direct effect on nutrient absorption, concentracion of nutrients in soil solution and indirect effect on chemical equilibria as well as sorption, desorption and microbial activity. All these effects have marked influence on the absorption of nutrients by rice crop under submerged conditions.

In submerged soils, pH influences the concentration of iron, manganese and aluminium. At high pH, rice suffers from iron deficiency and at low pH it is affected by iron toxicity (Ponnamperuma, 1955; Tanaka and Yoshida, 1970).

Yamada (1959) reported that potassium and phosphorus deficiencies are induced by excess iron.

Schatscnabel (1971) studied the causes and nature of soil acidity and indicated that soil pH less than 5 was governed by release of protons in soil solutions where as high pH values are associated with anological reduction of CO_2. Increase in pH of submerged soil also results in decrease in concentration of Mg, Ca and Mn.

Moore (1972) reported that nutrient absorption by plants is maximum at pH 5 to pH 7.

Boyer (1976) concluded that exchangeable aluminium was present in tropical soils when the pH dropped below 6. But toxicity develops only at pH values below 3. The mechanism of toxicity is often indirect through the inhibition of P and Ca and stimulation of Mn uptake.

Alice Abraham (1984) studied the status of exchangeable aluminium in the acid rice soils of Kerala and reported that many of them contain Al in toxic levels.

Helder and Mandal (1985) showed that lime requirement values are generally correlated negatively with pH and positively with exchangeable acidity, and exchangeable Al in soils of most of the regions.

Ananthanarayana et al., (1988) reported that pH value can be used as a useful index for predicting the phosphorus retention capacity and buffering reactions undergoing in soils.

The optimum pH for rice production is about 6.6. At this pH, organic matter decomposition will be high and microbial release of nitrogen and phosphorus from organic matter will also be high.

Rice-based cropping system analysis

(a) Cropping systems suited to rice areas

Long term experiments have revealed that the soil is exhausted by continuous cropping and as such yield declines. To overcome this, suitable cropping systems have to be identified for better soil management and thereby provide a better economy for the farmers.

Lim (1955) reported that continuous cropping with rice alone increases soil acidity.

Mohand and Singh (1968) have found that continous cultivation with rice decreases organic matter content of the soil.

Nair and Singh (1971) reported that in field experiments on rice-based cropping patterns, the available nitrogen and organic matter content slightly increased.

Sadanandan and Mahapatra (1972) reported decrease in soil pH in rice-jute and rice-rice cropping patterns. Several experiments have been conducted in different parts of India to find out rice-based cropping systems suited to different areas.

Sadanandan and Mahapatra (1972) reported that the maximum net profit was obtained from the crop sequence potato-rice-rice during the year 1967-68 and 1968-69 at Central Rice Research Institute, Cuttack.

Tripathi et al., (1973) have reported rice-rice-maize is suitable for the laterite tracts of West Bengal.

Out of the different cropping systems tried, rice-rice-tapioca and rice-rice-bhindi gave the highest yield in field experiment conducted in AICRP (1977).

Purushotnaman (1979) suggested rice-rice-greengram on the best suited for Coimbatore.

Sasidhar and Sadanandan (1980) reported that among the five rice-based cropping sequences, rice-rice-cowpea gave the highest yield of rice.

Vedaprakash et al., (1982) obtained the highest average annual net return and benefit cost ratios using rice-chick pea rotation, followed by rice-lentil, rice-field pea and rice-wheat sequences.

Budhar et al., (1985) found that growing greengram as a pure crop and relay growing of cotton intercropped with cowpea was most economical than growing greengrass-sorghum + cowpea in the dry lands of Dharmapuri. For SW and NE monsoons, the sequence greengram-cotton + cowpea or greengram-sorghum+cowpea was most economical.

Yadav and Singh (1986) obtained an increased yield of wheat crop after a Rhizobium-inoculated greengram or blackgram.

Sharma et al., (1987) reported that cowpea, greengram and blackgram could be grown successfully in monsoon season without adversely affecting the succeeding wheat yield. The grain yield of wheat increased when legumes were grown for green manuring or when blackgram stoves were incorporated in the soil after picking up pods. This practice saves 40-80 kg/ha nitrogen application of succeeding wheat.

Verma et al., (1987) noticed that rotational cropping of rice-wheat and cowpea is good for maintaining fertility status of soil.

Mahapatra et al., (1987) showed that highest yield was obtained with rice-potato and was the most efficient sequence. Single crop rice in rice-rice was the most inefficient one. Highest net profit was obtained with rice-potato in Orissa.

Gangwar (1987) reported that pulses, oilseeds and cereals performed well in residual soil moisture during rice fallows in Andamans. 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-blackgram, rice-sorghum and rice-rice-greengram gave highest yields.

Patel et al., (1987) found that rice crop (Jaya) transplanted in July after cowpea and fertilised with 100:50:50 Kg NPK per hectare yielded 4 tons ha^{-1}.

Sahu et al., (1988) reported that rice-pea nut and rice-blackgram had the highest total grain yields, closely followed by rice-wheat.

Selvaraj et al., (1988) reported 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 rice production in the region by 174 per cent.

Biswas et al., (1988) obtained the highest yield of rice in a potato-rice sequence. Rice after mustard and fallow gave idential yields.

Uttaray et al., (1988) reported that rice yield was higher from rice-peanut sequence than from a rice-wheat sequence.

(b) Physico-chemical properties of soils as affected by cropping patterns

Long-term experiments have revealed that constituent crops in a rotation and their management have marked effect on the various physico-chemical properties of soil.

i) <u>Soil organic matter and nitrogen</u>

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) reported that crop rotations including legumes maintained organic matter in soil at an optimum level.

Merchandani and Khan (1953) have suggested the inclusion of legume in cropping sequences for maintaining good fertility level in soils.

Nijhawan (1963) reported that continuous cultivation in a soil did not bring any change in total nitrogen content of the soil.

Mohand and Singh (1968) reported that continuous cultivation of rice decreased the organic matter content of soil.

Sharma and Saxena (1970) found that under double cropped sequences, a positive balance of nitrogen could be maintained.

Prasad and Jha (1973) reported that organic carbon was significantly reduced due to continuous cropping with dwarf rice.

Nair *et al.*, (1973b) obtained an increase in available nitrogen and organic matter content of soil due to the cultivation of leguminous crops.

Singh and Moorthy (1974) showed that the available nitrogen was better maintained in mung-rice-wheat than in fallow-bajraw-wheat or fallow-rice-wheat sequence.

Sadanandan and Mahapatra (1975) have reported a maximum decrease in organic carbon content of soil due to continuous cultivation of rice as compared to other cropping patterns.

According to Wivutronguania and Tiyawallee (1984), multiple cropping systems deplete the soil fertility differently, soil organic matter being depleted under all cropping systems. However, it was slightly enhanced where legumes were included.

Hati and Ray (1984) reported that the nitrogen content of soil and plant yield of inter-cropped ragi was found to increase in the study on pigean pea-finger millet inter-cropping systems. From the results of wheat yield and status of soil nutrients after eight years intensive cropping, Mandal *et al.*, (1984) showed a declining trend in organic carbon and total nitrogen content of the soil.

Deka and Singh (1984) showed that total nitrogen and organic matter content increased in all crop rotations except in pure cereals (rice-wheat).

A decrease in total nitrogen content of soil after wheat has been reported by Yadav (1985). According to Yadav and Singh, (1986), succeeding wheat after blackgram gave higher yield due to nitrogen fixation leading to a saving of 30 kg nitrogen/ha for the wheat crop.

Azam (1986) proposed that growing legumes in the cropping system can increase mineralisable nitrogen in soil.

Chaudhury and Veehami (1985) reported that the total nitrogen content of the soil remained unchanged after continuous cultivation of rice.

Prasad and Palaniappan (1987) have reported that when the residues of the preceding crops in the cropping system are incorporated into the soil, an increase in yield and fertility of soil could be obtained.

Sahu et al., (1988) observed an increase in soil organic carbon under various cropping patterns. The least increase was noted in rice-wheat, sequence and highest, in rice-cowpea sequence.

ii) Soil phosphorus

Cultivation of crops singly or in sequence may not have any effect on the total phosphorus content of soil. Sadanandan and Mahapatra (1972b) reported that there was no noticeable gain or loss of total phosphorus in all cropping patterns tried.

At the same time, there are other reports which show that continuous cultivation causes a change in available phosphorus status of the soil. Sturgis (1957) reported that due to continuous cultivation of rice, the available phosphorus content of soil was reduced from 12.5 to 4.5 ppm.

Ghosh and Kanzaria (1964) obtained a higher status of available phosphorus under a continuous cropping system in plots which received superphosphate.

Nair et al. (1973 a) reported that there was an increase of available phosphorus in soils, when leguminous crops were grown in multiple cropping.

Singh and Ramamoorthy (1974) reported that the available phosphorus status of soil was maintained better under mung-rice-wheat than under fallow-bajra-wheat or fallow-rice-wheat.

Raghavalu and Sreeramamoorthy (1975) recorded a slight increase in available phosphorus at the end of three years in all the rotations involving cereals and pulses.

Subha Rao and Ghosh (1981) reported that intensive cropping affect the depletion of inorganic-P more than the depletion of organic-P in soils.

Nad and Goswami (1984) reported that continuous application of phosphatic fertilizer in a rice-wheat cropping sequence for over ten seasons resulted in an increase in soil phosphorus, particularly in Al-P and Fe-P fractions.

Wivutronguania and Tiyawallee (1984) found that in a three year experient, the application of P fertilisers for two consecutive years gave a higher soil P for the third year.

Mandal et al. (1984) noticed that due to continuous cropping and manuring in a jute-rice-wheat rotation, an appreciable build-up of available P in soil has occurred.

Yaduvanshi et al. (1985) reported that after five years of continuous cropping and manuring in a long-term fertilizer experiment, the net gain in soil P progressively improved with increasing doses of P application.

Rana et al., (1984), from their study on crop yields and nutrient uptake in a cropping sequence, observed that nitrogen and phosphorus uptake of crops decreased with curtailment in fertilizer dose.

From his study of the different cropping systems, Yadav (1985) reported that the available P decreased from 18.4 to 14.5 kg/ha.

Sagar *et al*., (1986) have stated that in wheat-rice rotation, fertilizer should be applied to wheat rather than to rice and that if wheat receives adequate P application over a period of time, P application to the rice can be reduced. P was more available after rice harvest than after wheat harvest, because soil P is more available in submerged than in aerated soils.

Verma *et al*., (1987) reported that continuous cropping increased P status over the initial value, when P was applied in the cropping sequence.

Gill *et al*., (1987) reported that in the case of groundnut-wheat and greengram-wheat crop sequences grown in soils low and medium in phosphorus, both groundnut and greengram responded well to phosphate application and had marked residual effect on the succeeding wheat crop.

Sahu *et al*., (1988) reported that available P and exchangeable K decreased in rice-blackgram sequence, where there was maximum grain production.

iii) Soil potassium

Sturgis (1936) reported a reduction in the exchangeable potassium content of soil due to continuous cultivation of rice.

Sadanandan and Mahapatra (1972 a) reported that after completion of each rotation, the total potassium content of the soil decreased, the maximum decrease being observed in continuous cultivation of rice.

Lal (1973) reported that the available potash decreased with increase in cropping intensity.

Ghosh and Kanzaria (1964) reported that there was no change in total potash in soil by continuous cultivation with addition of potassic fertilizer.

Nair et al., (1973 b) found that the available potassium content slightly improved when leguminous crops were grown in rice-based cropping systems.

Sadanandan and Mahapatra (1974 b) reported that in the cropping pattern rice-rice, there was a slight gain in exchangeable potassium.

Singh and Ramamoorthy (1974) found that available potassium was maintained better under mung-rice-wheat than under fallow-bajra-wheat or fallow-rice-wheat.

Clerk and Mack (1974) found that exchangeable potassium decreased under continuous cropping for four years without fertilizers.

Raghavalu and SreeramaMoorthy (1975) reported that in all rotations involving cereals and pulses, the available potassium status decreased.

Venkatesh et al., (1982) showed that after six years of cropping, rice-wheat cowpea along with fertilisation the available K was still the lowest in soil.

Wivutronguania and Tiyawallee (1984), from the results of fertility changes under different multiple cropping systems, reported that available K was relatively higher in soil after three years.

Mandal et al., (1984) reported that continuous cropping and manuring in a jute-rice-wheat rotation increased the available K status of soil in plots which were fertilised.

Yaduvanshi et al., (1984), from the results of nutrient balance studies under cropping sequence in acid hill showed that HCl soluble K increased with higher doses of K fertilisation.

Verma et al., (1987) reported that continuous cropping coupled with fertilizer application resulted in only slight decrease in available K was lesser. The decrease in plots which received potassic fertilizers was less than those which did not receive it.

Sahu et al., (1988) reported a decrease in the available K and exchangeable K in rice-blackgram sequence where the grain production was maximum.

Soil pH

A change in the biotic conditions can be brought about by the differential absorption of nutrients by plants and by their excretions into the soil. The preferential absorption of cations and enions by growing plants may cause changes in pH of soil.

Kanwar and Prihar (1962) reported that continuous cultivation of crops that use ammonium results in the lowering of soil pH.

Sadanandan and Mahapatra (1972a) reported that maximum decrease in soil pH was in the cropping pattern rice-jute-rice and rice-rice.

Lal (1973) reported that soil pH decreased with increase in crop intensity from 100 to 400 per cent.

Raghavalu and Sreeramamoorthy (1975) reported that reduction in pH at the end of three years in all crop rotations involving rice, wheat, greengram, maize, bengalgram, bajra, barley and blackgram.

Juo and Lal (1975) reported that continuous cropping for three years resulted in decrease in soil pH.

Sasidhar (1979) reported that continuous cropping decreases pH in soil. The rice-rice sequence causes more acidity in soil.

Sahu *et al*., (1988) reported that rice-rice-cowpea recorded least soil acidity and gave good grain production. He also reported that fallow-rice-rice produced less acidity in soil than any other cropping systems tried.

(V) Organic carbon

Poyser *et al*., (1957) reported that there was an over-all decrease of 27.5 per cent 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 reported that there was a decrease in organic carbon content of soil due to continuous cropping. The maximum decrease was observed in rice-rice-rice sequence.

Sasidhar and Sadanandan, (1979) also reported that continuous cropping affects the organic carbon content of soils. The maximum decrease was observed in rice-rice-sequence. The least was noted in rice-rice-cowpea/pulses.

Mandal *et al*., (1984) reported that continuous cropping decreases the organic content in soil.

Deka and Singh (1984) reported that organic carbon and total nitrogen content decreased in soil after continuous cropping for eight years. The loss was maximum in rice-wheat rotation.

Sanchez and Lopez (1986) observed a decline in organic carbon in soil due to continuous cultivation. The decline was minimum in plots which were receiving organic matter or green manure.

Sahu et al., (1988) also found that continuous cropping with cereals decreased the organic carbon content of soil. However, organic carbon content of soil increased with cropping patterns like rice-cowpea, rice-greengram, and rice-peanut.

Nutrient requirement of crops included in the cropping sequence

Rice

(a) Nitrogen

Matsushima (1965) reported that the amount of nitrogen absorbed at the flowering stage is small as compared to the amount absorbed during vegetative stage.

Sadayappan and Kolendaiswamy (1974) reported that increase in plant height with increase in levels of applied nitrogen.

Sushamakumari (1981) and Surendran (1985) also reported that increase in plant height resulted with increase in nitrogen.

Lenka and Behera (1967), and also De Datta and Surjith (1981) reported that tiller production increases with increase in nitrogen.

Rothiram *et al.*, (1975) observed steady increase in yield with enhanced dose of nitrogen and the highest yield was obtained with 160 kg of 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.

Sharma (1980) found that increase in nitrogen rates from zero to 150 Kg ha^{-1} increased average yield from 1.75 to 5.56 t ha^{-1} and further increase in nitrogen rates gave no profit.

Singh and Mondal (1978) reported that optimum rate for Jaya was 158 Kg N ha^{-1}. Singh *et al.* (1978) reported that the optimum and most profitable nitrogen rate for Jaya was 140 Kg N ha^{-1}.

Rao and Ramanujam (1971) found that increasing nitrogen level from zero to 180 Kg ha^{-1} increased the grain yield.

Venkateswaralu (1978) stated that straw yield increased with nitrogen levels upto 200 kg ha^{-1}, beyond which it declined.

The trials conducted at Agricultural Research Station, Kanakanady (1985) reported that increase in yield of rice was observed upto 150 kg N ha^{-1}.

(b) Phosphorus

Phosphorus is one of the three major nutrients essential for plant growth. It is second only to nitrogen.

Mitsui (1955) reported that phosphorus applied to rice plant is utilised during the enthal light to 10 weeks of its growth.

Wukeleen and Patrick (1968) found that rice plants accumulate about two-thirds of total phosphorus at heading stage and about 80 per cent of the phosphorus of the entire plant is stored in grain at maturity.

Sahu and Lenka (1966) reported that response to P is increased when it is applied in conjunction with nitrogen. According to De Datta (1970), in the absence of phosphorus response of higher nitrogen level was negligible.

Khatua and Saha (1970), Tewari and Thakur (1976), Mahimairaja and Maylager (1985), and Didi Asde and Widjafa (1986) reported that phosphorus significantly increased rice grain yield.

(c) Potassium

Rice plant absorbs much more potassium than nitrogen and phosphorus. The amount of potassium absorbed is high [illegible]

[illegible] (1-7) [illegible]

[illegible]

[illegible] (1973) [illegible]

[illegible] and that field [illegible]

[illegible]

[illegible] 8000 [illegible] rons

an average of 40 kg nitrogen, 30 kg phosphorus and 75 kg potash from a hectare of land.

According to Mikkelsen and Patrick (1968), a crop producing 4000 kg of grain ha^{-1} removed 40 to 90 kg of potash.

Ginst (1969) found that rice crop producing only 1000 kg of grain removed 20.6 kg of nitrogen, 10.3 kg of phosphorus and 29.3 kg of potash from one hectare of land.

A rice crop producing 8 tonnes each of grain and straw was found to remove 192 kg of nitrogen, 80 kg of phosphorus and 240 kg of potash per hectare (Mahapatra, 1968).

In general, the high yielding varieties of rice remove from soil 150 kg of nitrogen, 80 kg of phosphorus and 240 kg of potash to produce 7000 to 8000 kg grain ha^{-1}.

2. Sweet Potato

(i) Nitrogen nutrition of sweet potato

Sweet potato responds more to nitrogen than to any other essential mineral nutrient, Jhonson and Ware (1948).

Tsuno and Fujise (1964) obtained a fairly close relationship between nitrogen concentration in the whole plant and leaf area index of sweet potato.

According to Nair et al., (1976), tuber yield and total nitrogen uptake was increased with nitrogen application.

Allen (1986) observed that tuber size and tuber content of NPK increased with increase in NPK application.

Kabeerathumma and Mohankumar (1986) reported an increase vine growth with increased NPK application.

ii) Phosphorus nutrition of Sweet potato.

Morgan (1934) reported that super phosphate in fertilizer mixture gave significant increase in tuber yield.

Landrau and Samuels (1957) and Allen (1976) reported increase in tuber yield due to phosphate application.

Prasad et al., (1982) reported that phosphorus application enhanced tuber formation when it is applied alongwith FYM and other fertilizers.

Kabeerathumma and Mohankumar (1986) observed that phosphate application in the form of rock phosphate enhanced the yield.

iii) Potassium nutrition of Sweet potato

Potassium is required for the formation of carbohydrates such as sugars and starches and for their translocation from one part of the plant to another. It is also essential for the synthesis of protein in plant. The crop quality also is improved by potash. It also helps in the development of healthy root system.

Scott (1950) has reported that potash fertilizers influence the size and shape of sweet potatoes.

Landran and Samuels (1957) reported an increase in yield of marketable sweet potatoes with increasing potash application.

Uriyo (1973) showed that potash application significantly increased the yield of sweet potato tubers.

Godfrey-Sam-Aggrey (1976) reported that fertilizers containing higher amount of potash (448 kg/ha of sulphate of Potash) and NK ratio of 3·4 gave maximum tuber yield and lower vine yields.

Prasad <u>et al</u>., (1982) found that an increase in available potassium in soil increases the uptake of nutrients and tuber yield.

Dahiya and Pestoge (1976) suggested that sweet potato removed larger quantities of potash as compared to nitrogen and phosphorus. A crop producing 40 tonn's per hectare removed 190 kg nitrogen, 75 kg phosphorus and 390 kg potash per hectare.

Yuan , (1964) showed that heavy application of nitrogen caused excessive vine growth.

Thomas (1965) observed significant increase in yield of vine by nitrogen application. He also reported that maximum number of shoots was noticed in plants receiving 88 kg of nitrogen and 80 kg of potash per hectare.

Merita (1967) reported that excess nitrogen resulted in excess to P growth.

Morita (1967) reported favourable effect of split application of nitrogen, once at planting and again 30 days after, on moderating top growth during tuber forming period and enhancing top growth during development period.

Mandal et al., (1968) observed a significant increase in sweet potato yield upto 75 kg nitrogen per hectare.

They have also reported a maximum yield of tuber by the application of 100 kg nitrogen per hectare.

Mandal and Mohankumar (1971) found that the size of tuber was not influenced by nitrogen but higher levels of nitrogen resulted in an increase in the number of tubers per plant.

Dasharathi and Padmanabha (1972) obtained a significant response of sweet potato to application of nitrogen upto 80 kg.

Kudrekri *et al.*, (1973) showed that increase in nitrogen beyond 11 kg/ha did not produce any increase in yield of cowpea.

Godsase and Dongale (1984) reported that on an average the crop absorbed 1.87 kg nitrogen to produce one quintal grain yield.

Vinodkumar *et al.*, (1985) found that the nitrogen content in leaves, stems, pods, husks and grain were enhanced with increasing levels of nitrogen.

Khandkhah *et al.*, (1986) reported that the crop responds well to N and P fertilisation and yield increase with increase in rate of N and P.

(2) Phosphorus nutrition of cowpea

Phosphorus has a definite stimulatory effect on the multiplication of rhizobia which in association with leguminous plants fix atmospheric nitrogen.

Robert and Olesen (1944) as well as Parr and Sen (1948) observed that the uptake of nitrogen by leguminous crop depend on phosphorus supply.

Parr and Bose (1944, 1945) revealed that cowpea responded highly to phosphate application.

Bains (1955) reported that increasing the rate of phosphorus increased nodulation in cowpea.

Sharma and Garg (1975) reported that green and dry matter production of cowpea increased significantly due to phosphorus application upto 70 kg phosphorus per hectare.

The trials conducted at Rice Research Station, Pattambi (Annual Report, 1976) revealed that application of 20 kg phosphorus per hectare through soil plus 20 kg phosphorus through foliage gave the maximum yield of 1022 kg/ha.

Subramonian et al., (1977) reported that 25 kg phosphorus ha^{-1} recorded the maximum grain yield of 1863 kg ha^{-1}.

Jayarani and Ramaiah (1980) suggested the application of 26.9 kg P_2O_5 ha^{-1} as the economically optimum dose for the crop.

Ramaswamy et al., (1985) found that application of N and P increases the nodulation in cowpea.

Krishnamoorthy et al., (1985) reported that an increase in NPK improved the yield of cowpea.

Jain et al., (1986) reported that at higher levels of phosphorus there was an increase in dry matter production, number of seeds per pod, weight of pods, and weight of grain.

Potassium nutrition of cowpea

Tiwari (1965) reported that response of cowpea to potassium has been low in Africa, although Potash application of 40 kg ha^{-1} had increased nodulation in Eastern Nigeria.

Jacquinot (1967) reported that this element is transported mainly to the stem in the early stages of growth and later to the seeds.

Worley *et al.*, (1971) suggested that the level of soil potassium should not exceed 42 kg ha^{-1}.

Badiger, *et al.*, (1982) reported that fertilizer potassium improved yield and quality of pulse.

Sadasivam (1985) found that the pulse plants having good K status produced better grain yield and showed an improvement with K fertilisation.

Subharamu *et al.*, (1985) reported that foliar application of K improved the yield of pulse crop and Dubey and Shinde (1986) have shown that increase in K fertilisation improved the yield.

The requirements of nitrogen, phosphorus and potassium have been established under specific conditions and for specific genotypes. Jacquinot (1967) reported cowpea seeds harvested from one hectare of land. Rachie and Robert (1974) reported that each tonne of cowpea seeds removes from the soils the mineral nutrients at the rate of 40 kg nitrogen, 17 kg phosphorus and 48 kg potash.

MATERIALS AND METHODS

MATERIALS AND METHODS

The study entitled "Nutrient dynamics in the rice-based cropping systems" was carried out by conducting field experiments and laboratory studies. It consists of:-

A. Field experiment for six seasons over two agricultural years.

B. Studies on the dynamics of nutrients N, P and K in soil under different cropping sequences.

C. Studies on the uptake of plant nutrients by individual crops in each cropping sequence.

D. Economics of cropping patterns studied.

A. Field experiment

1. Experimental site

The field experiments were conducted continuously for six seasons starting from February 1981 (Summer 1981) to June 1982 (Summer 1982) at the Regional Research Station, NARP (Central Zone) Pattambi. Existence of facilities for controlled irrigation as well as drainage in the experimental fields enabled the cultivation of various component crops in a rice-based cropping system. The experimental field selected had been under rice for two continuous seasons prior to it being laid out. The soil of the experimental site is a sandy clay loam and is typical of the wet land rice fields of the locality. The physico-chemical properties of the soil are presented in Table-1.

Table-1 <u>Physico-chemical properties of the soil</u>

a. <u>Physical properties</u>

Coarse sand (per cent)	24.0
Fine sand (per cent)	22.7
Silt (per cent)	18.0
Clay (per cent)	34.3
Textural Class-sandy clay loam	
Bulk density 1.18g/ml.	

b. <u>Chemical properties</u>

Soil pH	5.06
Organic carbon (per cent)	1.6160
Nitrogen (per cent)	0.1606
Total phosphorus (ppm)	900
Available P (ppm)	18
Total potash (ppm)	1200
Exchangeable potash (ppm)	40
C.E.C. (C mole kg^{-1})	5.6
Exchangeable hydrogen (C mole kg^{-1})	1.21

FIG I

LAY OUT PLAN

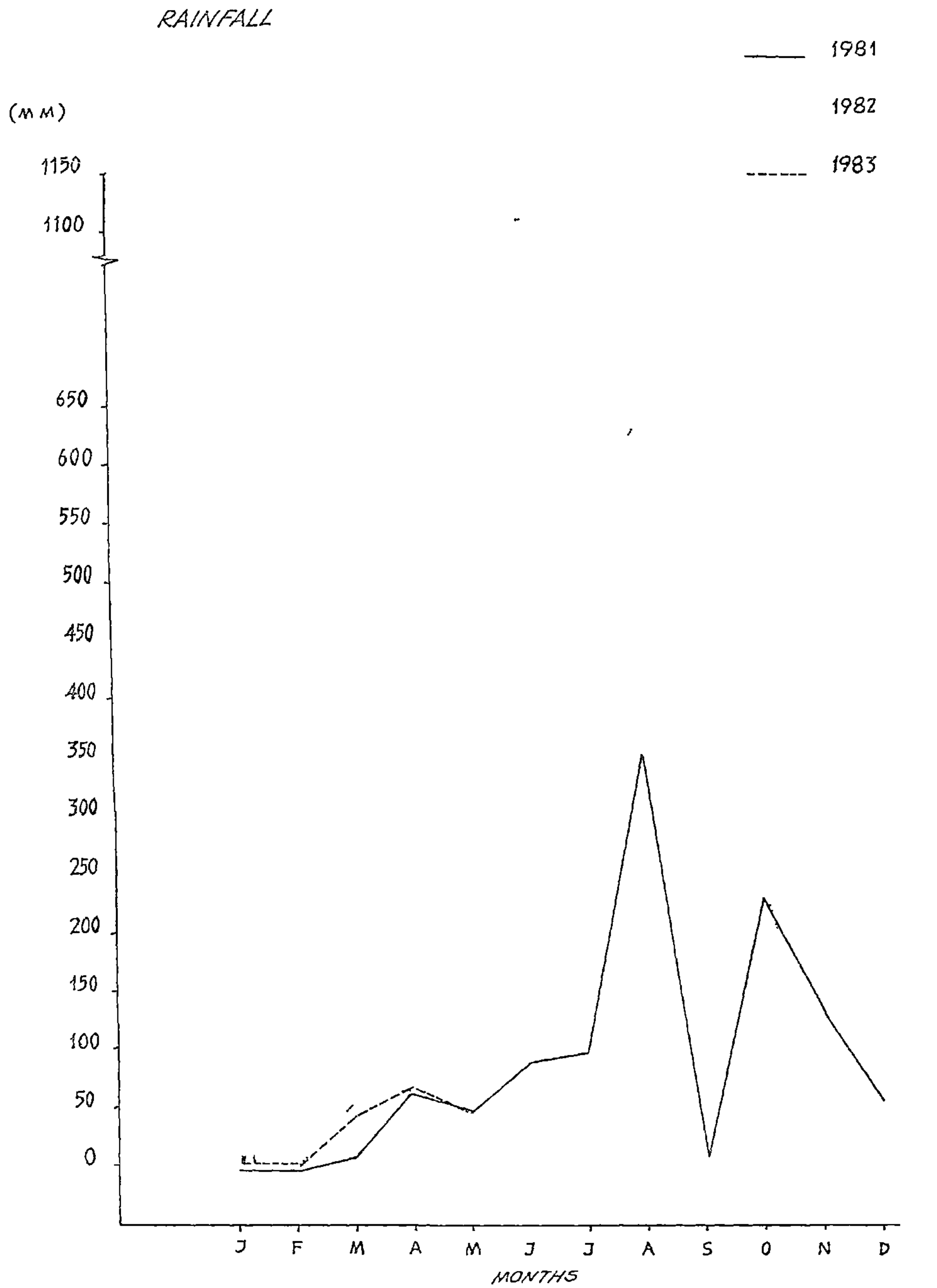
SWEET POTATO	PADDY	DAINCHA	FALLOW	PULSE
T_3	T_6	T_1	T_3	T_1
T_1	T_2	T_5	T_1	T_4
T_6	T_4	T_2	T_5	T_6
T_4	T_3	T_4	T_2	T_2
T_2	T_5	T_6	T_4	T_5
T_5	T_1	T_3	T_6	T_3

CHANNEL

T_6	T_5	T_1	T_4	T_5
T_4	T_2	T_4	T_2	T_3
T_2	T_6	T_3	T_5	T_6
T_5	T_4	T_6	T_1	T_2
T_3	T_1	T_2	T_3	T_4
T_1	T_3	T_5	T_6	T_1
PADDY	SWEET POTATO	PULSE	DAINCHA	FALLOW

QUARTERS – RESEARCH STATION ROAD

FIG 2



RAINFALL
1981
1982
1983
(MM)
1150
1100
650
600
550
500
450
400
350
300
250
200
150
100
50
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTHS

FIG 3

MAXIMUM & MINIMUM TEMPERATURE

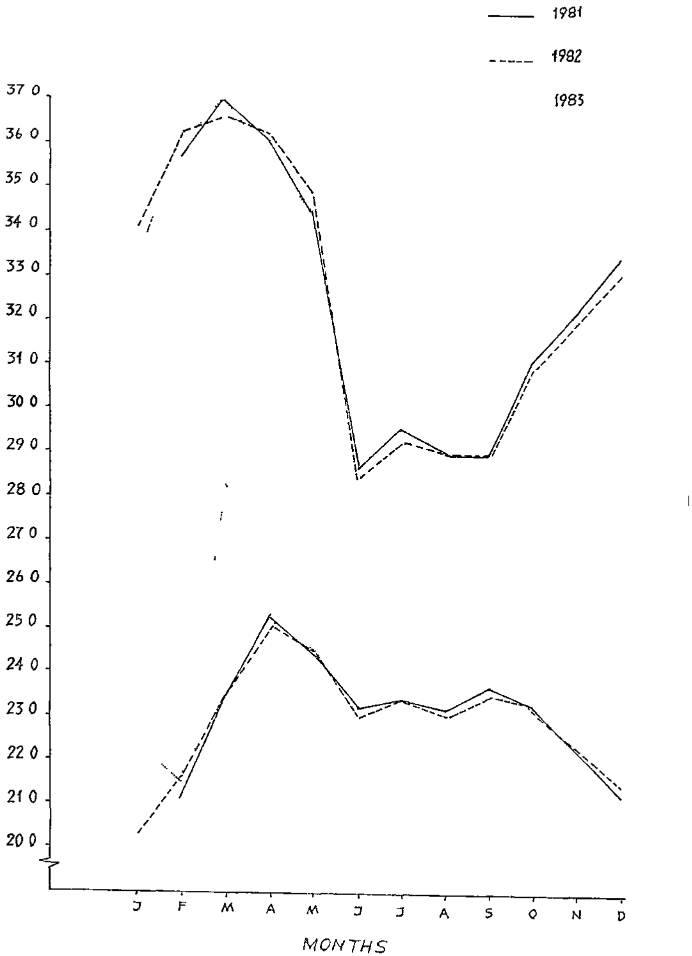


FIG RELATIVE HUMIDITY (/)

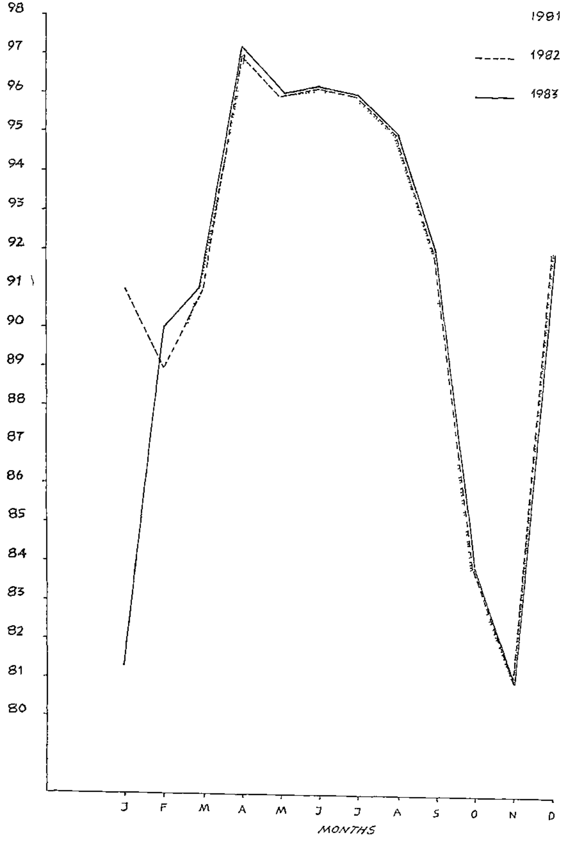


Table-4

Meteorological data from 1st February 1981 to 31st May 1983

Month	Rainfall (mm)	Temperature 0°C Maximum	Minimum	Relative humidity (%)
February 1981	0	35.8	21.1	87.0
March 1981	12.4	37.0	23.5	91.4
April 1981	66.0	36.0	25.3	97.0
May 1981	49.6	34.5	24.6	96.0
June 1981	93.0	28.7	23.3	96.2
July 1981	99.2	29.6	23.5	96.0
August 1981	353.4	29.0	23.3	95.0
September 1981	14.1	29.0	23.7	92.0
October 1981	238.7	31.2	23.4	84.0
November 1981	1[illegible]2.0	32.3	22.3	81.0
December 1981	58.9	33.5	21.4	92.0
January 1982	0	34.1	20.4	91.0
February 1982	0	36.2	21.7	89.0
March 1982	62.0	36.6	23.5	91.0
April 1982	66.0	36.4	25.2	96.8
May 1982	176.7	34.9	24.8	96.1
June 1982	1122.0	28.5	23.4	96.2
July 1982	549.5	29.4	23.5	96.0
August 1982	647.5	29.0	23.2	95.2
September 1982	348.0	29.0	23.6	92.1
October 1982	257.3	31.0	23.5	84.2
November 1982	96.0	32.0	22.4	81.2
December 1982	0	33.2	21.5	92.0
January 1983	0	32.2	22.4	81.2
February 1983	0	36.0	21.5	90.0
March 1983	52.0	37.0	28.3	91.2
April 1983	65.0	35.8	25.4	97.0
May 1983	52.0	34.6	24.6	96.0

II Season and weather conditions

The weather data recorded at the meteriological unit attached to the Regional Research Station, Pattambi from February 1981 to May 1983 are presented in Table-2 and Fig. 1, 2 and 3.

III Experimental details

Design of the experiment	-	Randomised block design
Number of Treatments	-	6 x 5 = 30
Cropping sequences	-	5
Fertilizer treatments	-	6
No. of Replications	-	2
Total number of plots	-	60
Gross plot size	-	3 x 2 m
Net plot size	-	2.5 x 1.5 m

Irrigation channels of 50 cm width were provided on all sides of the main plot so that each plot could be irrigated or drained as required.

Treatments

The following five cropping sequences were included in the experiment with six treatments for each crop.

Sequence symbol	Summer (Punja)	Kharif (Virippu)	Rabi (Mundakan)
A_1	Rice	Rice	Rice
A_2	Sweet Potato	Rice	Rice
A_3	Cowpea	Rice	Rice
A_4	Daincha	Rice	Rice
A_5	Fallow	Rice	Rice

Treatment symbol	Fertilizer treatments for all the three component crops of the sequence
T_1	Full recommended dose
T_2	3/4 of the recommended dose
T_3	1/2 of the recommended dose of NP and K
T_4	3/4 of the recommended dose of nitrogen and full dose of P and K
T_5	3/4 of the recommended dose of P and full dose of N and K
T_6	3/4 of the recommended dose of K and full dose of N and P

The layout plan is given in fig. 1

Description of the varieties used in experiment

1. Rice (*Oryza sativa*)

Two varieties namely *Triveni* and *Jaya* were used in the study. *Triveni* is a high yielding, short duration (about 100 days), short-statured and photo-insensitive variety evolved by a cross between Annapurna and Ptb 15.

Jaya is a high yielding, medium duration (about 125 days), short-statured and photo-insensitive variety evolved by a cross between J (N) 1 and T 141. It is a stable yielder with wide adaptability.

II. Sweet Potato (Ipomoea batatus)

The hybrid H-42 evolved by a cross between Velladamph (a local variety) and Triumph (An American Variety) was used in the experiment. It produces medium-sized, pink-coloured skinned tubers having yellowish white flesh.

III. Cowpea (Vignia sinensis)

New Era variety of cowpea was used for the study. The plants are bushy in nature and branching. The pods are small. Duration of the crop is about 90-100 days.

IV. Daincha

It is a green manure. The plants are bushy and resistant to drought. At the time of flowering it is ploughed into the soil as a green manure. The duration is 90-100 days.

V. Fallow

The land is kept fallow for the season without any cultivation.

VI. Details of cultivation

1. Rice: The rice crop in all the three seasons were transplanted in the mainfield.

Nursery: Wet nurseries were raised in all the three seasons and 20 to 25 days old seedlings were transplanted to the mainfield.

Cultural practices:

The field preparation for rice consisted of four ploughings and puddling. The bunds were trimmed and plastered, after which levelling of each plot was done.

Manures and manuring:

Fertilizers were applied as per Treatments T_1 to T_6 and according to package of practices recommendations of the Kerala Agricultural University, 1989. The full NPK recommended dose consisted NPK 70-35-35 for Triveni and 90-45-45 Kg/ha respectively for Jaya. Nitrogen (as urea 46 per cent) was applied in two split doses for Triveni, at planting and one month after transplanting and in three split doses for Jaya, half at planting, one-fourth at 30 days after transplanting. Phosphorus (as Mussorie phosphate 24 per cent P_2O_5) and Potassium (as muriate of Potash 60 per cent K_2O) were applied as basal dose to both the varieties. Treatments T_2, T_3, T_4, T_5 and T_6 were appropriately modified an already indicated and applied.

Transplanting:

The variety Triveni was transplanted during the summer season (Punja). A spacing of 15 x 10 cm was followed. Jaya was transplanted during the Khariff (Virippu) and Rabi (Mundakan) seasons at a distance of 10 cm between rows and 10 cm between plants. Two seedlings per hill were planted in all the cases.

Intercultivation and weeding

Gap filling was done one week after transplanting. Plots were hand weeded once at 30 days after transplanting and later after another 15 days.

Irrigation and water management:

All the plots were irrigated whenever necessary to maintain 5 cm water level throughout the growing period. The water was drained out from the plots 15 days before harvest.

Seedlings were dipped in parathion 0.05 per cent solution before transplanting. Prophylactic plant protection measures were taken against the attack of pests and diseases whenever necessary.

Harvesting and Threshing:

Two border rows of plants from all the four sides of each plot were removed. The remaining plants from all the plots were harvested and threshed separately and weighed.

ii) Sweet potato.

Preparatory tillage.

The land was drained out completely and the soil was allowed to dry. The soil was brought to a fine tilth by digging to a depth of 25cm. Ridges of 35 cm height were made at a distance of 75 cm apart.

Planting:

The vines were cut into 25 cm bits and planted on the ridges at a spacing of 20 cm between vines, using single vine cutting per hole. The vine cuttings were planted with the middle portion buried in the soil and both the cut ends exposed.

Manuring :

Farm yard manure was applied at the rate of 10 ha^{-1} at the time of preparation of the land. In addition to this, fertilizers were applied at the following rates:

Nitrogen	75 Kg ha^{-1} as urea
Phosphorus	50 Kg ha^{-1} as mussoorie rock phosphate
Potassium	75 Kg ha^{-1} as muriate of potash

Nitrogen was applied in two equal split doses, [illegible] at [illegible] and the second four weeks after planting. The full doses of phosphorus and potash were applied at the time of planting.

Interculti[illegible]t on:

The weeding and earthing up operations were conducted four weeks after planting and just prior to the application of second dose of nitrogen. The development of small tender tubers were prevented by disturbing the vine occasionally during the period of active growth.

Irrigation and water management

At the time of planting, sufficient moisture was ensured in the soil for early establishment of the cuttings. Necessary drainage was provided. Irrigation was applied once in [illegible] the [illegible] period of 15 days after planting and thereafter, [illegible] days.

Plant protection:

Sumithion 0.1 per cent was sprayed at 30 days interval, after planting as a prophylactic measure against the attack of sweet potato weevil. Against the attack of minor pests like leaf feeders, Ekalux was sprayed at 0.5 per cent.

Harvesting:

The border rows of plants from all the four sides were first harvested and removed. The remaining experimental area was then harvested and the tubers and the vines were immediately weighed and recorded.

iii) Cowpea:

The land was drained fully and the soil was allowed to dry. The soil was prepared to a fine tilth and levelled ensuring deep digging prior to the preparation of the land.

Seeds and sowing:

Seeds were sown in furrows at a spacing of 15 x 15 cm and covered with soil.

Manuring:

Farm yard manure at the rate of 2 t ha^{-1} was applied at the time of land preparation and incorporated into the soil. In addition, fertilizers were also applied at the following rates:

Nitrogen	10 Kg ha^{-1}	as ureax
Phosphorous	50 Kg ha^{-1}	as Mussorie rock phosphate
Potassium	50 Kg ha^{-1}	as muriate of potash

The entire dose of nitrogen, phosphorus and pota-ssium was applied as basal dressing at the time of planting.

Interculivation and weeding:

Gap filling was done ten days after sowing. Weeding and hoeing operations were conducted three and six weeks after sowing.

Irrigation and water management:

A light irrigation and was given four days after sowing. Subsequent irrigations were given once in seven days.

Plant protection:

As a prophylatic measure, 0.2 per cent sevin at 600 l ha^{-1} was applied at an interval of two weeks, from one month after planting.

Harvesting:

Two border rows of plants were removed. The remaining experimental area was harvested by cutting and removing the plants at the ground level along with the pods. The pods were then separated and shelled. The grains were dried under the sun, cleaned and the weight recorded.

iv) Daincha:

Preparatory tillage:

The land was drained and the soil was allowed to dry; ploughed twice, clods were broken, and levelled.

Seeds and sowing:

Daincha seeds were broadcasted after mixing it with three times its volume of sand to ensure uniform coverage and harrowed to cover the seeds with soil.

Manuring:

No manuring was given.

Intercultivation and weeding

No intercultural operations were carried out.

Irrigation and water management

No irrigation was given. The sprouting occurred using the available moisture of the soil. The soil moisture build up during the summer showers enabled it to be grown as pure rainfed crop.

Plant protection

No plant protection operations were carried out.

Harvesting:

Harvesting was done immediately after flowering and at about 3 months after seeding. The plants are cut at the base, chopped and ploughed into the soil.

v) Fallow:

No crop was raised in these plots. The field was ploughed 2 times, levelled and left without any crop for the viripru season.

vii) Dates of planting and harvest of crops included in the cropping sequence

The dates of planting and harvest of various crops included in the cropping sequences are presented in Table-3.

Table-3

Dates of planting and harvest of various crops in the Cropping Sequence

Cropping sequence (A_1) Paddy-Paddy-Paddy.

Year	Summer Paddy		Viripu Paddy		Mundakan Paddy	
	Planting	Harvesting	Planting	Harvesting.	Planting	Harvesting.
1981-82	11.2.81	13.5.81	16.6.81	3.10.81	6.10.81	25.1.82
1982-83	9.2.82	6.5.82	15.6.82	10.10.82	13.10.82	11.2.83

Cropping sequence (A_2) Sweet potato-paddy-paddy

Year	Summer sweet Potato.		Virippu Rice		Mundakan Rice	
	Planting	Harvesting.	Planting	Harvesting	Planting	Harvesting.
1981-82	11.2.81	13.6.81	16.6.81	3.10.81	6.10.81	25.1.82
1982-83	9.2.82	6.6.82	15.6.82	10.10.82	13.10.82	11.2.83

Cropping sequence (A_3) Pulse-paddy-paddy

Year	Summer Pulse		Virippu Rice		Mundakan Rice	
	Planting	Harvesting	Planting	Harvesting	Planting	Harvesting
1981-82	11.2.81	13.6.81	16.6.81	3.10.81	6.10.81	25.1.82
1982-83	9.2.82	6.6.82	15.6.82	10.10.82	13.10.82	11.2.83

Cropping sequence (A_4) Daincha-paddy-paddy

Year	Summer Daincha		Virippu Rice		Mundakan Rice	
	Planting	Harvesting.	Planting	Harvesting	Planting	Harvesting
1981-82	11.2.81	13.6.81	16.6.81	3.10.81	6.10.81	25.1.82
1982-83	9.2.82	6.6.82	15.6.82	10.10.82	13.10.82	11.2.83

Cropping sequence (A_5) Fallow-paddy-paddy

Year	Summer Fallow		Virippu Rice		Mundakan Rice	
	Planting	Harvesting	Planting	Harvesting	Planting	Harvesting.
1981-82	-	-	16.6.81	3.10.81	6.10.81	25.1.82
1982-83	-	-	15.6.82	10.10.82	13.10.82	11.2.83

viii) Pre-harvest observations:

I. Rice

Sampling technique:

Random sampling technique was adopted to study the agronomic characters such as height and number of tillers. Five sample units of 50 x 30 cm were randomly selected from each plot. Biometric observations were recorded first at 30 days after planting and subsequently at an interval of 15 days.

a) Plant height

Height of plant was measured from the ground level up to the tip of the top most leaf.

b) Tillering

Total number of tillers of plants of the five sample units were counted and the number of tillers per square metre computed. The number of effective tillers was made at the time of flowering.

II. Sweet potato

Sampling technique

Three rows were selected for observation from each plot and five plants from each row, thus making a total of 15 plants for each plot.

a) Length of main shoot.

The length of main shoot of the observational plants was measured from base of the main shoot up to the top of the leaf tip.

b) Number of branches.

The number of branches was counted for each observational plant, first 30 days after planting and subsequently at 15 days interval.

III. Cowpea.

Sampling technique.

Random sampling technique was adopted for selecting rows and plants for observations. The plants selected in the row was taken as the central plant of the rectangle. In this way, three rectangles were selected in each plot. There were nine plants in each rectangle and thus, 27 plants were taken from each plot for observation of the characters.

a) Plant height

The height of the selected plants were measured from the ground level upto the tip of the top most leaf, first at 30 days after planting and subsequently at 15 days interval.

b. The number of branches were counted from each sample plant, first 30 days after planting and subsequently at 15 days interval.

IV. Daincha

Sampling technique.

Random sampling technique was adopted to select observational plants for measuring the plant height. Five sample units of 50 x20 cm each were selected from each plot and the height was recorded first 30 days after sowing and subsequently at 15 days interval.

Plant height.

All the plants from each selected samples were taken for measuring the plant height. The height was measured from the ground level upto the tip of the top-most leaf.

IX. Post-harvest observations

1. Rice

a. Yield of grain and straw.

The plot-wise yield was recorded after cleaning and drying to 14 per cent moisture level. The straw was dried in the sun and the yield was recorded. In both cases, the per hectare yield was then computed.

II. Sweet Potato

a. Yield of tubers.

The weight of tubers was recorded immediately after the harvest. The yield per hectare was computed.

b. Green weight of vines:

The green weight of vines was recorded immediately after the harvest and the per hectare yield was also computed.

III. Pulse (Cowpea).

a. Yield of grain.

The yield of grain after air-drying was recorded plot-wise and per hectare yield was calculated on this basis.

b. Yield of haulm.

The sun-dried weight of haulm was recorded plot-wise and per hectare yield was computed.

IV. Daincha.

a. Yield of green manure

The crop was harvested plot-wise and the weight of green manure both stem and leaves included was recorded. From these data, per hectare yield was computed.

B. Soil studies

Studies on the changes in physico-chemical properties of soil due to cropping sequence were made. The soil from each plot was analysed for the various physico-chemical properties before the commencement of the various sequences and treatments and after each component crop.

i. Collection of soil samples.

For the purpose of collection of soil samples, each plot was divided into four equal parts. From each part, one soil sample was collected from the plough layer using a soil auger and four samples thus obtained were mixed together thoroughly and the composite sample was air-dried

ii. Processing of soil samples for chemical analysis

The air-dried samples were powdered and passed through a two mm seive.

III. Analytical methods

The methods followed for the analysis (physical and chemical) of soil samples are given below:

a. Mechanical analysis.

Mechanical analysis was carried out by International pipette method (Piper, 1950).

b. pH

The pH was determined using a Perkin - Elmer meter with a soil : water ratio of 1:2.5.

c. Organic carbon

Walkley and Black's rapid titration method was used for the determination of organic carbon (Jackson, 1967).

d. Total nitrogen

The conventional Kjeldahl's method was used for the determination of total nitrogen (Jackson, 1974).

Available nitrogen - Determined by the alkaline permanganat distillation method (Subbiah and Asija, 1956).

e. Total phosphorus

The precipitation method of Jackson, 1974.

f. Total potassium by Flame photometer method. (Black, 1985)

g. Available phosphorus

The available phosphorus was extracted by Bray No. 1 extractant (0.25 N HCl and 0.03 N NH_4F) Ammonium phosphomolydo blue colour developed was determined by the method of Dickman and Bray (1940).

Available potassium. This was determined by extraction with neutral normal ammonium acetate and determined flame photometrically (Black, 1985).

C. Studies on the uptake of plant nutrients

1. Collection and preparation of plant samples

I. Rice

The plants selected for recording various biometric observations were harvested after recording the observations and used for plant analysis. After air-drying the plants, the grains were separated from the straw. Straw was chopped into small bits and thoroughly mixed. The grain and chopped straw samples were then oven-dried at 60°C and separately ground to fine powder for chemical analysis.

II. Sweet potato

The marked plants selected for recording the observations were also used for plant analysis. The vines, after sun-drying, were oven-dried, ground to fine powder in an electric grinder and used for chemical analysis.

The tubers were cleaned thoroughly, cut into small slices, dried first in the sun and later oven dried at 60°C. The dried slices were ground into a fine powder in an electric grinder for chemical analysis.

III. Cowpea

The marked plants after harvest were sun-dried for a few days. They were then oven-dried and ground into fine powder.

The sun-dried pods were shelled and the grains powdered and used for chemical analysis.

IV. Daincha

The sample plants after harvest were sun-dried for a few days. They were then oven-dried, powdered and used for chemical analysis.

II. Methods of analysis:

The plant samples were analysed in duplicate for nitrogen, phosphorus and potassium using standard analytical procedure as outlined in Piper (1950).

Statistical analysis

The various analytical data collected from the experiments were subjected to statistical analysis by the test of significance at 5% level

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

A. Field experiments

Tables 4 to 24 present various biometric observations of the different summer crops in the various sequences experimented.

Tables 4 and 5 present data on the height of the rice plants in cm at successive stages of growth (Summer 1981 and 1982) of variety Triveni. From these results, it can be seen that the treatments and periods have significant effect. Among the treatments T_1, T_5 and T_6 have maximum effect. Maximum plant height is observed to be attained on the 60th day in all treatments.

From the above data, it is clear that plant height is significantly affected by nitrogen. The treatments where the nitrogen supply has been decreased (T_2, T_3 and T_4) recorded significantly lower height than the treatments with the full dose of fertilizer. In treatments T_5 and T_6 only, the level of P and K respectively have been decreased to 75 per cent of the quantity as in T_1 and therefore the height of plants under the treatments are not significantly lower than in the full dose of N, P and K ie. T_1. This shows that height is more influenced by nitrogen. The effect of nitrogen in significantly

Table-4

Height of plant in cm at successive stages of growth rice var. Triveni - Summer 1981

Treatments	Days 30	Days 45	Days 60	At harvest	Mean T
T_1	42.6	60.4	69.1	70.1	60.6
T_2	41.4	59.5	68.5	69.5	59.7
T_3	39.6	57.3	68.5	69.0	58.6
T_4	41.6	59.9	69.3	69.5	60.1
T_5	42.4	60.4	68.7	69.5	60.2
T_6	42.5	60.4	63 5	73.8	61.3
Mean	41.7	59.6	68.7	70.2	

CD = for treatments = 0.664

CD = for periods = 0.271

(5% level)

Table-5

Height of plant in cm at successive stages of growth rice variety Triveni - Summer 1982

Treatments	Days 30	45	60	At harvest	Mean T
T_1	38.0	52.0	70.0	68.0	57.0
T_2	38.0	50.0	68.0	68.0	55.0
T_3	34.0	49.0	68.0	67.0	55.0
T_4	36.0	50.0	69.0	68.0	56.0
T_5	38.0	51.0	70.0	68.0	57.0
T_6	38.0	51.0	70.0	67.0	56.0
Mean	36.0	51.0	69.0	68.0	

CD = for treatments = 0.6543

CD = for period = 0.27

(5% level)

Table-6

Number of tillers at successive stage of growth m^{-2}

Rice variety Triveni - Summer 1981

Treatments	Days			At harvest	Mean
	30	45	60		
T_1	543	578	446	408	490.7
T_2	520	502	530	391	485.7
T_3	510	499	429	378	454.0
T_4	517	504	430	390	460.0
T_5	528	509	439	396	468.2
T_6	530	512	440	398	47.0
Mean	524.6	577.3	452.3	393.5	

CD for treatments = 1.35

CD for periods = 0.620

5/ level)

Table-7

Number of tillers at successive stage of growth m^{-2}

rice variety Triveni - Summer 1982

Treatments	Days			At harvest	Mean
	30	45	60		
T_1	535	520	438	390	470.7
T_2	485	440	390	335	412.5
T_3	470	425	380	327	400.5
T_4	495	465	410	350	430.0
T_5	510	495	425	380	452.5
T_6	490	478	415	372	436.7
Mean	497.0	470.0	409.0	359.0	

CD for treatments = 1.272

CD for periods = 0.52

enhancing plant height in rice is well known. The lack of effect of both P and K in increasing the plant height is also equally well documented (Surendran, 1985 and Barnes et al., 1986).

Tables 6 and 7 represent the number of tillers at successive stages of plantgrowth of summer rice, variety Triveni during the years 1981 and 1982. The periods and treatments have a significant effect. The treatments T_1 and T_6 show maximum tiller number than other treatments. The maximum tiller number have been expressed in all the treatments by the 45th day. Beyond the 45th day an increase in tiller number has been recorded only in treatment T_2. At harvest, a decrease in the number of tillers has been noticed in all the treatments. This observation relates to the number of effective tillers under various treatments. The number of effective tillers is significantly more for the treatments T_1 and T_2 than for all the other treatments.

It is very clear from the effect of treatmentsthat decreasing the level of phosphorus to 75 per cent of the recommended level as in treatments T_2 and T_6 decreased the number of tillers. However, th number of effective tillers in treatments T_3 was significantly the lowest.

Table-8

Height of Cowpea plant in cm at successive stages of growth - Summer 1981

Treatment	Number of days				
	30	45	60	At harvest	Mean
T_1	34.8	49.8	63.5	75.0	55.7
T_2	31.9	46.5	60.2	69.5	52.0
T_3	31.5	45.2	59.0	68.1	50.9
T_4	32.5	49.0	61.6	71.6	53.6
T_5	32.9	49.6	62.0	72.5	54.1
T_6	33.1	47.3	62.2	73.1	54.0
Mean	32.8	47.8	61.4	71.6	

CD = Treatments = 0.610

CD = Periods = 0.249

(59 lind)

Table-9

Height of Cowpea plant in cm at successive stages of growth - Summer 1982

Treatment	Number of days				
	30	45	60	At harvest	Mean
T_1	29.0	43.5	56.8	68.0	49.3
T_2	26.9	41.2	54.8	64.6	46.8
T_3	26.2	40.0	53.5	64.0	45.9
T_4	27.2	41.5	55.4	65.0	47.2
T_5	27.5	42.0	55.9	65.4	47.7
T_6	27.7	42.2	56.0	65.5	47.8
Mean	27.4	41.7	55.3	54.0	

CD = Treatments = 0.612

CD = Periods = 0.237

(5% level)

Table-10

1981 Summer

Treatment	No. of nodules per plant (Cowpea)			Pod characters and seed weight		
	No. of nodules	Nodule weight (in g)	No. of pod/plant	No. of seed/pod	Length of pod (in cm)	100 seed weight (in g)
T_1	20.5	0.8	10.4	15.9	15.8	[illegible]
T_2	[illegible]	0.6	9.2	15.0	15.0	[illegible]
T_3	7.2	0.0	9.0	14.9	14.5	10.6
T_4	19.5	0.0	9.4	15.7	15.2	10.9
T_5	19.8	0.0	9.8	15.7	15.4	[illegible]
T_6	20.1	0.0	10.2	15.8	15.6	[illegible]
C.D. = (5% level)	0.104	NS	CD = 0.245	C.D-[illegible]	CD-0.252	CD 0.[illegible]

In the treatment, the NPK doses applied were only 1/2 of that in treatment T_1.

The observations on tiller number show the vital role played by phosphorus in maintaining the total number of tillers and also the effective number of tillers. It is all the more so in intensively cropped sequences according to Tewari and Thakur (1976). The present observations are in agreement with the earlier observations.

Tables 8 and 9 present the height in cm of the cowpea plant (summer) at successive stages of growth during the years 1981 and 1982. It is evident that both the treatments and periods have significant effect. The maximum plant height is observed at 75 days in all the treatments. This corresponds with the grand stage of vegetative growth viz. flowering. Among the treatments T_1 ie. full recommended dose of N P and K and T_6 ie. full dose of N and P and 3/4 dose of K record the maximum plant height.

In the cowpea plant, the role of P along with initial booster dose of nitrogen in the maintenance of plant height has been brought out. The significant action of P is due to its indirect effect on root nodule activity and consequently the nitrogen fixed by rhizobial association (Ramaswamy et al., 1985). This is partially substantiated by the data

Table-11

1982 Summer

Treatment	No. of nodules per plant (Count)			Pod characters and seed weight		
	No. of nodules	Nodule weight (mg)	No. of pod/plant	No. of seed/pod	Length of pod (in cm)	100 seed weight (in g)
T_1	18.7	0.0	9.9	15.6	15.8	11.2
T_2	6.9	0.0	8.4	14.5	14.2	10.8
T_3	16.5	0.0	8.0	14.2	14.0	10.7
T_4	17.3	0.0	8.8	15.2	14.6	10.9
T_5	17.9	0.7	9.2	15.4	15.2	10.9
T_6	18.2	0.7	9.5	15.5	15.3	11.9
C.D. = (5% level)	0.183	NS	CD=0.462	CD=0.246	C.D.= 0.253	C.D.= 0.771

Table-12

Number of branches of cowpea at different stages of growth - Summer 1981

Treatment	30 days	45 days	60 days	At harvest	Mean
T_1	3.8	4.5	4.6	4.3	4.4
T_2	3.3	3.7	3.9	4.2	3.7
T_3	3.0	3.5	3.2	4.1	3.6
T_4	3.5	3.9	4.2	4.3	4.2
T_5	3.5	4.2	4.5	4.5	4.2
T_6	3.0	4.3	4.5	4.6	4.2
Mean	3.4	4.0	4.2	4.4	

C.D for treatment = 0.212

C.D for period = 0.40

(5% level)

Table-13

Number of branches of cowpea at different stages of growth - Summer 1982

Treatment	30 days	45 days	60 days	At harvest	Mean
T_1	3.4	3.9	4.39	4.4	4.0
T_2	2.95	3.4	4.1	4.1	3.6
T_3	2.8	3.3	3.9	4.1	3.5
T_4	4.1	3.7	4.1	4.2	4.0
T_5	3.2	3.7	4.2	4.2	3.8
T_6	3.3	3.8	4.4	4.3	4.0
Mean	3.3	3.6	4.2	4.2	

C.D for treatment = 0.20

C.D for period = 0.38

(5% level)

on nodule number and nodule weight presented in the Table 10 & 11. It may be seen that both number of nodules and nodule weight is decreased by the reduction of phosphorus as seen in treatments T_2 and T_3.

Tables 10 and 11 also present the observation on number of pods per plant, length of pod and 100-seed weight. A general trend observed brings out the importance of P and K in the maintenance of pod diameters that contributes to a high seed yield. Thus, treatments which were lower in quality of P and K applied either marginally as in treatments T_2, T_4 and T_6 or substantially as in treatment T_3 had lower or decreased attributes for the pod characters. Similar observations on the effect P on pod characters. Similar observations on the effect P on pod characters on cowpea and effect of higher levels of K on some of the pod and seed characteristics in cowpea have been documented.

Tables 12 and 13 represent the number of branches of cowpea for summer 1981 and 1982. There is significant difference between the treatments and the doses. The treatments T_2 and T_3 where the quality applied of both P and K have been decreased significantly decreased the number of branches. It is significant to note that the number of branches have not been affected in the treatments T_5 and T_6

Table-14

Length of main shoot of sweet potato in cm at different stages of growth variety H-42

Summer 1981

Treatment	In days				
	30	45	60	At harvest	Mean
T_1	56.3	120.3	150.0	160.5	121.8
T_2	52.2	110.1	140.5	155.0	114.4
T_3	48.8	105.8	138.2	152.0	111.2
T_4	51.8	109.0	138.7	154.0	113.3
T_5	53.2	110.8	142.0	156.5	114.2
T_6	56.2	120.4	150.2	161.2	122.0
Mean	53.0	112.6	120.2	156.5	

C.D. for treatment = 3.10

C.D. for period = 1.27

(5% level)

Table-15

Length of main shoot of sweet potato in cm at different stages of growth Variety H-42 — Summer 1982

Treatment	In days 30	45	60	At harvest	Mean
T_1	54.1	120.9	150.0	156.0	120.2
T_2	50.0	110.2	145.0	152.0	114.3
T_3	48.0	108.0	142.0	150.0	112.0
T_4	49.5	108.0	144.0	152.0	113.3
T_5	50.7	112.0	146.0	153.1	102.7
T_6	54.1	122.0	122.2	156.4	120.9
Mean	51.0	113.5	146.3	153.5	

C.D. for treatment = 3.120

C.D. for period = 1.267

5 % level)

wherein one of the nutrients viz., P or K have been applied at a lower dose. In fact, such a trend has been discovered for pod characters also. It has to be emphasised that as the number of branches increase so will be an increase in leaf nodules and hence increase in leaf area index. This will enhance the photosynthetic rate. Thus, in the maintenance of a higher yield, the role of N and K has been brought out by the data presented. Similar observations have been made by other workers such as Sharma and Garg (1975).

Tables 14 and 15 represent the length of main shoots of sweet potato in cm at different stages of growth for summer 1981 and 1982. The result shows that the treatments and periods are significant. The treatments T_6 and T_1 gave the maximum shoot height. The maximum shoot height is noticed at the harvest period in all the treatments. The result indicates that N and P at recommended levels are required for the maintenance of optimum shoot growth through out the crop period. Thus, decreasing marginally the amount of applied potassium without changing the levels of N and P (T_6) does not significantly affect the shoot growth. In all other treatments, when more than one nutrient (T_2 and T_3), or a critical nutrient such as N or P (T_4 and T_5) has been decreased it leads to a decreased shoot length. Similar

Table-16

Number of branches of sweet potato at different stages of growth - Summer 1982

Treatment	Days 30	45	60	At harvest	Mean
T_1	6.7	8.7	10.6	11.2	9.21
T_2	6.3	7.9	10.4	10.6	8.8
T_3	6.0	7.8	9.5	10.2	8.3
T_4	6.5	8.2	10.3	10.8	8.9
T_5	6.6	8.4	10.4	10.9	9.0
T_6	6.8	8.5	10.4	11.0	9.1
Mean	6.4	8.2	10.2	10.7	

C.D. for Treatment = 0.234

C.D. for period = 0.510
(5% level)

Table-17

Number of branches of sweet potato at different stages of growth. Summer 1982

Treatment	Days				
	30	45	60	at harvest	Mean
T_1	6.4	8.3	9.8	10.3	8.7
T_2	5.8	7.5	8.9	9.6	7.9
T_3	5.7	7.5	8.8	9.5	7.9
T_4	6.1	7.9	8.2	9.7	8.0
T_5	6.2	7.9	9.3	9.8	8.3
T_6	6.3	8.1	10.1	9.7	8.5
Mean	6.1	7.9	9.2	9.8	

C.D. for treatment = 0.236

C.D. for per_od = 0.492

(5% level)

Table-18

Plant height in cm at successive stages of growth of Daincha - Summer 1981

Treatment	In days				
	30	45	60	At harvest	Mean
T_1	30.0	50.0	69.0	108.0	64.2
T_2	30.0	52.5	67.0	105.0	63.5
T_3	32.0	50.0	66.0	100.0	62.0
T_4	31.5	49.0	68.0	100.0	62.1
T_5	23.0	47.2	68.0	69.0	60.5
T_6	28.0	47.2	68.0	104.0	61.8
Mean	29.8	49.3	69.3	97.6	

C.D. for treatment = 0.620

C.D. for period = 0.360

(5% level)

Table-19

Plant height in cm at successive stages of growth of Daincha - Summer 1982

Treatment	In days				
	30	45	60	At harvest	Mean
T_1	32.5	53.2	74.5	120.0	70.0
T_2	30.2	50.2	72.0	110.0	65.6
T_3	29.0	49.0	71.5	108.0	64.3
T_4	31.4	51.0	72.8	115.0	67.3
T_5	32.1	51.8	73.4	117.2	68.4
T_6	33.0	52.2	73.5	117.5	69.0
Mean	31.3	51.2	72.9	114.6	

C.D. for treatment = 0.613

C.D. for period = 0.352

(5% level)

Table-20

Plant height in cm at successive stages of growth

(Pooled data Virippu 1981)

Sequences	Treatments						Periods in days					
	T_1	T_2	T_3	T_4	T_5	T_6	30 (C_1)	45 (C_2)	60 (C_3)	90 (C_4)	At harvest (C_5)	Mean A
A_1	67.830	66.560	65.930	67.180	67.680	68.030	54.400	63.533	71.603	74.516	71.941	67.210
A_2	65.[illegible]21	66.950	66.200	67.474	67.966	68.286	54.820	65.985	71.993	74.701	72.091	67.499
A_3	70.002	69.524	68.562	69.[illegible]16	69.898	70.028	54.976	67.008	7[illegible].965	77.060	73.338	69.570
A_4	72.[illegible]90	71.768	70.696	72.192	72.192	72.316	56.716	67.885	77.[illegible]25	80.053	77.185	71.893
A_5	72.690	71.858	70.388	72.522	72.522	72.452	56.31[illegible]	67.728	77.765	80.855	77.866	72.165

MEAN C

C_1	56.079	54.906	54.002	55.672	55.934	56.030
C_2	66.650	65.600	64.313	66.130	66.428	66.482
C_3	75.[illegible]24	74.730	75.520	74.3[illegible]8	75.078	75.334
C_4	77.690	77.292	76.166	77.568	77.832	78.070
C_5	75.240	74.232	73.570	74.590	74.976	75.140

TM_1	70.196	CM_1	55.445
TM_2	69.292	CM_2	66.018
TM_3	68.415	CM_3	74.752
TM_4	69.757	CM_4	77.437
TM_5	70.049	CM_5	74.624
TM_6	13[illegible]		

CD VALUES (5% level)

observations on the effectiveness of more than one nutrient in the maintenance of a high level of yield as well as yield contributing parameters have been worked by Mandal et al., (1976), Allen, 1976 and Prasad et al., (1982). The present observations are in agreement with these findings.

Tables 16 and 17 present the number of branches of sweet potato at different stages of growth for the summer 1981 and 1982. The data again bring out the need for balanced NPK fertilisation for maintenance of high number of branches for sweet potato plants.

Tables 18 and 19 present the plant height in cms. at successive stages of growth of daincha for summer 1981 and 1982. At the time of cultivation of summer daincha, no treatment had been given and therefore the observations made in 1981 on the intial daincha crop did not show the treatment effects. In 1982, the observed differences in the plant height have to be attributed to the previous virippu and mundakan crops, wherein differential treatments had been applied. It has been indicated in materials and methods that for the daincha crop, no manuring had been done and only the rice crops in the sequence had been fertilised.

Table-20 presents data on the height of rice plants (Jaya) in cm at successive stages of growth (pooled data) for the virippu 1981. The plant height in cm have been recorded from the 30th day at 15 day intervals till harvest. The results indicate that the sequence daincha-rice-rice (A5) and fallow-rice-rice (A6) recorded the highest mean plant height and were on par followed by the sequence pulse-rice-rice (A3). The sequence A5 and A3 are on par. The least plant height has been recorded for rice in summer (A1).

The combination between treatment and sequence reveals that among the sequences, the daincha-rice-rice gave the maximum height in all treatments followed by the sequence pulse-rice-rice, sweet potato-rice-rice and rice-rice-rice. However, in all the sequences the treatments have a significant effect on plant height. The treatments with the full recommended dose of fertilizer (T_1) and a fertilizer dose of full N and P with three-fourth of the recommended dose of K (T_6) recorded the maximum plant height. This was followed by T_1, T_4, T_5 and T_3. The least plant height was recorded on T_3 in all the sequences. However, the treatments T_1, T_6, T_2, T_4 and T_5 were on par.

In a nut-shell, it is worthy to note that the sequences commencing with a leguminous crop namely daincha (A4) or a pulse such as cowpea (A3) has been able to effectively raise or increase the mean height of rice plant in the subsequent virippu crop. This has happened both in the initial season of the virippu crop immediately after the starting of the season with summer daincha and the summer pulse crop. In 1982 virippu also, the plots with the previous history of the sequences of daincha-rice-rice and cowpea-rice-rice showed the same trend of results. It should be noted that for the sequence with daincha-rice-rice, no fertilisers had been added for the green manure crop either in 1981 or 1982. Fertilisers had been added only to the rice crop in the sequence. Due to the ploughing in of the green manure crop, a marked effect on soil fertility had been brought about as to register it on the height of the rice plants during the subsequent virippu season. It is also significant to note that the treatment T_1 and T_2 i.e. treatments with full recomended dose and three-fourths of the recomended dose recorded the maximum height in both the virippu season of 1981 and 1982. It has been observed that height of plants was maximum on the 90th day observation.

A similar observation on the effect of leguminous fodder crop or leguminous green manure crop like cowpea on the subsequent virippu season (kharif) crop has been

Table-21

Plant height in cm at successive stages of growth (Pooled data of rice)

Mundakan-1981

Sequences	Treatments T_1	T_2	T_3	T_4	T_5	T_6	Periods in days 30 (C_1)	45 (C_2)	60 (C_3)	75 (C_4)	At harvest (C_5)	Mean A (C_5)
A_1	67.640	67.410	65.550	66.820	67.620	67.700	54.050	64.458	71.333	74.141	71.583	67.123
A_2	68.030	66.590	65.950	67.550	67.640	68.130	54.566	63.708	71.750	74.541	72.116	67.316
A_3	69.830	69.110	68.040	69.550	69.680	69.730	54.775	66.741	71.691	76.833	73.575	6[illegible].323
A_4	72.040	71.520	70.300	71.390	71.980	72.030	56.491	67.675	77.458	79.791	77.133	7[illegible].710
A_5	72.460	71.640	70.630	72.320	72.320	72.230	56.158	67.583	77.566	80.650	77.708	71.933
C_1	55.790	54.690	53.760	55.370	55.630	55.840						
C_2	66.380	66.550	64.570	66.160	66.280	66.260						
C_3	75.040	74.130	73.570	74.700	74.830	75.050						
C_4	77.560	76.910	75.920	77.460	77.600	77.700						
C_5	72.230	73.940	73.160	74.440	74.300	74.970						

TM_1	70.000	CM_1	55.188
TM_2	69.254	CM_2	66.033
TM_3	68.196	CM_3	74.570
TM_4	69.626	CM_4	77.191
TM_5	69.348	CM_5	74.423
TM_6	73.60		

CD Values (5% level)

[illegible] 0 [illegible]797[illegible]1   CD-$\overline{T}$ = 0.[illegible]215424   CD-C = 0.2178931   CD-A$\overline{T}$ – 0.7135[illegible]5 observed by Sadayappan and Kothandaswamy (1974) and Pillai *et al*., (1976) in situations outside Kerala and Sushamakumari (1981) and Surendran (1985) inside Kerala.

Table-21 presents the data on the plant height in cm at successive stages of growth (pooled data) of paddy during Rabi (Mundakan) 1981. The results indicate that in sequences, periods and treatments are significant.

The sequence which commences with daincha in summer (A4) and fallow in the summer (A6) recorded the highest mean plant height and were on par. This was followed by the sequence pulse-rice-rice (A3). The sequence sweet potato rice-rice (A2) and the sequence rice-rice-rice (A1) recorded lowest plant height. The treatment of full dose as per package of practices (T_1) recorded the highest plant height. However, the next best has been observed for full dose of N and P as per Package and 3/4 K (T_6) and full dose of N and K as per package and 3/4 P (T_5). In all, the sequences the lowest plant height is recorded by T_3, wherein all major nutrients N, P and K have been applied only at half the recommended dose.

The combination of period of observation of plant height (C) with sequence indicates that the maximum height of plant have been recorded at 90 days. The maximum plant height was noted in the sequence (A_5) fallow in summer, followed by dainicha (A_4) in summer and pulse (A_3) in summer. The least plant height in Mundakan was observed in the sequence rice-rice-rice.

The present observation of enhanced height of rice plant in the Mundakan season of 1981 in the sequence daincha rice-rice-rice and pulse clearly brings out the importance of nitrogen fixation by a leguminous crop, be it a green manure or a pulse crop. Small additions of nitrogen to soil through excretion of ammonia and amino acids from the root of leguminous crop and substantial addition through the ploughing under of the entire crop at flowering stage as in sequence A_4 or the partial addition of haulms and the root stubbles from the pulse crop as in sequence (A_5) have, it appears, made significant contributions in enhancing the performance of the subsequent rice crop in the mundakan season. This performance of the plant is optimised in the treatment with the full dose of fertilizers NPK or full dose of N and K with 3/4 P or full dose of N and P with 3/4 K. It may be noted that the marginal additions of nitrogen as in T_1, T_5 and T_6 alone were able to maintain the maximum height of plant. These results are in agreement with the findings of Sasidhar and Sadanandan (1980), Rethinam *et al.*, (1975) and Tewari and Thakur (1976).

Table-22

Plant height in cm at successive stages of growth of rice - Virippu 1982

Sequences	Treatments						Periods in days					
	T_1	T_2	T_3	T_4	T_5	T_6	30 (C_1)	45 (C_2)	60 (C_3)	75 (C_4)	At harvest (C_5)	Mean A (C_6)
A_1	67.[illegible]90	66.110	65.320	66.730	67.100	67.400	53.916	63.283	71.016	73.866	71.300	66.676
A_2	67.880	66.410	65.770	67.320	67.420	67.270	53.706	63.466	71.575	74.350	71.900	67.011
A_3	69.650	68.980	67.900	69.510	69.480	69.490	54.608	66.475	74.550	76.641	73.400	69.[illegible]35
A_4	71.550	71.250	70.250	71.460	71.760	71.660	56.233	67.433	76.966	79.233	76.741	71.321
A_5	72.240	71.330	70.360	71.720	72.100	72.230	55.916	67.441	77.291	80.350	77.316	71.663
A												
C_1	55.580	54.580	53.600	55.170	55.340	55.060	54.890					
C_2	66.250	65.130	64.370	65.710	6[illegible]050	66.210	65.600					
C_3	74.800	73.900	73.050	74.460	74.600	74.870	74.280					
C_4	77.350	76.800	75.[illegible]	77.020	77.270	77.230	76.870					
C_5	74.830	73.670	72.920	74.180	74.510	74.680	74.130					

TM_1	60.762	CM_1	54.868
TM_2	68.816	CM_2	65.620
TM_3	67.920	CM_3	74.280
TM_4	69.307	CM_4	76.888
TM_5	69.554	CM_5	74.131
Tm6	70.4		

CD Values (5% level)

CD-A - 0.230315 CD C = 0.2089957 CD [illegible]

17027

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Table-23

Plant height at successive stages of growth in cm (Pooled data)

Mundakan 1982

Sequences	Treatments						Period in days					
	T_1	T_2	T_3	T_4	T_5	T_6	30 (C_1)	45 (C_2)	60 (C_3)	75 (C_4)	At harvest (C_5)	Mean A (C_o)
A_1	67.660	66.290	65.410	66.940	67.420	67.500	54.133	63.316	71.383	74.266	71.250	66.870
A_2	67.680	65.570	64.410	56.430	69.882	69.882	53.405	63.033	70.506	72.668	69.923	66.907
A_3	70.994	70.066	68.346	70.682	70.928	70.928	55.510	67.321	75.796	77.798	75.013	70.388
A_4	70.990	69.696	68.748	70.732	70.920	70.920	56.055	67.020	74.226	78.123	75.393	70.264
A_5	70.790	68.918	69.116	68.560	70.734	70.734	54.631	55.236	74.108	78.345	75.758	69.726
C_1	55.436	54.266	53.382	54.903	55.264	55.286						
C_2	66.964	64.634	64.136	66.366	66.702	68.912						
C_3	74.192	72.822	71.980	73.660	72.044	74.528						
C_4	77.070	75.768	74.968	76.378	76.808	77.056						
C_5	74.452	73.050	72.064	73.530	74.123	74.132						

TM_1	69.628	CM_1	54.757
TM_2	68.108	CM_2	66.235
TM_3	67.306	CM_3	73.204
TM_4	68.963	CM_4	76.341
TM_5	68.989	CM_5	73.567
TM_6	72.4		

CD Values (5% level)

CD-A = 0.9043653 CD-B = 0.5982281 CD-C = 0.4165285 CD-AT = 1.37779 CD AC = 0.931366

Table 2? presents data on the mean plant height in cm at successive stages of growth of rice virippu 1982. The results indicate that the sequences, treatments and periods are significant. The sequences fallow-rice-rice gave the maximum plant height for virippu rice followed by the sequence daincha-rice-rice (A4) and pulse rice-rice (A3). All these three sequences are on par. The sequence rice-rice-rice (A_) recorded the lowest plant height.

The combination between treatment and sequence reveals that for all the sequences the maximum plant height has been recorded by the highest dose of fertilisers. In all, the sequences the treatments T_1 and T_6 gave the maximum height and were on par followed by T_5, T_4 and T_2. The least plant height has been recorded by treatment T_3 in all the sequences.

The combination of period of observation of plant height with sequence indicates invariably that in all sequences the maximum height was noted at 90 days.

Table-23 presents data on the mean plant height in successive stages of growth of rice during mundakan 1982. The result indicates that the sequences daincha-rice-rice (A4) and pulse-rice-rice (A3) are the best. They were on par and next in order comes the sequence fallow-rice-rice (A5). The sequences A3, aA4 and A5 were on par. The least plant height is noticed in the sequence A1 (rice-rice-rice).

Table-24

Number of tillers m^{-2} at successive stages of growth
(Pooled data Virippu 1981)

Sequences	Treatments T_1	T_2	T_3	T_4	T_5	T_6	Periods in days 30 (C_1)	45 (C_2)	60 (C_3)	75 (C_4)	At harvest (C_5)	Mean A
A_1	507.000	481.000	433.600	467.800	486.000	496.000	517.333	580.333	530.333	456.666	308.333	478.900
A_2	525.800	459.400	438.000	487.000	486.500	504.000	525.916	586.333	534.166	456.666	315.333	4[illegible].788
A_3	563.000	520.500	491.500	538.400	554.900	567.500	535.000	632.500	636.083	492.916	350.000	5[illegible]9.300
A_4	594.900	538.800	517.600	543.600	568.000	573.600	610.000	648.333	652.500	514.000	355.583	556.083
A_5	590.000	530.000	515.400	543.000	568.600	572.000	606.500	631.333	648.333	525.333	353.333	553.166
C_1	594.000	554.400	530.900	570.600	578.500	585.300						
C_2	656.000	596.000	574.600	602.600	626.600	640.000						
C_3	634.300	583.000	559.600	593.700	607.900	621.000						
C_4	535.400	474.500	433.000	478.000	504.000	510.400						
C_5	360.500	321.300	298.000	355.600	349.000	355.400						

TM_1	556.140	CM_1	568.950
TM_2	505.940	CM_2	615.966
TM_3	479.220	CM_3	600.383
TM_4	515.960	CM_4	489.216
TM_5	533.200	CM_5	336.716
Tm6	5610		

CD Values (5% level)

CD-A = 15.370099 CD-B = 6.257386 CD-C = 3.455022 CD-AB = 13.99183 CD-AC = 7.725663

The combination between treatment and sequence reveals that, the sequence pulse-rice-rice (A3) and daincha-rice-rice (A4) recorded the maximum plant height for Mundakan rice followed by the sequence fallow in summer (A5). These three sequences were on par, recording the maximum plant height at full dose of fertilisers (T_1), followed by T_6, T_5 and T_4. These treatments T_6, T_5 and T_4 were on par with T_1 in sequences daincha-rice-rice (A4) fallow-rice-rice (A5) and pulse-rice-rice (A3). In all, the sequences the lowest plant height recorded was in treatment T_3 where fertiliser had been applied at half the recommended doses.

The combination of period of observation with sequence indicates that invariably in all the sequences the maximum plant height is recorded at 90 days.

The trends observed in virippu and mundakan 1982 are similar to those of the corresponding seasons in 1981. The earlier inferences on the contribution of a summer leguminous crop in enhancing the performance of the rice crop in the subsequent seasons of the sequence have been strengthened by the present observation during the virippu and mundakan seasons of 1982.

Table 24 presents the data on the mean number of tillers in the rice crop for the virippu season of 1981. The results indicate that the sequence daincha-rice-rice

Table-25

Number of tillers at successive stages of growth m^{-2}

(Pooled data) Viripu rice 1982

Sequences	Treatments T_1	T_2	T_3	T_4	T_5	T_6	Periods in days 30 (C_1)	45 (C_2)	60 (C_3)	75 (C_4)	At harvest (C_5)	Mean A (C_6)
A_1	482.200	428.200	400.000	446.400	450.000	477.600	490.333	532.833	495.500	422.333	295.500	447.400
A_2	467.000	431.600	410.200	446.400	452.300	465.800	438.166	535.333	502.333	421.666	280.666	445.633
A_3	494.600	463.600	430.600	478.200	439.600	493.200	503.333	550.000	527.666	472.333	321.000	474.966
A_4	544.800	509.600	492.600	513.200	565.200	534.200	570.333	617.000	574.333	496.166	373.666	526.600
A_5	536.200	508.400	496.200	515.300	525.200	534.200	571.500	610.166	579.500	496.166	336.333	519.333
C_1	544.400	515.600	498.300	520.800	534.200	539.400						
C_2	588.400	557.300	536.600	572.000	567.000	592.600						
C_3	562.600	526.400	495.600	534.600	542.200	553.300						
C_4	493.800	437.200	417.000	458.300	477.400	433.000						
C_5	335.600	304.400	281.600	313.300	362.000	331.200						

CD Values (5% level)

CD-A = 3.205449 CD-$\bar{B}$ = 2.790267 CD-C = 2.8061 CD-A$\bar{B}$ = 6.239227 CD-AC = 6.274629 as a green manure crop in summer (A5) and fallow in the summer season (A6) recorded the highest mean tiller number and were on par. The sequences sweet potato-rice-rice (A2) and rice-rice-rice (A1) were on par and recorded the maximum tiller number. The sequence pulses-rice-rice (A3) occupied an intermediary status.

The combination between treatment and sequence reveals that for all the sequences except those commencing with pulse (A3), the maximum tiller numbers have been recorded by the highest dose ie. full dose as per package of practices. However, for all the sequences, the next best is the treatment with a fertiliser schedule of N and P as per package of practice and 3/4 K (T_6) and the dose N and K as per package of practices and 3/4 P (T_5). In all the sequences, the lowest tiller number is recorded by T_3, wherein all the major nutrients N, P and K have been applied at 50 per cent of the recommended level.

Table-25 presents the data on the mean number of tillers per m^2 at successive stages of growth for the virippu paddy 1982. The tiller numbers have been recorded at different periods of intervals. The results indicate that the sequences, treatments and periods are significant. The sequences Daincha-rice-rice (A4) and fallow-rice-rice

Table-26

Mean Tillers/m^{-2} at successive stages of growth of rice

(Pooled data) Mundakan 1931

Sequ-ences	Treatments						Periods in days					
	T_1	T_2	T_3	T_4	T_5	T_6	30 (C_1)	45 (C_2)	60 (C_3)	75 (C_4)	At harvest (C_5)	Mean A
A_1	506.400	458.300	430.200	464.400	580.400	506.600	515.500	579.500	527.666	437.666	311.333	474.333
A_2	520.000	452.000	436.300	479.000	488.200	500.200	522.000	577.000	533.333	451.166	313.333	499.366
A_3	583.200	516.000	492.300	534.500	550.300	575.000	599.333	628.500	650.000	505.000	347.666	542.100
A_4	581.300	538.000	513.300	519.000	563.300	570.200	598.3 3	652.333	647.333	509.500	335.416	552.633
A_5	559.500	525.400	511.000	539.400	564.200	568.200	603.[illegible]66	627.333	642.000	552.333	349.666	548.900
C_1	602.000	551.200	527.000	569.000	573.400	583.400						
C_2	651.000	593.400	569.300	606.200	619.000	638.300						
C_3	629.800	576.300	553.400	589.000	607.200	620.200						
C_4	33.800	440.300	433.000	468 400	500.300	520.000						
C_5	35 .500	318.200	296.400	334.000	317.000	357.000						

TM_1	555.220	CM_1	567.666
TM_2	497.880	CM_2	615.033
TM_3	76.920	CM_3	596.066
TM_4	513.520	CM_4	435.133
TM_5	529.180	CM_5	335.433
TM_6 535.5			

CD Values [illegible]

CD-A = 3 724395 CD-B = 2.261626 CD-C = 1.30673 CD-AB = 5.05715 CD-AC = 4 034972

(A5) recorded the highest mean tiller number and were on par. The sequence sweet potato-rice-rice (A2) and rice-rice-rice (A1) were on par.

The combination between the treatment and sequence reveals that the sequence daincha-rice-rice (A4) and fallow-rice-rice (A5) gave maximum tiller number for virippu of 1982, followed by the pulse sequence (A3). All these sequences gave higher tiller numbers at T_1 and T_6 and were on par. The lowest tiller number has been recorded for the T_3 treatment wherein the nutrients N, P and K have been applied at 50 per cent of the recommended rates.

Table 26 presents the mean value of tiller numbers per m^2 at successive stages of growth for the rice crop of mundakan 1981 at five periods of observation, for six treatments and five sequences. From the results and critical difference worked out, it is found that the sequence daincha-rice-rice (A4) and fallow-rice-rice (A5) recorded the highest mean tiller number and are statistically on par while the lowest is recorded by the sequence-rice-rice-rice(A1) in both virippu and mundakan.

The lowest tiller numbers are observed in the lowest fertiliser doses viz. T_3 and T_2. The highest mean tiller numbers have been obtained for the sequences A5 and A4 for

Table-27

Number of tillers at successive stages of growth m^{-2} (Pooled data) of rice Mundakan 1982

Sequences	Treatments T_1	T_2	T_3	T_4	T_5	T_6	Periods in days 30 (C_1)	45 (C_2)	60 (C_3)	75 (C_4)	At harvest (C_5)	Mean
A_1	[illegible]5 000	[illegible]000	[illegible]5 000	51.000	[illegible] 300	50.000	49[illegible]	[illegible]	51[illegible] 100	501 [illegible]60	[illegible]25.000	296.156	[illegible]52 9[illegible]
A_2	163.670	4[illegible]3.000	[illegible].000	50.400	[illegible].400	69 00	492 [illegible]3	5[illegible]4.500	506.333	429 166	283 3[illegible]	[illegible]1.233
A_3	477.200	46[illegible].000	455 000	52.000	[illegible].200	[illegible].300	490 [illegible]	555.000	531.000	7[illegible].166	32[illegible]	4[illegible].300
A_4	547 000	517.000	[illegible].000	523.000	[illegible] 000	538 600	57[illegible]	[illegible]0.000	571.166	498.333	375.[illegible]	529 600
A_5	[illegible]10.000	511.000	456.000	521.000	[illegible]0.100	535.300	57[illegible]	[illegible]4.166	571.000	[illegible]99.500	339 166	521.033
C_1	578.200	522.000	502.000	532.400	5[illegible]8.300	54[illegible].400						
C_2	592 400	560.000	51[illegible] 000	576.000	557.600	596 [illegible]						
C_3	561 700	526 000	[illegible]9.000	[illegible] 000	[illegible] 7.400	558 400						
C_4	[illegible]96.000	[illegible]7.000	416 000	464.000	[illegible].000	[illegible]89.500						
C_5	336 [illegible]00	30[illegible] 000	23[illegible] 000	[illegible]6.000	[illegible]5.000	3[illegible].400						

T_1	503 56	C_1	5[illegible]7.80
T_2	[illegible]72[illegible]	CM_2	575.70
T_3	446.60	CM_3	55[illegible] 4[illegible]
T_4	435 [illegible]3	CM_4	[illegible]6[illegible] 63
T_5	504.15	CM_5	3[illegible]3.6[illegible]
T_{m6}	523 60		

CD Values

CD-A = 2.58[illegible] 15 CD-B = 2 [illegible]67[illegible] CD-C = 1.9[illegible]4[illegible]67 CD-AB = [illegible] 979916 CD-AC = 4.25[illegible]639 the full dose of N and P with 3/4 K (T_6) while in the sequence A1 the highest tiller number is recorded for the full dose of N and K and 3/4 P. The sequence A3 and A4 have recorded the highest tiller number only with highest dose of fertiliser. However, in these cases the treatment T_6 with full dose of N and P and 3/4 K gave a mean tiller number which is on par. The lowest tiller number is recorded invariably by the lowest fertiliser dose in respect of the sequences.

Invariably, the highest tiller number has been recorded in all the treatments at 45 days interval.

In both the virippu and mundakan crop 1981, the best sequences are A4 and A5. The best treatments are T_1, T_5 and T_6. The sequence pulse-rice-rice (A3) immediately follows A4 and A5. The results on tiller numbers indicate the trend in the performance of the rice crop in terms of yield for the virippu and mundakan seasons. The cropping sequence studies conducted elsewhere by other workers such as Verma et al., (1987) and De Datta and Surjith (1981) confirm the present findings.

Table-27 presents data on the mean tillers at successive stages of growth of paddy (Pooled data) Jaya during the mundakan season of 1982. The result shows that the treatments, periods and the sequences and all significant. Among the sequences, daincha-rice-rice (A_4) produced the maximum tiller number, followed by the sequence fallow-rice-rice (A_5) and pulse-rice-rice (A_3). However, statistically these sequences are on par. The rice-rice-rice (A_1) sequence has the lowest mean tiller numbers.

The combination treatment and sequences show that the treatments T_1 and T_6 gave the maximum tiller number for sequences fallow-rice-rice (A_5), followed by daincha-rice-rice (A_4) and pulse-rice-rice (A_3). All the above sequences are on par at T_1 and T_6.

The combination of period of observation with sequence indicates that the highest number of tillers have been obtained at 45 days in all these sequences.

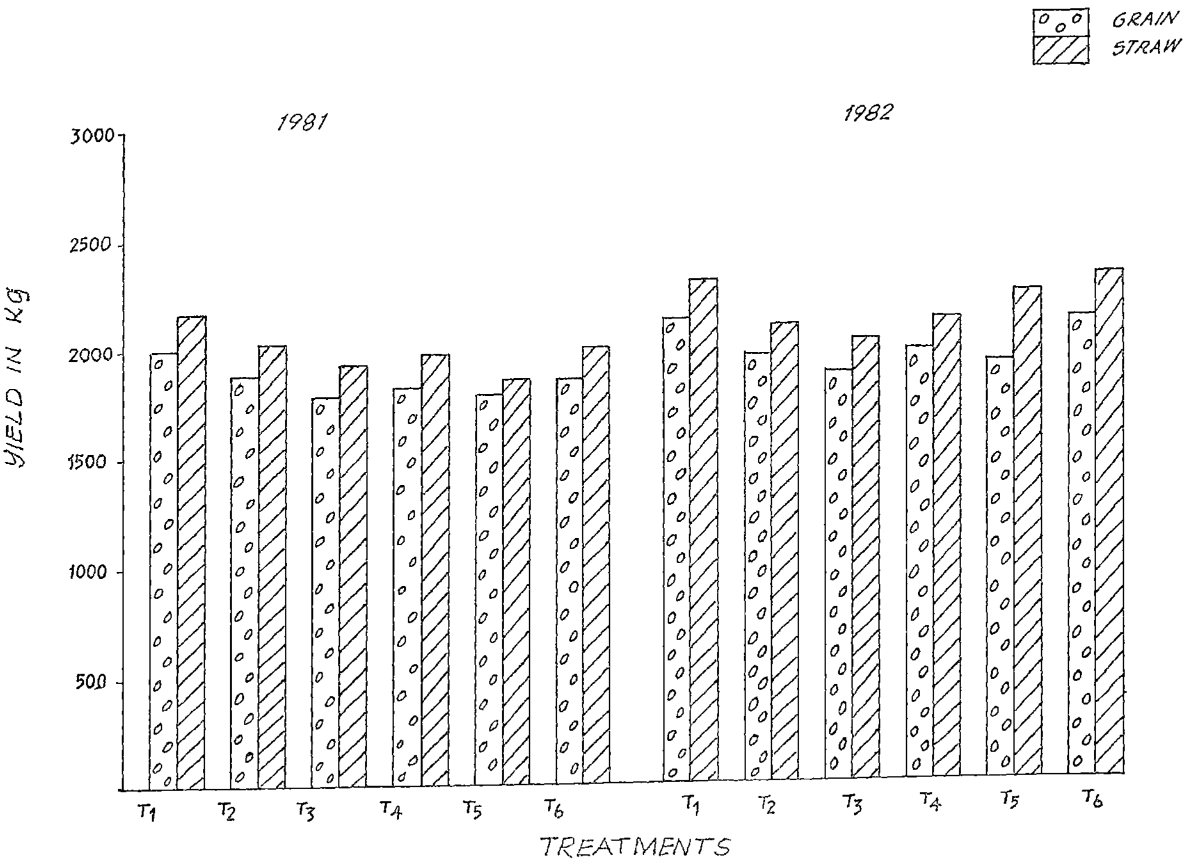
The result on average tiller number for the virippu and mundakan season 1982 also reveals that the sequences daincha-rice-rice and fallow-rice-rice the maximum effective tiller numbers. The fertiliser combinations producing the highest effective tiller numbers are T_1 ie. recommended dose of fertiliser for every crop in the sequence, followed by the treatment T_6 with the full recommended dose of N and P with 3/4 of K. These results on tiller numbers are fairly in agreement with earlier results of the virippu and

Table-28

Yield in Kg ha^{-1} Rice - Summer 1981			Yield in Kg ha^{-1} Rice Summer 1982		
Treatment	Grain	Straw	Treatment	Grain	Straw
T_1	1998.0	2155.0	T_1	2126.2	2296.3
T_2	1873.0	2026.3	T_2	1940.6	2095.8
T_3	1771.8	1906.8	T_3	1873.1	2022.9
T_4	1839.3	1987.0	T_4	1974.3	2132.3
T_5	1771.8	1863.0	T_5	1932.1	2241.6
T_6	1856.2	2014.8	T_6	2126.0	2295.0
CD : Teatment = (5% level)	64.8	88.3	CD: T =	95.3	95.3

FIG 5

FIG YIELD IN kg ha^{-1} - SUMMER RICE



mundakan season of 1981 and also the height of plants recorded for these seasons. Thus, the major yield contributing factors for grain and straw of the rice crop are optimised in the sequence daincha-rice-rice (A4). This is closely followed by pulse-rice-rice (A3). Results similar to the present study on yield contributing factors of rice as affected by the sequence in a multiple cropping system have been recorded by earlier workers such as Sharma et al., (1986), Verma et al., (1987) and Yadav and Singh (1986). The results of the present study are thus in full agreement with those of earlier workers.

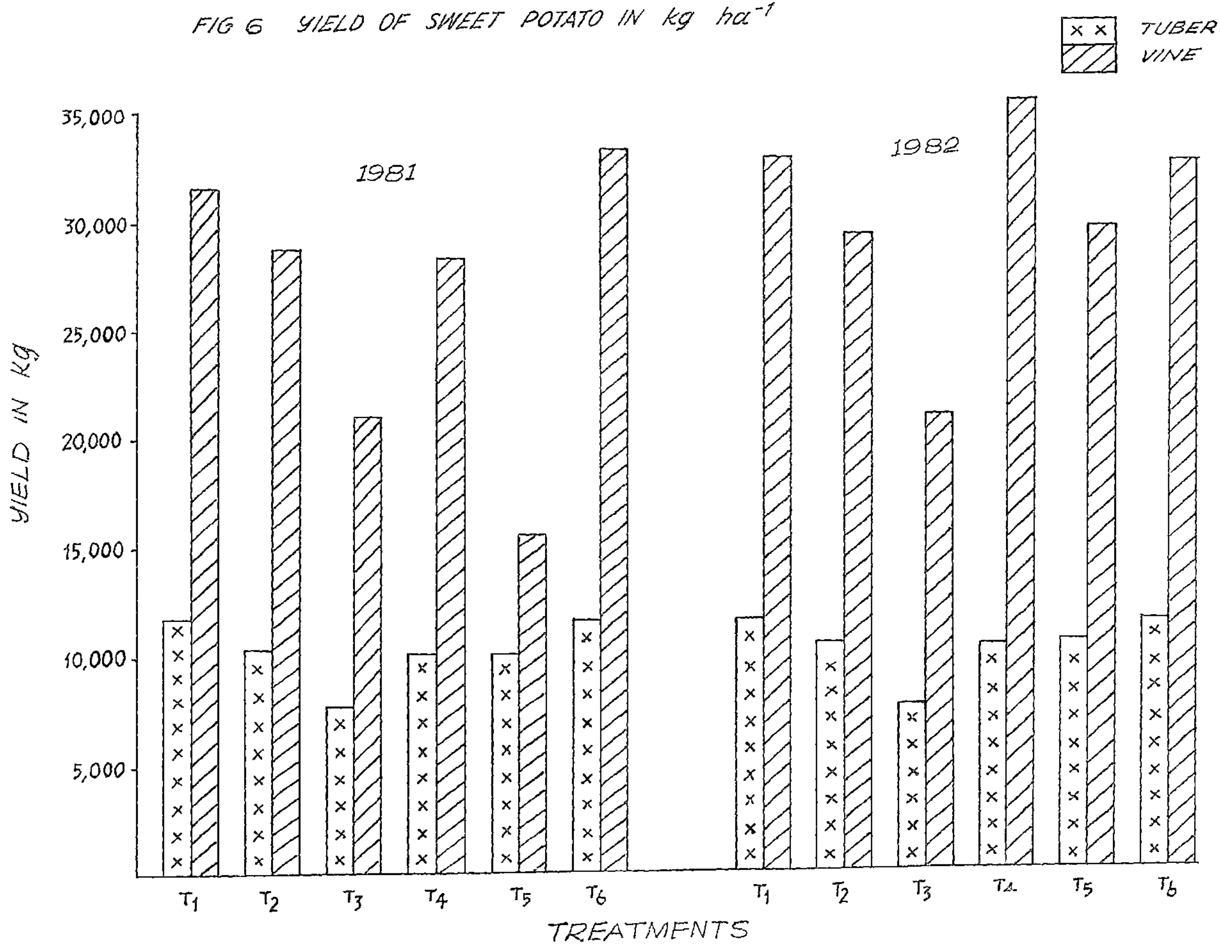
In the present study, all the sequences commenced in the summer season as already explained under materials and methods. In view of this, the yield of various summer crops namely rice-sweet potato, cowpea and daincha are initially presented in Tables 28 to 31 and discussed.

Tables 28 and Fig. 5 present the yield of grain and straw in Kg ha^{-1} for summer rice in 1981 and 1982. The results indicate that the treatments are significant. The highest yield of grain has been obtained for treatments T_1 and T_6, followed by T_2 and T_4.

Table-29

Yield in Kg ha^{-1} Sweet potato Summer 1981			Yield in Kg ha^{-1} Sweet potato Summer 1982		
Treatment	Tuber	Vine	Treatment	Tuber	Vince
T_1	11880	3[illegible]142	T_1	11718	32810
T_2	10260	28728	T_2	10462	29295
T_3	7509	21026	T_3	7492	20979
T_4	10125	28350	T_4	10378	356602
T_5	10040	15568	T_5	10479	29295
T_6	1[illegible]812	330751	T_6	11670	32676
CD T = (5% level)	479.7	CD T=1502.3		CD=601.456	CD T = 1662.256

FIG 6 YIELD OF SWEET POTATO IN kg ha^{-1}



In the case of straw yield also, significant differences in yield have been noticed. T_1 gives the highest yield followed by T_6.

In 1982 summer rice crop again treatments T_1 and T_6 gave the highest yield of grain as well as of straw.

The above results clearly indicate that the full recommended doses of N, P and K as in T_1 are required to get the maximum yield. The treatment where in K level had been decreased to 3/4 or 75 percent of the recommended levels performs equally well. The variety Triveni has been cultivated for the summer season.

Table-29 and Fig. 6 present the yield data in Kg ha^{-1} of the summer crop of sweet potato for the year 1981 and 1982.

The treatments are significant both in tuber and vine yields for 1981 and 1982. The treatments T_1 and T_6 have higher yields of sweet potato tuber and vine.

The result shows that N K fertilisation at recommended level is absolutely essential for maintaining yields in all other treatments wherein NPK levels, N levels alone or K levels alone had been applied at less than the recommended doses the yield had been decreased. These results indicate that for a crop like sweet potato with a high

Table-30

Yield in $Kg\,ha^{-1}$ of Cowpea Summer 1981				Yield in $Kg\,ha^{-1}$ of Cowpea Summer 1982			
Treatment	Grain	Husk	Haulm	Treatment	Grain	Husk	Haulm
T_1	799.8	319.9	4455	T_1	826.8	330.7	4604.1
T_2	681.7	272.7	3773	T_2	767.8	307.1	4276.8
T_3	662.1	264.6	3700	T_3	700.3	280.1	3900.4
T_4	695.2	278.7	3874	T_4	749.2	310.5	4173.1
T_5	786.3	314.5	4421	T_5	793.9	325.3	4483.3
T_6	789.7	315.2	4401	T_6	816.7	326.3	4546.1
CD = II = 31.4				CD = I = 26.3		19.8	147.9

FIG. 7a YIELD OF COWPEA kg ha⁻¹ SUMMER 1981

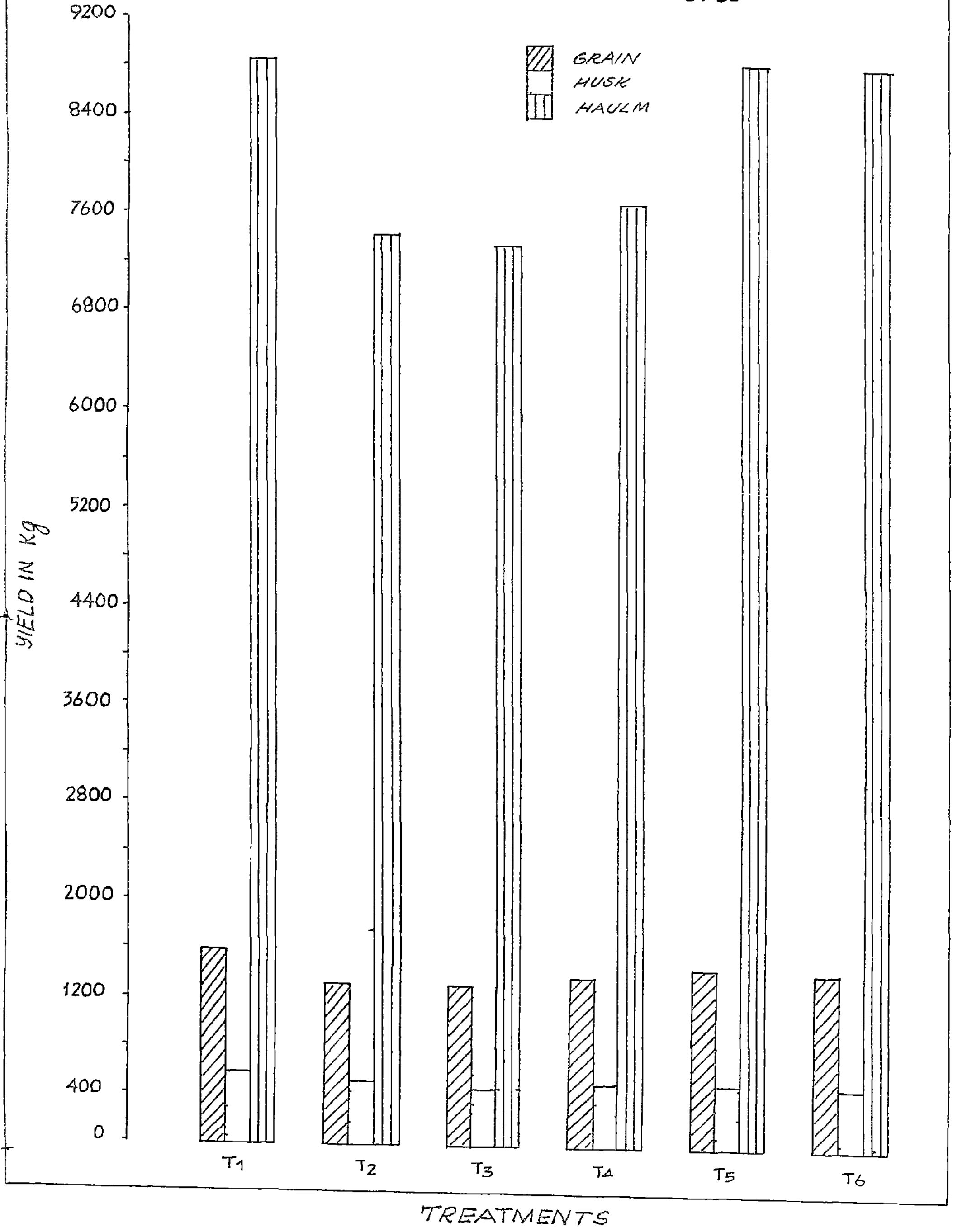
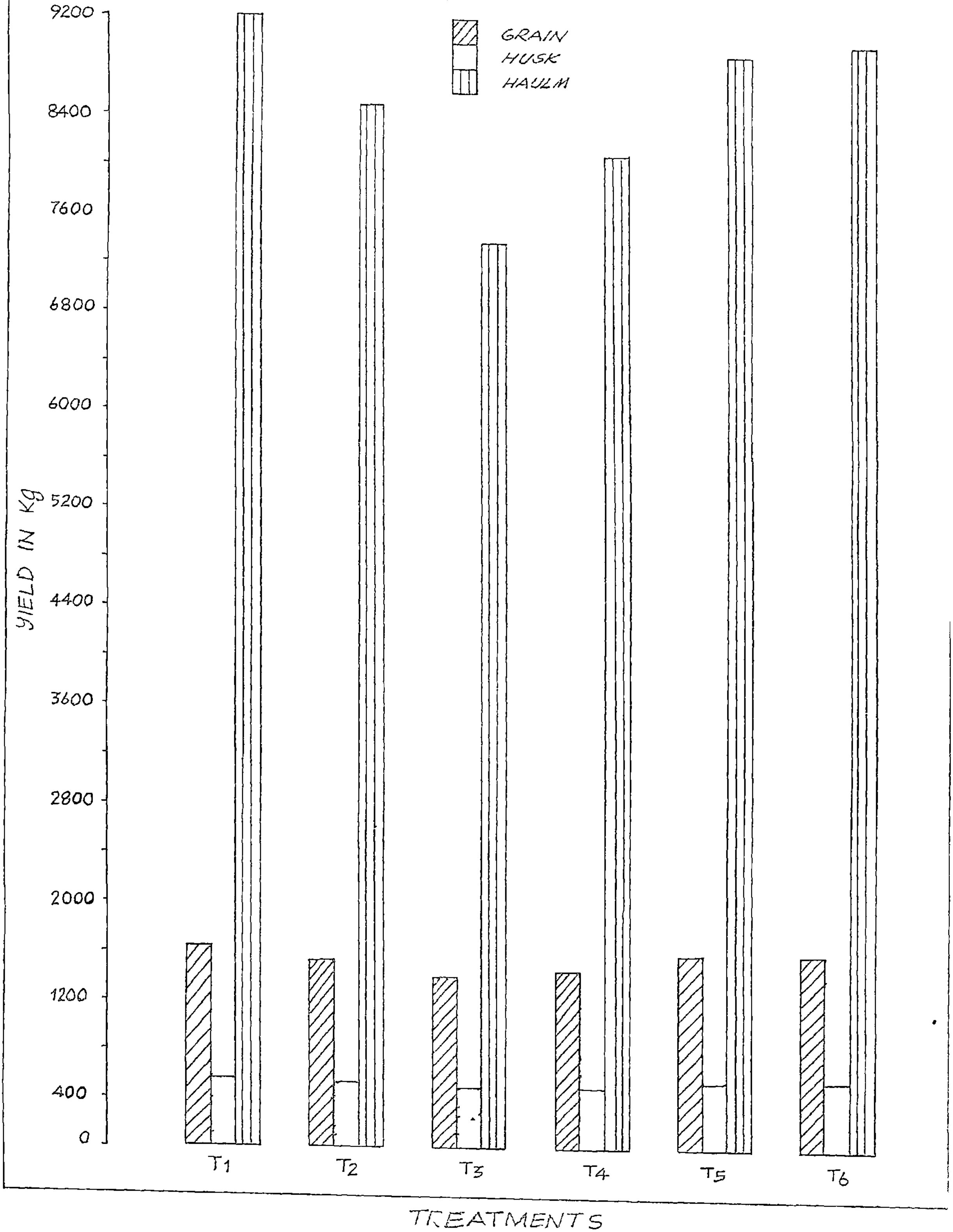


FIG 7b YIELD OF COWPEA kg ha⁻¹ SUMMER 1982



per day photosynthetic rate, the importance of N K ferti-lisation cannot be minimised. The views on similar lines have been observed by Kabeerathumma and Mohankumar (1986).

Table-30 and Fig. 7 present data on the yield in Kg ha^{-1} of the cowpea crop for the year 1981 and 1982.

The results show that treatments are significant. The treatment T[illegible] gave the highest yield of pulse grain; husk and haulm both during 1981 and 1982.

This trend in yield indicates that neither P or K can be decreased from the recommended levels nor can it be dispensed with. Part of the initial marginal dose of nitrogen recommended and applied for the pulse crop and possibly the major quantity of unutilised P and K applied gives rise to a significant residual effect which is carried forward to the subsequent Virippu paddy crop. The aerobic conditions prevailing in summer leads to greater and gradual solubilisation of phosphates applied and during the subsequent reducing conditions consequent to water-logging leads to an increased availability of phosphates. This naturally leads to enhanced availability and utilisation of phosphates. The P, K fertilisation as well as

Table-31

Yield in Kg ha^{-1} daincha Summer 1981		Yield in Kg ha^{-1} daincha Summer 1982	
T_1	11407.5	T_1	11981.2
T_2	11812.5	T_2	11738.2
T_3	11411.2	T_3	11053.1
T_4	12116.2	T_4	11880.0
T_5	11542.5	T_5	11441.2
T_6	11610.0	T_6	12403.1
	NS		NS

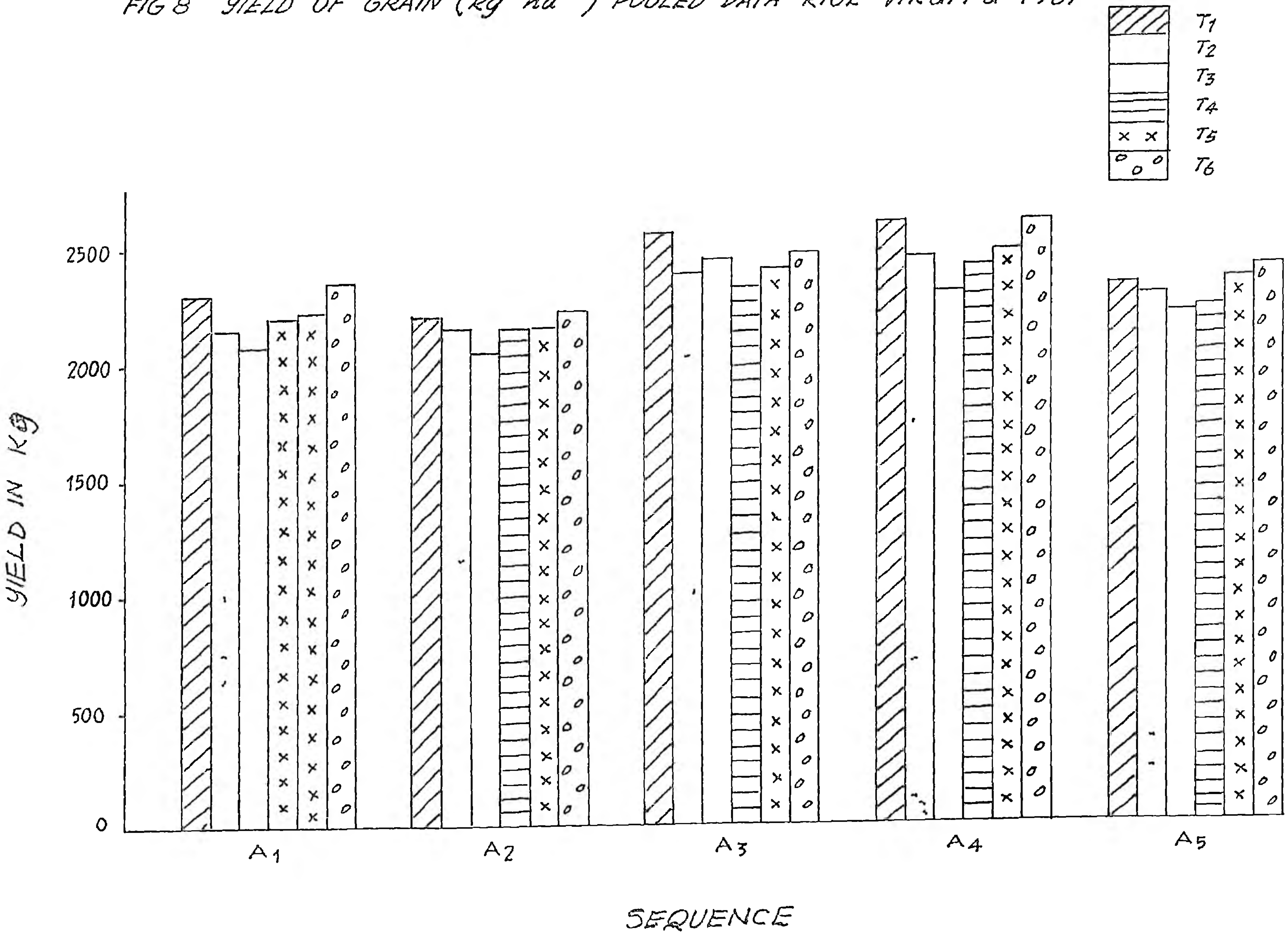
Table-32

[illegible] yield in kg ha^{-1} (pooled data) for the Rice variety Jaya - Virippu 1981

Sequences	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
A1	2288.2	2193.7	2058.7	2210.6	2224.1	2278.1	2208.9
A2	2217.8	2153.2	2082.3	2153.2	2153.2	2217.3	2162.8
A3	2511.0	2379.3	2453.2	2295.0	2362.5	2480.6	2413.6
A4	2571.7	2490.7	2369.2	2419.6	2497.5	2551.5	2483.4
A5	2355.1	2295.0	2234.2	2264.6	2311.8	2389.5	2308.5

CD for A = 108.7493

FIG 8 YIELD OF GRAIN (kg ha^{-1}) POOLED DATA - RICE VIRUPPU 1981



initial boost of N is essential for the pulse crop and has been observed earlier by workers like Ebong (1965) and Vinodkumar *et al.*, (1985). The present findings only reaffirm the need for maintaining the recommended dose of fertilisation for pulse crop in the sequence.

Table-31 presents the yield in kg ha^{-1} of the green manure daincha for the year 1981 and 1982. The results show that there have been no significant difference in yield between treatments both for the years 1981 and 1982 This is mainly because of the fact that no differences in fertility had been created for the initial summer crop of 1981. However, due to the differences in the fertility treatments due to the operation of the virippu and mundakan rice crops of 1981-82 by 1982 summer, moderate differences in fertility levels of the soils of the various plots cropped to daincha could have occurred. However, this had not been expressed in the yield of daincha in a significant manner.

Table-32 and Fig. 8 present the yield in kg ha^{-1} (pooled data) for the virippu rice crop variety Jaya 1981. The result shows that the treatments had no significant effect on yield of grain. The sequence daincha-rice-rice (A4) recorded the highest grain yield, followed by the sequence

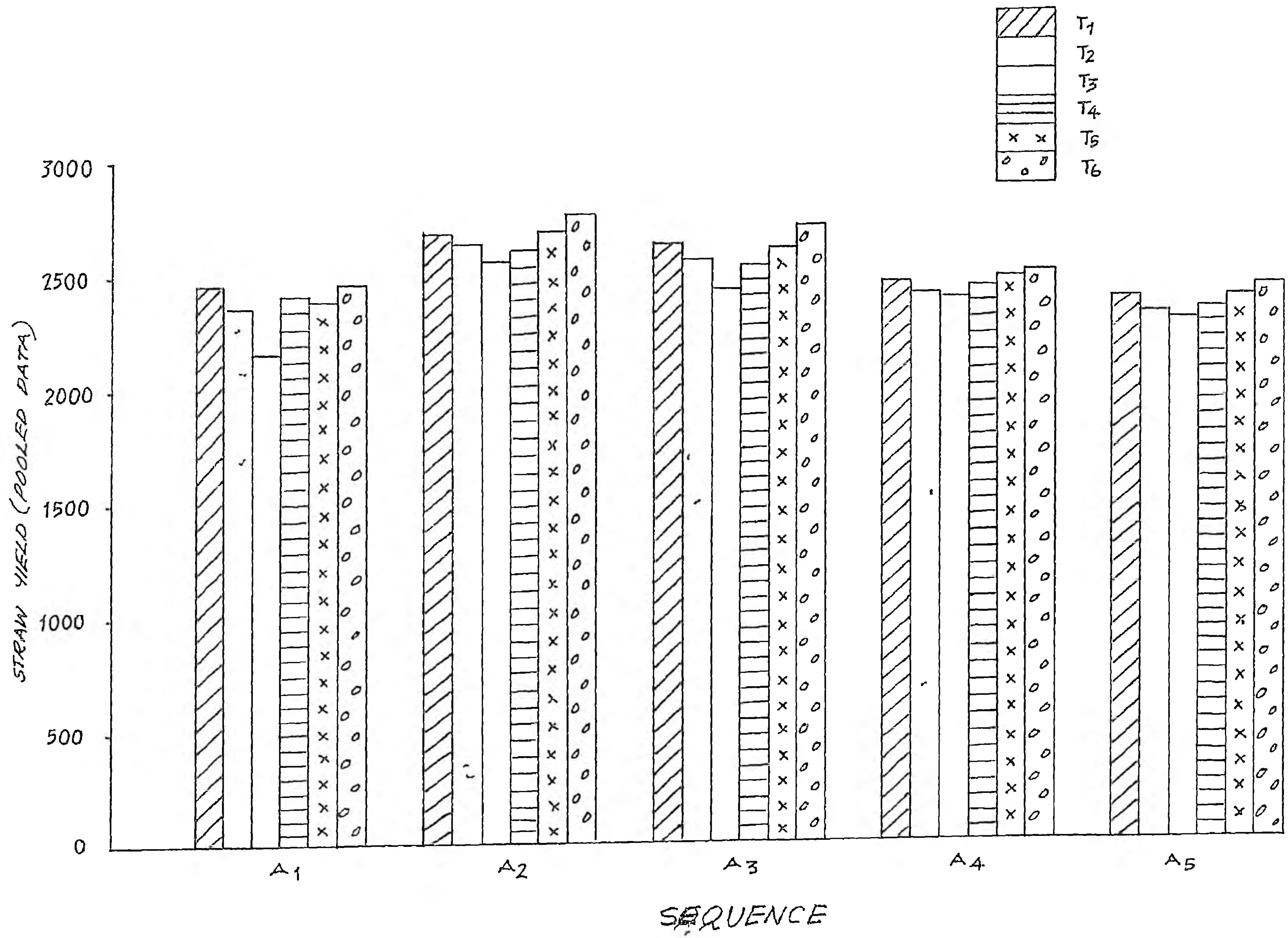
Table-35

[illegible]r yield in kgha^{-1} (pooled data) for variety Jaya - Virippu 1981

Sequ-ences	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
A1	2471.1	2369.2	2223.4	2387.4	2401.9	2460.3	2385.6
A2	2394.5	2205.2	2155.0	2325.0	2325.2	2394.9	2300.0
A3	2711.8	2569.7	2325.3	2356.7	2551.5	2679.0	2532.5
A4	2777.2	2589.8	2558.2	2613.2	2697.0	2755.2	2681.8
A5	2544.0	2477.2	2412.7	2478.6	2496.8	2579.8	2498.2

CD for A T = 584.9

FIG 9 YIELD OF STRAW (kg ha⁻¹) POOLED DATA RICE(JAYA) WRIPPU 1981



pulse-rice-rice (A5). The least yield was obtained in the sequence sweet potato-rice-rice.

The results on the yield of grain indicate that summer green manure or pulse crop or fallowing during summer has an effect on the subsequent virippu rice crop, while growing rice in summer or growing a very exhaustive crop like sweet potato instead of exhibiting such an effect show a decrease in yield. All these show that the *in situ* ploughing under of the daincha crop and the tops of the pulse crop adds organic matter and nutrients to the soil. The legumes have the capacity to fix atmospheric nitrogen and this addition of nitrogen incidentally had shown the effect. This result is in agreement with the finding of Sharma *et al.*, 1986 and Verma *et al.*, (1987).

Table-33 and Fig. 9 present the data on the straw yield in Kg ha^{-1} (Pooled) for the rice crop'Jaya 1981. The results indicate that the sequences tried are not significant with respect to straw yield. But between treatments, a significant difference in straw yield has been noticed. The treatments T_1 and T_6 produced the highest straw yield. The poor yield was recorded by T_3 and T_4. T_1 and T_6 are found to be the two treatment and phosphorus have been applied. In T_6, only the level of K was decreased

Table-34

Grain yield in Kg ha^{-1} (pooled data) for rice variety Jaya - Mundakan 1981

Sequences	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
A1	2278.1	2166.7	2008.1	2203.8	2187.0	2261.2	2184.1
A2	2497.5	2436.7	2376.0	2403.0	2450.2	2500.8	2444.0
A3	2490.7	2349.0	2301.7	2335.5	2362.5	2494.1	2388.9
A4	2311.8	2234.2	2166.7	2085.7	2261.2	2322.0	2230.3
A5	2193.7	2139.7	2085.5	2162.7	2149.8	2193.7	2154.2

CD for A = 265.0

CD for A T = 510.6

(5% level)

FIG 10

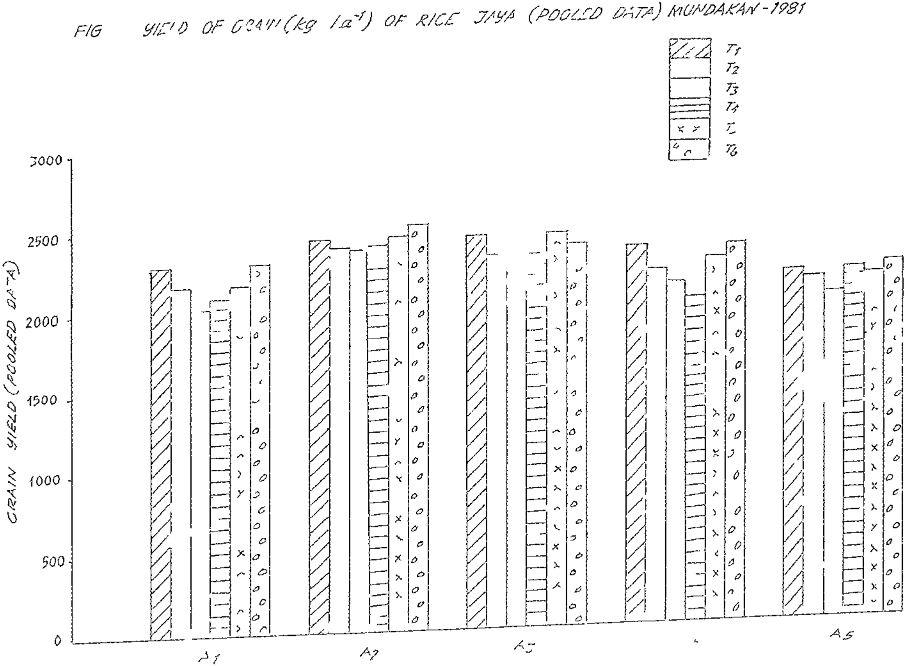


FIG YIELD OF GRAIN (kg/ha-1) OF RICE JAYA (POOLED DATA) MUNDAKAN-1981
T1
T2
T3
T4
T5
T6
3000
2500
2000
1500
1000
500
0
GRAIN YIELD (POOLED DATA)
A1
A2
A3
A5

to 75 per cent of the recommended dose. It is very much evident that the addition of nutrients in sufficient quantities are required in maintaining straw yield. Levels lower than the full recommended levels affect the yield.

Table-34 and Fig. 10 show that the grain yield in Kg ha^{-1} (Pooled data) for the rice crop mundakan 1981, variety Jaya. The result shows that the treatments and sequences are significant. The sequence daincha-rice-rice gave the highest grain yield, followed by the sequence of pulse-rice-rice. The lowest yield is recorded by the sequence sweet potato-rice-rice. Among the treatments T_1 and T_6 gave the highest yield, which were on par with T_5 and T_4. The least yield is recorded by T_3 in all the sequences tried.

In the Mundakan season also the trend of the early virippu season 1981 is noticed. In fact, as the component crops in the various sequences progress, there is a growing reinforcement of positive effects as well as of negative effects leading to the emergence of a more clear cut difference among both sequences and treatments. This observation made both in 1981 and 1982 cropping seasons have also been observed in field experiments conducted later and reported by Sahu et al., 1988 and Patel et al., 1987.

Table-35

Grain yield in $Kg ha^{-1}$ (Pooled data) for the rice variety Jaya - Mundakan 1981

Sequences	T_1	T_2	T_3	T_4	T_5	T_6	Mean
	Treatments						
A1	2442.1	2340.2	2168.7	2380.0	2365.2	2441.8	2356.3
A2	2695.9	2631.4	2566.0	2591.3	2645.6	2702.0	2638.7
A3	2689.8	2536.6	2485.6	2522.1	2550.8	2693.5	2579.7
A4	2490.8	2376.3	2323.6	2389.8	2441.8	2506.2	2422.4
A5	2375.3	2309.1	2252.4	2281.1	2319.9	2362.1	2316.7

CD for A = 35.259

CD for A T = 68.866

15, ncl

Table-36

Grain yield in kg ha^{-1} (Pooled data) for the

[illegible] - Viripu[illegible] 1982

Sequences	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
S1	222[illegible].5	[illegible]	1[illegible]64.[illegible]	2035.1	2257.2	2295.0	2141.0
S2	2174.1	[illegible]099.2	20[illegible]8.2	2052.0	2100.6	2185.3	210[illegible]
S3	2504.2	2426.6	2354.7	2421.5	2411.4	2504.2	2437.1
S4	2504.2	[illegible]77.2	2363.0	2430.0	2453.6	2500.8	2464.9
S5	2342.2	2227.5	2176.8	2227.8	2261.2	2364.1	2266.6

CD for S - 13.97

CD for T - 64.27

(5% level)

FIG II

YIELD OF STRAW (kg ha^{-1}) OF RICE JAYA (POOLED DATA) MUNDAKAN - 1981

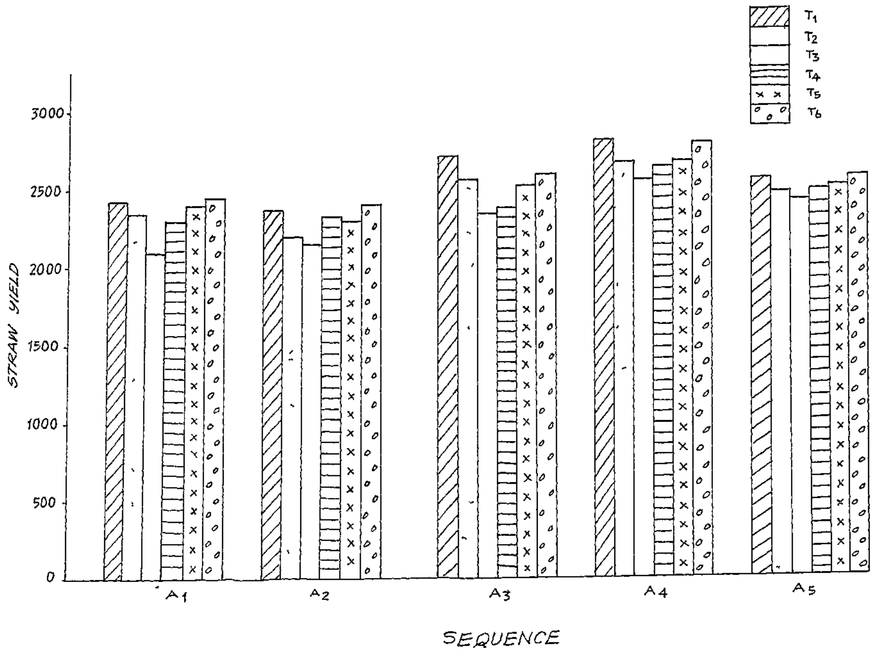


FIG 12

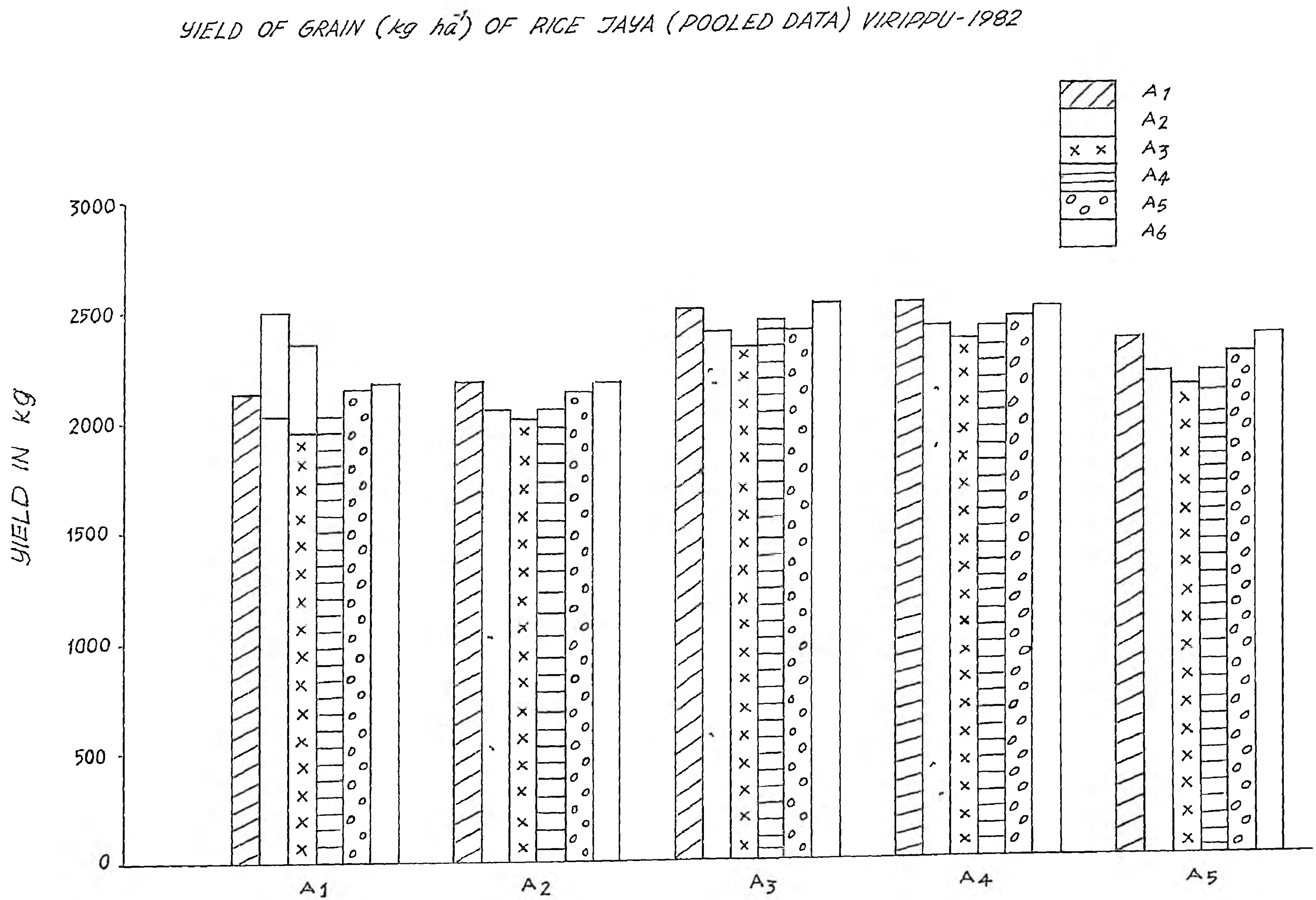

YIELD OF GRAIN (kg ha-1) OF RICE JAYA (POOLED DATA) VIRIPPU-1982
A1
A2
A3
A4
A5
A6
YIELD IN KG
3000
2500
2000
1500
1000
500
0
A1
A2
A3
A4
A5

Table-35 and Fig. 11 present the data on the straw yield in Kgs/ha (Pooled data) for rice crop variety Jaya during Mundakan season 1981. The result shows that both sequences and treatments are significant. The sequence daincha-rice-rice gave the highest straw yield, followed by the sequence pulse-rice-rice. The least yield is recorded by the sequence sweet potato-rice-rice. Among the treatments T_1 and T_6 gave the highest yield. The lowest yield is given by the treatment T3 where all the nutrients NP and K have been applied only at 50 per cent of the recommended quantities. Perusal of the result on the yield of straw reveals that it follows the same trend as followed by grain yield. This is inevitable for the rice crop since the grain straw ratio in high yielding rice is approximately (1.1.2). In view of this, the yield trends of grain and straw are related by this ratio. The observations made in this study are in conformity with similar observations made by Patel et al.. (1987).

Table-36 and Fig. 12 present the yield of grain in kg ha^{-1} (Pooled). The result shows that both sequences and treatments are significant. Among the sequences tried, daincha-rice-rice (A4) is the best, followed by the sequences pulse-rice-rice (A3) and fallow-rice-rice (A5). The

Table-37

Straw yield in kg ha^{-1} (Pooled data) for the rice variety Jaya - Virippu 1982

Sequences	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
A1	2405.7	2231.5	2121.1	2193.9	2437.4	2477.9	2311.7
A2	2347.3	[illegible]	2179.5	2217.3	2193.7	2419.5	2270.7
A3	2704.3	2517.9	2557.5	2514.9	2603.8	2703.7	2249.0
A4	2702.3	2673.0	2595.3	2521.3	2546.0	2593.2	2655.2
A5	2531.2	2404.6	2351.0	2407.7	2441.3	2552.5	2448.1

CD for A = 37.93

CD for A T = 61.62

CD for T = 27.55

(5% level)

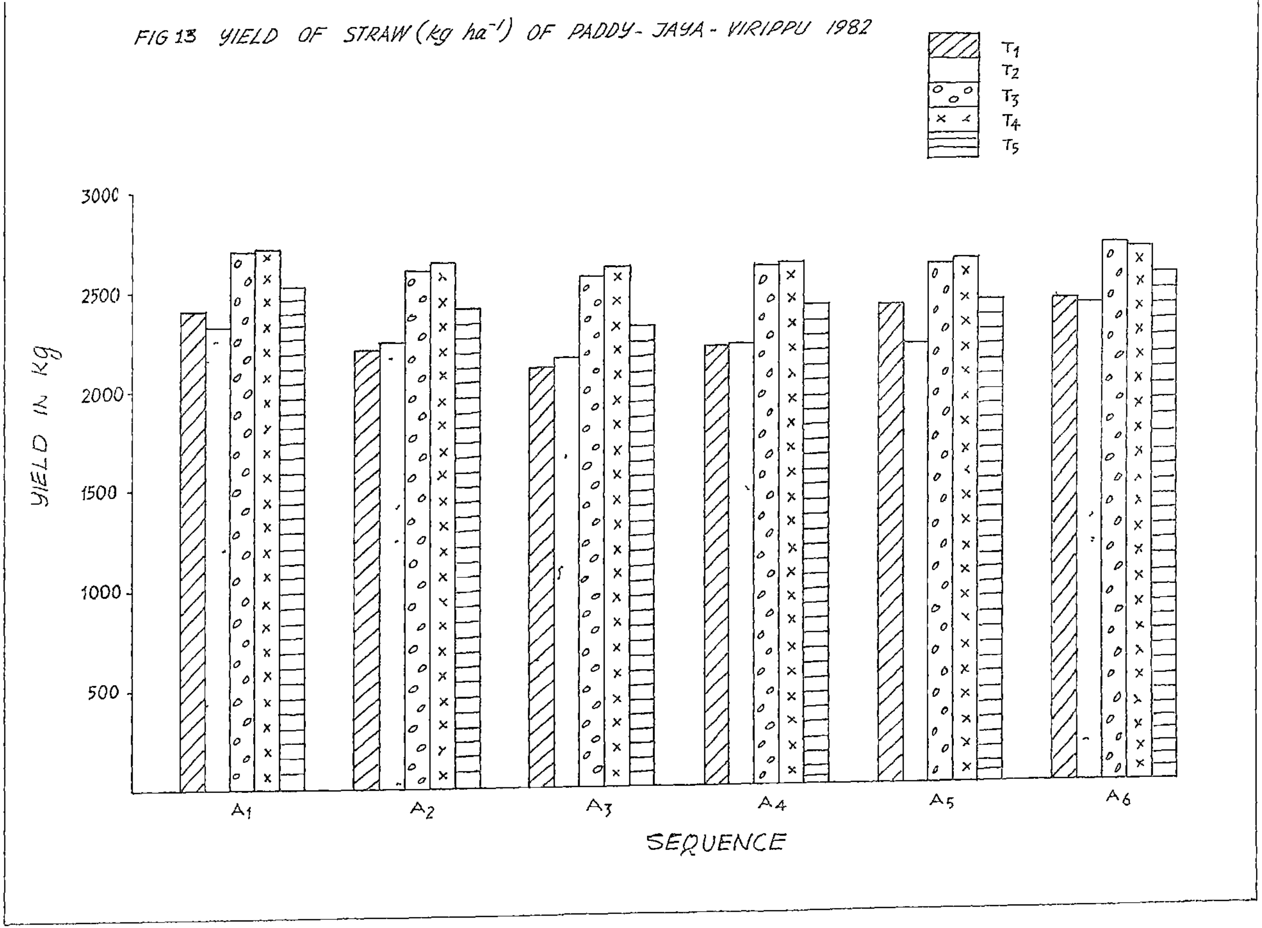


FIG 13 YIELD OF STRAW (kg ha-1) OF PADDY - JAYA - VIRIPPU 1982
T1
T2
T3
T4
T5
3000
2500
2000
1500
1000
500
YIELD IN Kg
A1
A2
A3
A4
A5
A6
SEQUENCE

lowest yield is recorded in the sequence ▣ sweet potato-rice-rice. Among the various treatments T6 is found to be the best for all the sequences, clearly followed by T_1.

Though the trend in 1981 was more in favour of daincha-rice-rice and fallow-rice-rice, by 1982 the sequences daincha-rice-rice and pulse-rice-rice were found to be better. A similar reinforcement of positive effects in treatments lead to the indication that T6 ie. full dose of N and P with 3/4 dose of K is enough to maintain a higher yield for the component crop of the sequence daincha-rice-rice and pulse-rice-rice. In view of the multiple crop sequence, there is a need for taking a whole system approach especially for manuring purposes. Under these circumstances, the possibility of decreasing the total K applied to all the three crops put together appears to be warranted. The picture becomes clearer in the mundakan season of 1982, the result of which is indicated below.

Table 37 and fig. 13 represents the yield of straw in Kg ha^{-1} for the rice crop variety Jaya during Virippu 1982. The result shows that both the sequences and treatments are significant. The result shows that the sequence daincha-rice-rice (A4) gives the highest straw yield. This is followed by the rice crop of the sequence pulse-rice-rice (A3). The lowest virippu straw yield is noticed

Table-38

Grain yield in kg ha^{-1} (Pooled data) for Rice variety

Jaya - Mundakan 1982

Sequences	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
A1	2227.5	2139.6	2041.5	2065.5	2157.5	2229.1	2142.7
A2	2151.5	2084.7	2028.3	2089.1	2115.1	2156.6	2104.2
A3	2446.6	2362.5	2294.3	2369.2	2394.5	2451.9	2382.5
A4	2499.7	2435.7	2370.9	2427.3	2426.6	2510.3	2443.6
A5	2318.6	2234.2	2159.3	2241.0	2263.6	2308.5	2254.0

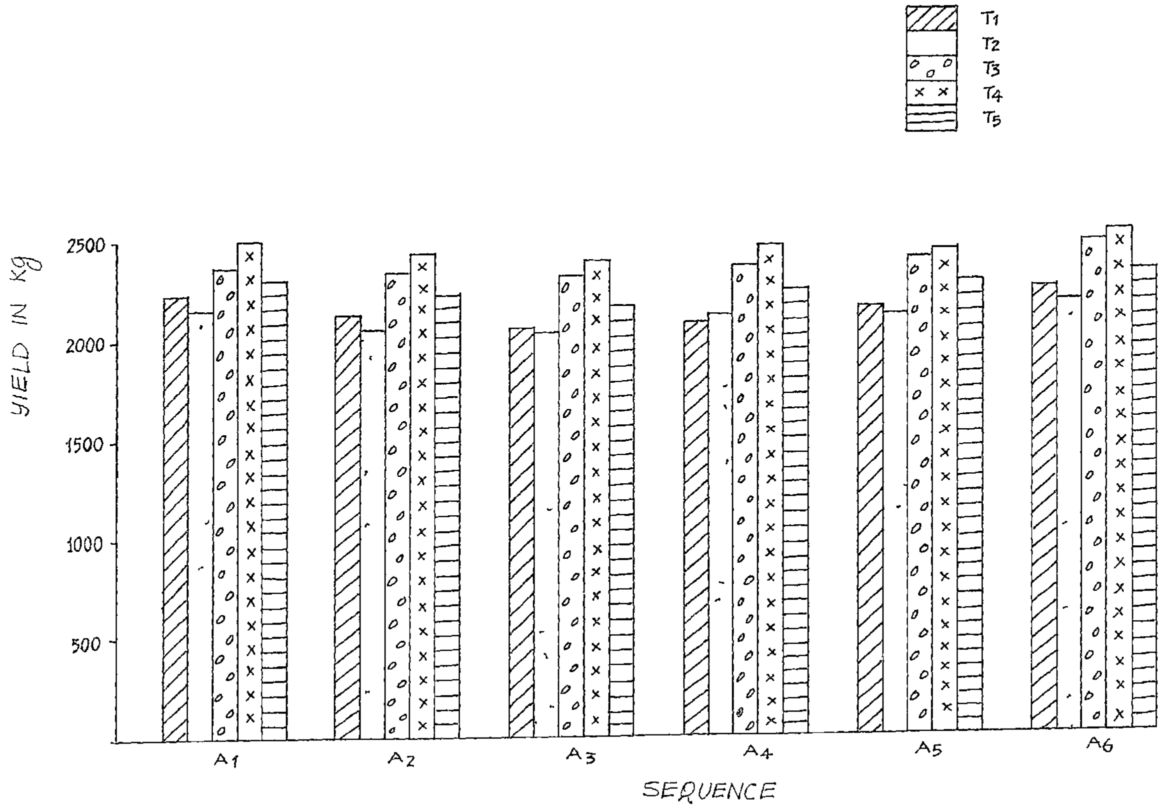
CD for A = 14.33

CD for T = 11.42

CD for A T = 25.34

(5% level)

FIG 14 YIELD OF GRAIN (kg ha⁻¹) POOLED DATA FOR PADDY-JAYA MUNDAKAN 1982



in the sequence sweet potato-rice-rice. It is also to be noted that in the sequence A5 and A2, straw yield for the virippu rice crop is on par.

Among the treatments T_6 and T_5 gave the highest straw yield. In all the sequences, they are on par. This is followed by the Treatment T_1. The T_1 and T_3 treatments are also on par.

Straw yields are fairly high only in treatments which have N at recommended doses and sequence which include a leguminous crop. Marginal decrease of either P or K as in T_5 and T_6 does not appear to decrease the performance in terms of yield. This evidently means that in the management of component crops only a marginal decrease of either P or K is possible in a system approach.

Table-38 and Fig. 14 show the yield of grain in Kg ha^{-1} of rice crop variety Jaya for mundakan season 1982. The result indicates that both sequences and treatments are significant. The sequence daincha-rice-rice (A4) records the highest yield. This is followed by the sequence pulse-rice-rice. The third sequence but in decreasing order is pulse-rice-rice (A3) followed by fallow-rice-rice (A5). The lowest yield for the mundakan rice crop is in the sequence rice-rice-rice.

Among the treatments, T_6 gave the highest yield which is followed by T_5 and T_1. Both T_6 and T_5 are on par and T_5 and T_1 also are on par.

The result thus becomes more clear cut in that the best sequences are daincha-rice-rice and pulse-rice-rice. The better sequences out of the five tried are found to be daincha-rice-rice (A4) and pulse-rice-rice (A3). The best treatments are T_6, T_5 and T_1. From the nature of the effect of the treatments it can be concluded that full dose of N, 3/4 recommended dose of P and K would be good enough for the component rice crop of the various sequences.

A consideration of the rice yield for both the seasons and for both the years shows that the sequences daincha-rice-rice and pulse-rice-rice are the best. The total yield for virippu and mundakan for the sequence rice-rice-rice is also lower than the above. The virippu and mundakan season rice yields of the sequence Sweet potato-rice-rice is the lowest. The sweet potato yield

Table-39

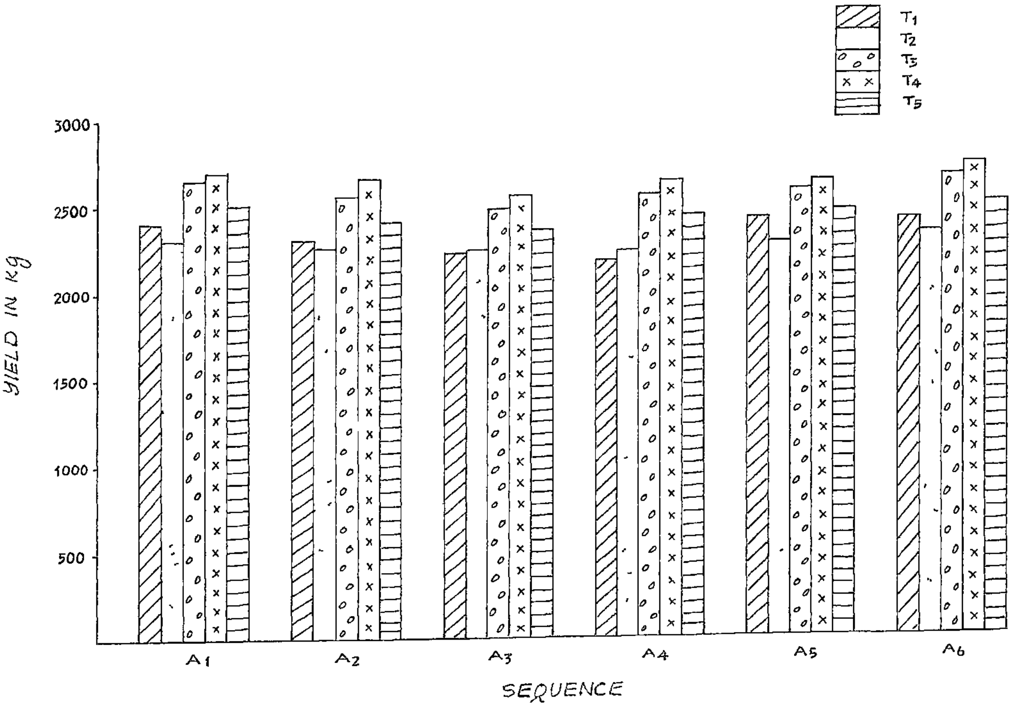
Yield of straw in kg ha^{-1} (pooled data) for the rice (Jaya) - Mundakan 1982

Sequences	Treatments						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean
A1	2399.2	2310.8	2205.2	2187.0	2402.7	2407.0	2318.6
A2	2307.1	2250.7	2237.6	2229.1	2284.4	2330.7	2273.3
A3	2642.6	2550.8	2577.5	2558.2	2565.9	2567.6	2577.1
A4	[illegible]	2625.7	2560.6	2572.0	2620.6	2710.8	2638.3
A5	2503.9	2412.7	2347.[illegible]	2420.2	244[illegible].5	2493.0	2437.0

CD for A = 39.80

CD for T = 29.[illegible]
(5% level)

FIG 15 YIELD OF STRAW IN kg ha⁻¹ (POOLED DATA) FOR PADDY-JAYA-MUNDAKAN 1982



in summer, when calculated on the basis of economic of return, however, makes the sequence sweet potato-rice-rice emerge in terms of economics of return as the best, followed by pulse-rice-rice. This is in agreement with the findings of workers like Mahapatra et al., (1987).

Table-39 and Fig. 15 present the yield of straw in Kg ha^{-1} for the rice crop variety Jaya during Mundakan season 1982. The result indicates that both treatments and sequence are significant. A scrutiny of the data reveals that the sequence daincha-rice-rice (A4) gave the highest straw yield. This is followed by the sequence pulse-rice-rice (A3) and sweet potato-rice-rice (A2).

An examination of data reveals that the treatment T_6 gave the highest yield, followed by T_5 and T_1. The treatments T_6 and T_5 were on par. The treatments T_5 and T_1 were also on par. The treatments T_3 and T_4 gave the lowest yield.

The final crop of the experiment namely mundakan 1982 shows that rice grain and straw yields follow the same trend. Straw yield of the daincha-rice-rice and pulse-rice-rice sequences are the best. The treatments T_6 ie, full recommended dose of N and P and 3/4 recommended dose of K is the best for the sequences. This

Table-40

Nitrogen, [illegible] and [illegible] content in percentage at harvest of rice variety Triveni Summer 1981

Treatment	N		P		K	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1	1.31	0.96	0.29	0.49	0.58	1.68
T_2	1.22	0.94	0.2[illegible]	0.49	0.58	1.63
T_3	1.18	0.9[illegible]	0.28	0.44	0.58	1.68
T_4	1.26	0.48	0.28	0.48	0.58	1.68
T_5	1.28	0.95	0.28	0.47	0.58	1.63
T_6	1.29	0.95	0.29	0.49	0.58	1.68
	NS	NS	NS	NS	NS	NS

Table-42

Nitrogen, [illegible] and Potash content in percentage at harvest of cowpea Summer 1981

Treatment	N			P			K		
	Grain	Husk	Haulm	Grain	Husk	Haulm	Grain	Husk	Haulm
T_1	3.66	1.19	2.87	0.55	0.13	0.41	1.13	0.43	0.73
T_2	3.59	1.11	2.83	0.55	0.12	0.41	1.13	0.43	0.73
T_3	3.54	1.10	2.82	0.54	0.12	0.41	1.12	0.43	0.73
T_4	3.63	1.11	2.84	0.55	0.13	0.41	1.12	0.43	0.73
T_5	3.65	1.16	2.86	0.55	0.13	0.41	1.30	0.43	0.73
T_6	3.65	1.17	2.86	0.55	0.13	0.41	1.31	0.43	0.73
	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-43

Nitrogen, [illegible] and Potash content in percentage at harvest of cowpea Summer 1982

Treatment	N			P			K		
	Grain	Husk	Haulm	Grain	Husk	Haulm	Grain	Husk	Haulm
T_1	3.62	1.16	2.85	0.55	0.13	0.41	1.13	0.43	0.73
T_2	3.58	1.06	2.83	0.54	0.12	0.40	1.12	0.42	0.73
T_3	3.55	0.99	2.82	0.54	0.12	0.40	0.12	0.42	0.72
T_4	3.61	1.09	2.84	0.55	0.12	0.41	1.12	0.42	0.73
T_5	3.61	1.12	2.84	0.55	0.13	0.41	1.30	0.43	0.73
T_6	3.61	1.15	2.85	0.55	0.13	0.41	1.31	0.43	0.73
	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-11

Nitrogen, [illegible] and [illegible] content in percentage at harvest of rice variety Triveni Summer 1982

Treatment	N		P		K	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1	1.30	0.96	0.29	0.47	0.58	1.68
T_2	1.30	0.94	0.28	0.42	0.58	1.68
T_3	1.16	0.94	0.28	0.41	0.58	1.68
T_4	1.21	0.94	0.28	0.44	0.58	1.68
T_5	1.25	0.95	0.28	0.45	0.58	1.68
T_6	1.28	0.95	0.28	0.46	0.58	1.68
	NS	NS	NS	NS	NS	NS

finding points out the decrease in the dose of P and K fertilisers to the extent of 25 per cent of the recommended dose is possible. Daincha-rice-rice and pulse-rice-rice are the best sequences. This is in conformity with the findings of the earlier workers like Verma et al., (1987), Yadav and Singh (1986) and Sharma et al., (1986).

Tables 40 and 41 present the NPK content of both grain and straw in per cent at harvest of rice variety Triveni of summer 1981 and 1982. The result indicates that there is no significant difference in N, P and K content of grain and straw between treatments. It has to be borne in mind that generally application of N, P, K leads to an increase in yield but not an increase in the content of N, P and K.

Tables 42 and 43 present the data on the NPK content at harvest of summer cowpea for the year 1981 and 1982.

The result shows that there is no significant difference in the N, P and K content at harvest of grain, husk and haulm of the summer cowpea. Application of N, P and K has resulted in an enhancement of yield of cowpea grain and haulm. However, their application has not

Table-44

Nitrogen, [illegible] and [illegible] content in percentage at harvest of sweet potato Summer 1981

Treatment	N		P		K	
	Tuber	Vine	Tuber	Vine	Tuber	Vine
T_1	0.48	1.57	0.25	0.26	1.62	3.96
T_2	0.45	1.52	0.25	0.24	1.59	3.93
T_3	0.43	1.48	0.24	0.24	1.59	3.90
T_4	0.46	1.54	0.25	0.24	1.61	3.94
T_5	0.47	1.55	0.25	0.24	1.61	3.95
T_6	0.47	1.56	0.25	0.25	1.61	3.95
	NS	NS	NS	NS	NS	NS

Table-45

Nitrogen, [illegible] and [illegible] content in percentage at harvest of sweet potato Summer 1982

Treatment	N		P		K	
	Tuber	Vine	Tuber	Vine	Tuber	Vine
T_1	0.47	1.55	0.25	0.25	1.61	3.95
T_2	0.44	1.48	0.24	0.24	1.58	3.92
T_3	0.43	1.47	0.24	0.23	1.58	3.89
T_4	0.45	1.49	0.24	0.24	1.58	3.92
T_5	0.46	1.51	0.24	0.24	1.59	3.93
T_6	0.47	1.53	0.25	0.25	1.60	3.95
	NS	NS	NS	NS	NS	NS

Table-46

Nitrogen, Phosphorus and Potash at harvest of Daincha - Summer 1981

Treatment	N	P	K
T_1	3.28	0.70	1.30
T_2	3.35	0.69	1.28
T_3	3.26	0.70	1.30
T_4	3.34	0.70	1.30
T_5	3.31	0.71	1.30
T_6	3.31	0.70	1.30
	NS	NS	NS

Table-47

Nitrogen, Phosphorus and Potash at harvest of Daincha - Summer 1982

Treatment	N	P	K
T_1	3.34	0.71	1.31
T_2	3.30	0.69	1.30
T_3	3.32	0.70	1.30
T_4	3.31	0.71	1.30
T_5	3.32	0.71	1.30
T_6	3.32	0.71	1.30
	NS	NS	NS

Table-48

(pooled) value of N in paddy grain variety Jaya virippu 1981

Treatment	A1	A2	A3	A4	A5
T_1	1.22	1.21	1.20	1.21	1.21
T_2	1.22	1.22	1.21	1.20	1.20
T_3	1.20	1.22	1.22	1.22	1.22
T_4	1.22	1.22	1.22	1.23	1.23
T_5	1.22	1.23	1.23	1.23	1.22
T_6	1.22	1.22	1.22	1.22	1.22
	NS	NS	NS	NS	NS

Table-49

(pooled) value of N in paddy grain variety Jaya virippu 1982

Treatment	A1	A2	A3	A4	A5
T_1	1.22	1.21	1.20	1.20	1.21
T_2	1.22	1.22	1.22	1.21	1.21
T_3	1.22	1.22	1.22	1.22	1.22
T_4	1.22	1.22	1.22	1.23	1.22
T_5	1.22	1.22	1.22	1.23	1.22
T_6	1.22	1.22	1.22	1.22	1.22
	NS	NS	NS	NS	NS

Table-50

Percent content of nitrogen in rice straw variety Jaya (pooled) Virippu 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.823	0.820	0.820	0.822	0.821
T_2	0.824	0.822	0.820	0.822	0.820
T_3	0.820	0.823	0.824	0.823	0.821
T_4	0.822	0.823	0.824	0.825	0.824
T_5	0.824	0.824	0.823	0.823	0.825
T_6	0.823	0.825	0.821	0.823	0.825
	NS	NS	NS	NS	NS

Table-51

[illegible] of nitrogen in rice straw variety Jaya (pooled) Virippu 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.820	0.820	0.820	0.824	0.820
T_2	0.821	0.820	0.820	0.823	0.822
T_3	0.819	0.820	0.825	0.824	0.821
T_4	0.821	0.822	0.823	0.824	0.823
T_5	0.822	0.824	0.823	0.824	0.820
T_6	0.820	0.820	0.820	0.825	0.820
	NS	NS	NS	NS	NS

resulted in a significant difference in the content of N, P and K of cowpea grains or haulm.

Tables 44 and 45 present the N, P and K content in percentage at harvest of summer sweet potato CVH-142 for the year 1981 and 1982. The result shows that there has been no significant increase in the NPK content of the tuber and vines of sweet potato as a result of manurial treatments.

Tables 46 and 47 present the percentage of NPK at harvest of the green manure crop daincha for the year 1981 and 1982. A close perusal of the result shows that there is no significant difference in the per cent of NPK content of the daincha crop.

Tables 48 and 49 present the data on the percentage of nitrogen in rice grain variety Jaya for the virippu season of 1981 and 1982. The results show that there is no significant difference between the sequences and treatments. The N percentage in rice grain has not been affected by the treatment as well as sequence.

Tables 50 and 51 present the data on the percentage N content of rice straw for the virippu 1981 and 1982. The results show that there is no significant difference in the per cent of N in the rice. There is no significant difference between treatments and sequences.

Table-52

... of P in rice grain variety Jaya (pooled) Virippu 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.276	0.275	0.274	0.275	0.275
T_2	0.275	0.275	0.274	0.273	0.274
T_3	0.274	0.275	0.278	0.277	0.276
T_4	0.277	0.277	0.279	0.281	0.279
T_5	0.278	0.279	0.2[illegible]0	0.280	0.277
T_6	0.276	0.275	0.276	0.277	0.277
	NS	NS	NS	NS	NS

Table-53

... of P in rice grain variety Jaya (pooled) Virippu 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.273	0.274	0.273	0.273	0.274
T_2	0.275	0.275	0.274	0.273	0.274
T_3	0.274	0.275	0.277	0.279	0.279
T_4	0.276	0.276	0.277	0.279	0.279
T_5	0.277	0.277	0.278	0.279	0.276
T_6	0.275	0.274	0.275	0.274	0.276
	NS	NS	NS	NS	NS

Table-54

[illegible] of P in rice straw variety Jaya (pooled) Virippu 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.163	0.162	0.161	0.162	0.163
T_2	0.164	0.162	0.161	0.160	0.161
T_3	0.162	0.162	0.165	0.164	0.163
T_4	0.164	0.164	0.165	0.166	0.165
T_5	0.164	0.165	0.166	0.166	0.165
T_6	0.164	0.163	0.164	0.165	0.165
	NS	NS	NS	NS	NS

Table-55

[illegible] of P in rice straw variety Jaya (pooled) Virippu 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.162	0.160	0.159	0.161	0.160
T_2	0.161	0.162	0.161	0.160	0.161
T_3	0.162	0.161	0.164	0.163	0.162
T_4	0.163	0.163	0.164	0.165	0.164
T_5	0.163	0.164	0.164	0.165	0.164
T_6	0.16[illegible]	0.162	0.162	0.162	0.164
	NS	NS	NS	NS	NS

Table-56

[illegible] of K in rice grain variety Jaya (pooled) Virippu 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.576	0.575	0.574	0.575	0.576
T_2	0.576	0.576	0.574	0.573	0.574
T_3	0.566	0.575	0.574	0.570	0.560
T_4	0.570	0.575	0.580	0.590	0.580
T_5	0.570	0.580	0.590	0.590	0.575
T_6	0.560	0.550	0.560	0.565	0.565
	NS	NS	NS	NS	NS

Table-57

[illegible] of K in rice grain variety Jaya (pooled) Virippu 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.575	0.574	0.573	0.574	0.574
T_2	0.575	0.574	0.573	0.574	0.574
T_3	0.573	0.574	0.573	0.573	0.573
T_4	0.574	0.573	0.572	0.573	0.574
T_5	0.575	0.573	0.574	0.574	0.573
T_6	0.573	0.574	0.573	0.576	0.574
	NS	NS	NS	NS	NS

Table 58

Percentage of K in rice straw variety Jaya (pooled)
Vellayani 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	1.68	1.67	1.66	1.67	1.63
T_2	1.69	1.67	1.65	1.67	1.67
T_3	1.63	1.67	1.67	1.66	1.65
T_4	1.67	1.66	1.65	1.65	1.67
T_5	1.63	1.65	1.65	1.66	1.66
T_6	1.63	1.65	1.65	1.65	1.67
	NS	NS	S	NS	NS

Table-59

Percentage of K in rice straw variety Jaya (pooled)
Vellayani 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	1.67	1.66	1.65	1.65	1.66
T_2	1.63	1.67	1.66	1.65	1.66
T_3	1.67	1.67	1.52	0.16	0.15
T_4	1.67	0.16	0.15	1.60	1.59
T_5	1.68	1.66	1.59	1.60	1.67
T_6	1.66	1.55	1.56	1.66	1.67
	NS	NS	NS	S	NS

Table-60

[illegible] of nitrogen in rice grain variety Jaya (pooled) Mundakan 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.275	0.276	0.275	0.274	0.275
T_2	0.275	0.275	0.274	0.273	0.275
T_3	0.275	0.274	0.275	0.275	0.274
T_4	0.274	0.275	0.275	0.274	0.275
T_5	0.275	0.275	0.275	0.275	0.275
T_6	0.275	0.276	0.275	0.274	0.275
	NS	NS	NS	NS	NS

Table-61

[illegible] of nitrogen in rice grain variety Jaya (pooled) Mundakan 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.275	0.275	0.274	0.275	0.274
T_2	0.275	0.275	0.275	0.274	0.275
T_3	0.274	0.274	0.275	0.275	0.274
T_4	0.275	0.275	0.274	0.275	0.275
T_5	0.275	0.275	0.275	0.275	0.275
T_6	0.275	0.275	0.275	0.275	0.275
	NS	NS	NS	NS	NS

Table-62

Percentage of nitrogen in rice straw variety Jaya (pooled) Mundakan 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.822	0.820	0.820	0.821	0.820
T_2	0.823	0.821	0.820	0.820	0.821
T_3	0.820	0.820	0.821	0.821	0.820
T_4	0.822	0.821	0.820	0.820	0.820
T_5	0.823	0.821	0.821	0.820	0.821
T_6	0.822	0.820	0.820	0.821	0.820
	NS	NS	NS	NS	NS

Table-63

Percentage of nitrogen in rice straw variety Jaya (pooled) Mundakan 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.821	0.820	0.820	0.821	0.820
T_2	0.820	0.821	0.820	0.821	0.820
T_3	0.819	0.620	0.821	0.820	0.821
T_4	0.820	0.821	0.820	0.821	0.820
T_5	0.821	0.821	0.821	0.821	0.821
T_6	0.821	0.820	0.821	0.820	0.821
	NS	NS	NS	NS	NS

Tables 52 and 53 present data on the percentage of P in rice grain of variety Jaya for the Virippu season 1981 and 1982. The result shows that sequences and treatments have not made any significant effect on the content of P.

Tables 54 and 55 present the data on the percentage of P in rice straw of the variety Jaya for the virippu season of 1981 and 1982. The result shows that there is no significant difference in the P content of the straw. Thus, sequence and treatment has not made any significant effect on the P content of rice straw.

Tables 56 and 57 present data on the per cent K in rice grain variety Jaya for the virippu season year 1981 and 1982. The result indicates that there is no significant effect of treatments and sequences on the per cent K content in rice grain.

Tables 58 and 59 present data on the percentage of K in rice straw variety Jaya of the virippu season 1981 and 1982. The result shows that neither sequences or K percentage treatments had any significant effect on the K content of the grain.

Tables 60, 61, 62 and 63 present the percentage of N in the rice grain and straw of variety Jaya for the

Table-64

ercent of P in rice grain variety Jaya (pooled) Muncakan 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.244	0.242	0.241	0.242	0.243
T_2	0.243	0.242	0.241	0.240	0.241
T_3	0.241	0.241	0.244	0.243	0.242
T_4	0.241	0.243	0.244	0.245	0.244
T_5	0.244	0.243	0.243	0.244	0.244
T_6	0.243	0.242	0.241	0.242	0.243
	NS	NS	NS	NS	NS

Table-65

Percent of P in rice grain variety Jaya (pooled) Mundakan 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.243	0.242	0.241	0.242	0.242
T_2	0.243	0.241	0.240	0.249	0.241
T_3	0.241	0.240	0.243	0.242	0.240
T_4	0.242	0.242	0.243	0.244	0.243
T_5	0.242	0.241	0.240	0.243	0.241
T_6	0.241	0.240	0.241	0.242	0.240
	NS	NS	NS	NS	NS

Table-66

Percentage of P in rice straw variety Jaya (pooled) Mundakan 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.169	0.168	0.167	0.168	0.169
T_2	0.169	0.168	0.167	0.166	0.167
T_3	0.167	0.168	0.170	0.169	0.166
T_4	0.168	0.169	0.170	0.171	0.170
T_5	0.169	0.169	0.170	0.171	0.169
T_6	0.168	0.167	0.168	0.169	0.168
	NS	NS	NS	NS	NS

Table-67

Percentage of P in rice straw variety Jaya (pooled) Mundakan 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.168	0.167	0.166	0.167	0.167
T_2	0.168	0.168	0.167	0.168	0.166
T_3	0.165	0.168	0.169	0.168	0.167
T_4	0.168	0.168	0.169	0.170	0.169
T_5	0.168	0.167	0.166	0.167	0.168
T_6	0.167	0.166	0.167	0.167	0.168
	NS	NS	NS	NS	NS

Table-68

Percentage of K in rice grain variety Jaya (pooled) Mundakan 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.575	0.575	0.575	0.573	0.575
T_2	0.575	0.575	0.574	0.573	0.574
T_3	0.566	0.575	0.574	0.568	0.575
T_4	0.574	0.560	0.574	0.580	0.575
T_5	0.573	0.571	0.580	0.580	0.574
T_6	0.574	0.550	0.568	0.569	0.574
	NS	NS	NS	NS	NS

Table-69

Percentage of K in rice grain variety Jaya (Pooled) Mundakan 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	0.575	0.574	0.573	0.574	0.574
T_2	0.574	0.574	0.574	0.573	0.570
T_3	0.570	0.570	0.570	0.574	0.570
T_4	0.575	0.560	0.570	0.573	0.572
T_5	0.574	0.572	0.571	0.572	0.573
T_6	0.573	0.571	0.572	0.568	0.574
	NS	NS	NS	NS	NS

Table-70

Percentage of K in rice grain variety
Jaya (pooled) Mundakan 1981

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	1.67	1.65	1.67	1.65	1.67
T_2	1.67	1.65	1.67	1.65	1.67
T_3	1.67	1.65	1.67	1.65	1.67
T_4	1.67	1.67	1.67	1.67	1.67
T_5	1.67	1.68	1.67	1.67	1.67
T_6	1.66	1.67	1.67	1.67	1.67
	NS	NS	NS	NS	NS

Table-71

Percentage of K in rice straw variety
Jaya (pooled) Mundakan 1982

Treatment	Sequence				
	A1	A2	A3	A4	A5
T_1	1.67	1.66	1.65	1.66	1.66
T_2	1.68	1.67	1.66	1.65	1.66
T_3	1.67	1.67	1.62	1.61	1.59
T_4	1.67	1.67	1.61	1.61	1.59
T_5	1.53	1.59	1.59	1.64	1.67
T_6	1.66	1.65	1.66	1.66	1.67
	NS	NS	NS	NS	NS

mundakan seaso 1981 and 1982. There is no significant effect for the sequence or treatment.

Tables 64 and 65 present the per cent P content in rice grain of variety Jaya for the mundakan season 1981 and 1982. Tables 66 and 67 present the data on the percentage of P content in the paddy straw of the same variety for the corresponding periods.

Tables 68 and 69 present the data on the per cent K in rice grain of variety Jaya for the Mundakan 1981 and 1982 and Tables 70 and 71 present K content of rice straw for the year 1981 and 1982. Both treatment and sequence had no effect on K content of either grain of straw.

NPK content of rice grain and straw of variety Triveni of summer 1981 and 1982 of variety Jaya of virippu of 1981 and 1982 and of the same variety of Mundakan 1981 and 1982 do not show any significant difference either due to sequence or due to treatment. The summer crop other than rice such as pulse, sweet potato, and gaincha also do not show any effect due to treatment or sequences in their NPK content. The main aspect to be considered from the trend of the result is that the NPK content of various plant parts and of the economic

Table-72

Effect of various cropping sequences on soil pH measured after the harvest of each crop

Sequence	Treatment	Initial status (C0)	Periods					
			1981			1982		
			After summer crops (C1)	After virippu (C2)	After mundakan (C3)	After summer crops (C4)	After virippu (C5)	After mundakan (C6)
Rice-rice-rice (A1)	T_1	5.06	5.03	4.98	4.93	4.88	4.84	4.80
	T_2	5.06	5.03	4.98	4.93	4.88	4.84	4.80
	T_3	5.06	5.03	4.98	4.93	4.88	4.84	4.80
	T_4	5.06	5.03	4.98	4.93	4.88	4.84	4.80
	T_5	5.06	5.03	4.98	4.93	4.88	4.84	4.80
	T_6	5.06	5.03	4.98	4.93	4.88	4.84	4.80
Sweet potato-rice-rice (A2)	T_1	5.06	5.05	5.03	5.00	4.97	4.92	4.88
	T_2	5.06	5.05	5.03	5.00	4.97	4.92	4.88
	T_3	5.06	5.05	5.03	5.00	4.97	4.92	4.88
	T_4	5.06	5.05	5.03	5.00	4.97	4.92	4.88
	T_5	5.06	5.05	5.03	5.00	4.97	4.92	4.88
	T_6	5.06	5.05	5.03	5.00	4.97	4.92	4.88

(Contd....2)

The result shows that the cultivation of various crops tends to decrease the soil pH. It is noted that in the rice-rice-rice sequence the pH has decreased considerably after the two component crops in the sequence rice-rice-rice. It is also to be noted that treatments have no effect on soil pH.

Each crop in the sequence sweet potato-rice-rice also tends to reduce the pH considerably. The cultivation of the sweet potato crop decreased the soil pH by 0.17 while the succeeding rice crop reduced the soil pH slightly. The same trend was observed in the second year also. Here also, it was found that the treatments have no effect on the soil pH.

In the sequence cowpea-rice-rice also, the cultivation of all the component crops decreased the soil pH from its initial status. However, the decrease of soil pH was slightly lesser in the second year or second cycle of the sequence.

The component crops of the sequence daincha-rice-rice also tend to decrease the soil pH. The sequence had an effect in decreasing the soil pH while the treatments had no effect on the same. The decrease of soil pH by the cropping sequence was found to be less when compared with other sequences.

Sequence	Treatment	Initial status (C0)	Periods: 1981 After summer crops (C1)	1981 After virippu (C2)	1981 After mundakan (C3)	1982 After summer crops (C4)	1982 After virippu (C5)	1982 After mundakan (C6)
Cowpea-rice-rice (A3)	T_1	5.08	5.04	5.00	4.97	4.93	4.89	4.85
	T_2	5.08	5.04	5.00	4.97	4.93	4.89	4.85
	T_3	5.08	5.04	5.00	4.97	4.93	4.89	4.85
	T_4	5.08	5.04	5.00	4.97	4.93	4.89	4.85
	T_5	5.08	5.04	5.00	4.97	4.93	4.89	4.85
	T_6	5.08	5.04	5.00	4.97	4.93	4.89	4.85
Daincha-rice-rice (A4)	T_1	5.06	5.04	5.00	4.98	4.95	4.93	4.89
	T_2	5.06	5.04	5.00	4.98	4.95	4.93	4.89
	T_3	5.06	5.04	5.00	4.98	4.95	4.93	4.89
	T_4	5.06	5.04	5.00	4.98	4.95	4.93	4.89
	T_5	5.06	5.04	5.00	4.98	4.95	4.93	4.89
	T_6	5.06	5.04	5.00	4.98	4.95	4.93	4.89
Fallow-rice-rice (A5)	T_1	5.06	5.06	5.03	4.98	4.98	4.94	4.90
	T_2	5.06	5.06	5.03	4.98	4.98	4.94	4.90
	T_3	5.06	5.06	5.03	4.98	4.98	4.94	4.90
	T_4	5.06	5.06	5.03	4.98	4.98	4.94	4.90
	T_5	5.06	5.06	5.03	4.98	4.98	4.94	4.90
	T_6	5.06	5.06	5.03	4.98	4.98	4.94	4.90

Table-73

Changes in soil pH over initial status due to different cropping sequences

Sequence	Treatment	1981 After summer	1981 After virippu	1981 After mundakan	1982 After summer	1982 After virippu	1982 After mundakan
Rice-rice-rice (A1)	T_1	-0.03	-0.08	-0.13	-0.05	-0.11	-0.13
	T_2	-0.03	-0.08	-0.13	-0.05	-0.11	-0.13
	T_3	-0.03	-0.08	-0.13	-0.05	-0.11	-0.13
	T_4	-0.03	-0.08	-0.13	-0.05	-0.11	-0.13
	T_5	-0.03	-0.08	-0.13	-0.05	-0.11	-0.13
	T_6	-0.03	-0.08	-0.13	-0.05	-0.11	-0.13
Sweet potato-rice-rice (A2)	T_1	-0.01	-0.03	-0.06	-0.03	-0.08	-0.12
	T_2	-0.01	-0.03	-0.06	-0.03	-0.08	-0.12
	T_3	-0.01	-0.03	-0.06	-0.03	-0.08	-0.12
	T_4	-0.01	-0.03	-0.06	-0.03	-0.08	-0.12
	T_5	-0.01	-0.03	-0.06	-0.03	-0.08	-0.12
	T_6	-0.01	-0.03	-0.06	-0.03	-0.08	-0.12
	T						

(Contd....2)

Sequence	Treatment	1981 After summer	1981 After virippu	1981 After mundakan	1982 After summer	1982 After virippu	1982 After mundakan
Cowpea-rice-rice (A3)	T_1	-0.04	-0.08	-0.11	-0.04	-0.08	-0.12
	T_2	-0.04	-0.08	-0.11	-0.04	-0.08	-0.12
	T_3	-0.04	-0.08	-0.11	-0.04	-0.08	-0.12
	T_4	-0.04	-0.08	-0.11	-0.04	-0.08	-0.12
	T_5	-0.04	-0.08	-0.11	-0.04	-0.08	-0.12
	T_6	-0.04	-0.08	-0.11	-0.04	-0.08	-0.12
Daincha-rice-rice (A4)	T_1	-0.02	-0.06	-0.08	-0.03	-0.02	-0.06
	T_2	-0.02	-0.06	-0.08	-0.03	-0.02	-0.06
	T_3	-0.02	-0.06	-0.08	-0.03	-0.02	-0.06
	T_4	-0.02	-0.06	-0.08	-0.03	-0.02	-0.06
	T_5	-0.02	-0.06	-0.08	-0.03	-0.02	-0.06
	T_6	-0.02	-0.06	-0.08	-0.03	-0.02	-0.06
Fallow-rice-rice (A5)	T_1	+0	-0.03	-0.08	+0	-0.04	-0.04
	T_2	+0	-0.03	-0.08	+0	-0.04	-0.04
	T_3	+0	-0.03	-0.08	+0	-0.04	-0.04
	T_4	+0	-0.03	-0.08	+0	-0.04	-0.04
	T_5	+0	-0.03	-0.08	+0	-0.04	-0.04
	T_6	+0	-0.03	-0.08	+0	-0.04	-0.04

Table-74

Summary table: Changes in pH of the soil over initial status

Sequence	Treatment	1981	1982
1) After summer			
Rice-rice-rice (A1)	T_1	-0.03	-0.05
	T_2	-0.03	-0.05
	T_3	-0.03	-0.05
	T_4	-0.03	-0.05
	T_5	-0.03	-0.05
	T_6	-0.03	-0.05
Sweet potato-rice-rice (A2)	T_1	-0.01	-0.03
	T_2	-0.01	-0.03
	T_3	-0.01	-0.03
	T_4	-0.01	-0.03
	T_5	-0.01	-0.03
	T_6	-0.01	-0.03
Cowpea-rice-rice (A3)	T_1	-0.04	-0.04
	T_2	-0.04	-0.04
	T_3	-0.04	-0.04
	T_4	-0.04	-0.04
	T_5	-0.04	-0.04
	T_6	-0.04	-0.04
Daincha-rice-rice (A4)	T_1	-0.02	-0.03
	T_2	-0.02	-0.03
	T_3	-0.02	-0.03
	T_4	-0.02	-0.03
	T_5	-0.02	-0.03
	T_6	-0.02	-0.03

(Contd....2)

Sequence	Treatment	1931	1982
Fallow-rice-rice (A5)	T_1	+0	+0
	T_2	+0	+0
	T_3	+0	+0
	T_4	+0	+0
	T_5	+0	+0
	T_6	+0	+0
ii) <u>After virippu</u>			
Rice-rice-rice (A1)	T_1	-0.08	-0.11
	T_2	-0.08	-0.11
	T_3	-0.08	-0.11
	T_4	-0.08	-0.11
	T_5	-0.08	-0.11
	T_6	-0.08	-0.11
Sweet potato-rice-rice (A2)	T_1	-0.03	-0.08
	T_2	-0.03	-0.08
	T_3	-0.03	-0.08
	T_4	-0.03	-0.08
	T_5	-0.03	-0.08
	T_6	-0.03	-0.08
Cowpea-rice-rice (A3)	T_1	-0.08	-0.08
	T_2	-0.08	-0.08
	T_3	-0.08	-0.08
	T_4	-0.08	-0.08
	T_5	-0.08	-0.08
	T_6	-0.08	-0.08
Daincha-rice-rice (A4)	T_1	-0.06	-0.02
	T_2	-0.06	-0.02
	T_3	-0.06	-0.02
	T_4	-0.06	-0.02
	T_5	-0.06	-0.02
	T_6	-0.06	-0.02

Sequence	Treatment	1981	1982
Fallow-rice-rice (A5)	T_1	-0.03	-0.04
	T_2	-0.03	-0.04
	T_3	-0.03	-0.04
	T_4	-0.03	-0.04
	T_5	-0.03	-0.04
	T_6	-0.03	-0.04
iii) After mundakan			
Rice-rice-rice (A1)	T_1	-0.13	-0.13
	T_2	-0.13	-0.13
	T_3	-0.13	-0.13
	T_4	-0.13	-0.13
	T_5	-0.13	-0.13
	T_6	-0.13	-0.13
Sweet potato-rice-rice (A2)	T_1	-0.06	-0.12
	T_2	-0.06	-0.12
	T_3	-0.06	-0.12
	T_4	-0.06	-0.12
	T_5	-0.06	-0.12
	T_6	-0.06	-0.12
Cowpea-rice-rice (A3)	T_1	-0.11	-0.12
	T_2	-0.11	-0.12
	T_3	-0.11	-0.12
	T_4	-0.11	-0.12
	T_5	-0.11	-0.12
	T_6	-0.11	-0.12
Daincha-rice-rice (A4)	T_1	-0.08	-0.06
	T_2	-0.08	-0.06
	T_3	-0.08	-0.06
	T_4	-0.08	-0.06
	T_5	-0.08	-0.06
	T_6	-0.08	-0.06

(Contd. .4)

Sequence	Treatment	1981	1982
Fallow-rice-rice (A5)	T_1	-0.08	-0.04
	T_2	-0.08	-0.04
	T_3	-0.08	-0.04
	T_4	-0.08	-0.04
	T_5	-0.08	-0.04
	T_6	-0.08	-0.04

produce such as grain or tuber appear to be not significantly affected in their quality especially NPK content by marginal difference in the NPK content of the manuring schedule (Treatments) or due to sequences. This observation is fairly of universal application in various situations.

The nutrient NPK that have residually accumulated from the previous crop/crops together with the quantity currently applied for the succeeding component crop has produced differential responses in the yield of various crops. This has been discussed at length under yield for various component crops of the different sequences. However, the nutrient levels in the soil have not been able to make the differences to be felt in their content in various plant parts.

B. Soil studies

Tables 72 to 74 present data on the changes in soil pH over the initial status due to the different cropping sequences and treatments. The pH was determined before and after each component crop and the data are presented in Tables 72 and 73. The summary of the data showing the pH changes in each cropping sequences after each year is presented in Table 74.

The sequence fallow-rice-rice also decreased the soil pH in both the years of the experiments. In all the component crops tried, it was found that treatments had no effect in decreasing the soil pH. Only the crops of the sequences had any effect of soil pH. The maximum decrease in pH was observed in the sequence rice-rice-rice.

Cropping definitely will have influence on thesoil pH. According to Lal(1973) the soil pH decreasex considerably with increase in cropping intensity from 100 percent to 400 per cent. Raghavulu andSreeramamoorthy (1975) reported that there is a slight reduction in soil pH at the end of three years of cropping rotations involving rice-wheat, greengram, maize, bengalgram, bajra, barely and blackgram. Juo and Lal (1975) reported that continuous cropping x result in decrease in soil pH.

The plant roots excrete CO_2 in soil solution and this will affect the acidity of the soil. The bases like Ca present in soil, neutralise the acidity so developed and gets leached asCalcium bicarbonate. Depletion of bases in soils leads to increased acidity. Under submerged condition, large quantities of Fe^{++} and Mn^{++} are brought into solution and these ions replace other x cations from the clay complex. Due to this the concentration of NH_4^+, K^+, Ca^{++} and Mg^{++} in the soil solution is increased. The loss from the soil of the calcium and magnesium displaced from soil colloids into the soil solution leads to soil acidification (Brinkman, 1970).

The various component crops of all cropping sequences are fertilised as per the various treatment schedules. Being chemical fertilizers their continuous use for six seasons can increase soil acidity.

The microbial activity in the soil is higher due to the continuous cultivation of crops and due to addition of organic residues of daincha, sweet potato vine and haulms of the pulse crop into the soil. There might be an increase in soil acidity due to release of organic acids to the soil by the decomposition of these residues.

The rice crop is usually grown always under waterlogged conditions. The pH of the waterlogged soils is always near neutral (Ponnamperuma, 1979). Dent (1986) reported that sulphides are present in waterlogged soils. When water is completely drained at the time of harvest of the rice crop, the sulphides get oxidised to sulphates and consequently acidity is generated. This results in a decrease in pH. The present investigation thus is in agreement with the findings of Sadanandan and Mahapatra (1972); and

Table-75

Organic carbon in (Percentage) after each cropping sequence

Sequence	Treatment	Initial status	Period 1981 After summer (C0)	Period 1981 After virippu (C1)	Period 1981 After mundakan (C2)	Period 1982 After summer (C3)	Period 1982 After virippu (C4)	Period 1982 After mundakan (C5)
Rice-rice-rice (A1)	T_1	1.616	1.560	1.570	1.452	1.396	1.356	1.304
	T_2	1.616	1.561	1.509	1.450	1.395	1.355	1.303
	T_3	1.616	1.558	1.507	1.448	1.393	1.352	1.300
	T_4	1.616	1.562	1.568	1.451	1.396	1.355	1.304
	T_5	1.616	1.561	1.508	1.452	1.395	1.357	1.304
	T_6	1.616	1.560	1.510	1.452	1.397	1.356	1.304
Sweet potato-rice-rice (A2)	T_1	1.612	1.671	1.620	1.565	1.614	1.572	1.524
	T_2	1.612	1.668	1.617	1.562	1.612	1.570	1.521
	T_3	1.612	1.665	1.614	1.560	1.610	1.568	1.518
	T_4	1.612	1.670	1.620	1.566	1.613	1.571	1.523
	T_5	1.612	1.671	1.620	1.565	1.614	1.572	1.524
	T_6	1.612	1.676	1.620	1.566	1.615	1.572	1.524

(Contd.....2)

Sequence	Treatment	Initial status	Period					
			1981			1982		
			After summer (C0)	After virippu (C1)	After mundakan (C2)	After summer (C3)	After virippu (C4)	After mundakan (C5)
Cowpea-rice-rice (A3)	T_1	1.615	1.705	1.652	1.612	1.722	1.668	1.613
	T_2	1.615	1.702	1.650	1.610	1.720	1.665	1.611
	T_3	1.615	1.699	1.648	1.607	1.718	1.662	1.608
	T_4	1.615	1.704	1.651	1.611	1.721	1.667	1.613
	T_5	1.615	1.705	1.652	1.612	1.721	1.668	1.612
	T_6	1.615	1.705	1.652	1.612	1.722	1.667	1.613
Daincha-rice rice (A4)	T_1	1.620	2.170	2.105	2.065	2.605	2.245	2.495
	T_2	1.620	2.180	2.103	2.060	2.600	2.541	2.491
	T_3	1.620	2.170	2.100	2.055	2.596	2.538	2.486
	T_4	1.620	2.170	2.104	2.065	2.604	2.546	2.494
	T_5	1.620	2.170	2.105	2.065	2.605	2.545	2.495
	T_6	1.620	2.170	2.105	2.065	2.605	2.545	2.495
Fallow-rice rice (A5)	T_1	1.608	1.609	1.568	1.518	1.519	1.477	1.427
	T_2	1.608	1.609	1.566	1.516	1.517	1.474	1.423
	T_3	1.608	1.609	1.562	1.513	1.513	1.479	1.428
	T_4	1.608	1.609	1.567	1.517	1.516	1.475	1.424
	T_5	1.608	1.609	1.568	1.518	1.519	1.477	1.427
	T_6	1.608	1.609	1.568	1.518	1.519	1.477	1.427

CD for T = 0.002 CD for A = 0.003 CD for C = 0.002

CD for AT = 0.005 CD for AC = 0.005

(5% level)

Table-76

Change in percentage organic carbon content in soil over initial status due to different cropping sequence and Treatments

Sequence	Treatment	Period					
		1981			1982		
		After summer	After virippu	After mundakan	After summer	After virippu	After mundakan
Rice-rice-rice (A1)	T_1	-0.056	-0.050	-0.058	-0.056	-0.052	-0.052
	T_2	-0.058	-0.052	-0.059	-0.055	-0.040	-0.052
	T_3	-0.058	-0.051	-0.059	-0.055	-0.041	-0.052
	T_4	-0.054	-0.054	-0.057	-0.055	-0.041	-0.051
	T_5	-0.055	-0.053	-0.053	-0.057	-0.038	-0.053
	T_6	-0.056	-0.050	-0.050	-0.058	-0.055	-0.052
Sweet potato-rice-rice (A2)	T_1	+0.059	-0.051	-0.055	+0.049	-0.042	-0.048
	T_2	+0.056	-0.051	-0.055	+0.050	-0.042	-0.049
	T_3	+0.053	-0.051	-0.054	+0.050	-0.042	-0.050
	T_4	+0.058	-0.050	-0.054	+0.047	-0.042	-0.080
	T_5	+0.058	-0.050	-0.054	+0.047	-0.042	-0.048
	T_6	+0.059	-0.050	-0.055	+0.047	-0.042	-0.048

(Contd....2)

Sequence	Treatment	Period					
		1981			1932		
		After summer	After virippu	After mundakan	After summer	After virippu	After mundakan
Cowpea-rice-rice (A3)	T_1	+0.090	-0-053	-0-040	+0.110	-0.054	-0.055
	T_2	+0.087	-0.052	-0.040	+0.110	-0.055	-0.054
	T_3	+0.084	-0.051	-0.041	+0.111	-0.056	-0.054
	T_4	+0.089	-0.053	-0.046	+0.110	-0.054	-0.054
	T_5	+0.089	-0.053	-0.046	+0.109	-0.053	-0.056
	T_6	+0.090	-0.053	-0.040	+0.110	-0.055	-0.054
Daincha-rice rice (A4)	T_1	+0.550	-0.065	-0.040	+0.400	-0.060	-0.050
	T_2	+0.560	-0.067	-0.043	+0.430	-0.059	-0.050
	T_3	+0.055	-0.070	-0.044	+0.044	-0.058	-0.052
	T_4	+0.550	-0.064	-0.056	+0.390	-0.060	-0.050
	T_5	+0.550	-0.065	-0.040	+0.400	-0.060	-0.050
	T_6	+0.550	-0.065	-0.040	+0.400	-0.060	-0.050
Fallow-rice-rice (A5)	T_1	+0.001	-0.041	-0.051	+0.001	-0.042	-0.050
	T_2	+0.001	-0.047	-0.050	+0.001	-0.043	-0.051
	T_3	+0.001	-0.047	-0.049	+0.001	-0.044	-0.051
	T_4	+0.001	-0.042	-0.050	+0.001	-0.043	-0.051
	T_5	+0.001	-0.041	-0.050	+0.001	-0.042	-0.050
	T_6	+0.001	-0.041	-0.050	+0.001	-0.042	-0.050

Juo and Lal (1975) who had also observed that maximum decrease in pH of soil occurs in cropping sequences of rice-rice-rice.

Tables 75 to 77 presents the data on the changes in percentage of organic carbon due to the various cropping sequences.

Table 75 shows the data on the changes in organic carbon over the initial status due to the different cropping sequences and treatments. The table 76 represents the net changes and the loss or gain in percentage of organic carbon due to the cropping sequences and treatments under study.

The results show that the organic carbon content of soil decreased after each of the cropping sequences under study. The sequences as well as the treatments have an effect on the percentage of organic carbon in the soil.

In the sequence rice-rice-rice from a level of 1.62 per cent of organic carbon a decrease to 1.30 per cent was observed after the cropping in sequence rice-rice-rice. The treatments T2 and T3 decreased the organic carbon content to the maximum extent in the sequences.

The sequence sweet potato-rice-rice also showed a decrease in organic carbon status of the soil during and after two years of the sequence. Here also the treatments T2 and T3 showed maximum decrease in the organic carbon status of soil. After the harvest of the component crop of sweet potato in the summer season, a slight increase in organic carbon content in all the treatments could be noticed. The treatments have also an effect in decreasing the organic carbon status. The treatments T2 and T3 were shown to have a lesser status of organic carbon in the sequence.

The sequence cowpea-rice-rice also shows a decrease in organic carbon status of the soil but the decrease is very moderate and negligible when compared with the sequences sweet potato-rice-rice, rice-rice-rice and fallow-rice-rice. The treatments T2 and T3 also show less organic carbon per cent in the soil after cultivation of the component crops of the sequence.

The sequence daincha-rice-rice has shown an increase in organic carbon over the initial status throughout the period of the sequence for two years. The treatment has a significant effect in decreasing the organic carbon percentage. Further, T2 and T3 treatments have a lesser percent of organic carbon in the soil.

The fallow-rice-rice sequence also shows the same trend as the rice-rice-rice sequence.

Table-77

Summary table showing change in organic carbon content in soil (Percentage)

Sequence	Treatment	Increase or decrease over initial status	
		1981-82	1982-83
I. After Summer			
Rice-rice-rice (A1)	T_1	-0.056	-0.056
	T_2	-0.058	-0.055
	T_3	-0.058	-0.055
	T_4	-0.054	-0.055
	T_5	-0.055	-0.057
	T_6	-0.056	-0.058
Sweet potato-rice-rice (A2)	T_1	+0.059	+0.049
	T_2	+0.056	+0.050
	T_3	+0.053	+0.050
	T_4	+0.058	+0.047
	T_5	+0.058	+0.047
	T_6	+0.059	+0.047
Cowpea-rice-rice (A3)	T_1	+0.090	+0.110
	T_2	+0.870	+0.110
	T_3	+0.084	+0.111
	T_4	+0.089	+0.109
	T_5	+0.090	+0.109
	T_6	+0.090	+0.110
Daincha-rice-rice (A4)	T_1	+0.550	+0.400
	T_2	+0.560	+0.430
	T_3	+0.550	+0.440
	T_4	+0.550	+0.390
	T_5	+0.550	+0.400
	T_6	+0.550	+0.400

(Contd....2)

Sequence	Treat- ment	Increase or decrease over initial status	
		1981-82	1982-83
Fallow-rice-rice (A5)	T_1	+0.001	+0.001
	T_2	+0.001	+0.001
	T_3	+0.001	+0.001
	T_4	+0.001	+0.001
	T_5	+0.001	+0.001
	T_6	+0.001	+0.001

II After virippu

Sequence	Treat- ment	1981-82	1982-83
Rice-rice-rice (A1)	T_1	-0.050	-0.052
	T_2	-0.052	-0.040
	T_3	-0.051	-0.041
	T_4	-0.054	-0.041
	T_5	-0.053	-0.038
	T_6	-0.050	-0.055
Sweet potato-rice-rice (A2)	T_1	-0.051	-0.042
	T_2	-0.051	-0.042
	T_3	-0.051	-0.042
	T_4	-0.050	-0.042
	T_5	-0.050	-0.042
	T_5	-0.050	-0.042
Cowpea-rice-rice (A3)	T_1	-0.053	-0.054
	T_2	-0.052	-0.055
	T_3	-0.051	-0.056
	T_4	-0.053	-0.054
	T_5	-0.053	-0.053
	T_6	-0.053	-0.055
Daincha-rice-rice (A4)	T_1	-0.065	-0.060
	T_2	-0.067	-0.059
	T_3	-0.070	-0.058
	T_4	-0.064	-0.058
	T_5	-0.065	-0.060
	T_6	-0.065	-0.060

Sequence	Treat-ment	Increase or decrease over initial status	
		1981-82	1982-83
Fallow-rice-rice (A5)	T1	-0.041	-0.042
	T2	-0.047	-0.043
	T3	-0.047	-0.044
	T4	-0.042	-0.043
	T5	-0.041	-0.042
	T6	-0.041	-0.042
III After Mundakan			
Rice-rice-rice (A1)	T1	-0.058	-0.052
	T2	-0.059	-0.052
	T3	-0.059	-0.052
	T4	-0.057	-0.051
	T5	-0.053	-0.053
	T6	-0.050	-0.052
Sweet potato-rice-rice (A2)	T1	-0.055	-0.048
	T2	-0.055	-0.049
	T3	-0.054	-0.050
	T4	-0.054	-0.048
	T5	-0.054	-0.048
	T6	-0.055	-0.048
Cowpea-rice-rice (A3)	T1	-0.040	-0.055
	T2	-0.040	-0.054
	T3	-0.041	-0.054
	T4	-0.046	-0.054
	T5	-0.046	-0.056
	T6	-0.040	-0.054

(Contd.....3)

Sequence	Treat-ment	Increase or declrease over initial status	
		1981-82	1982-83
Daincha-rice-rice (A4)	T1	-0.040	-0.050
	T2	-0.043	-0.050
	T3	-0.044	-0.052
	T4	-0.056	-0.050
	T5	-0.040	-0.050
	T6	-0.040	-0.050
Fallow-rice-rice (A5)	T1	-0.051	-0.050
	T2	-0.050	-0.051
	T3	-0.049	-0.051
	T4	-0.050	-0.051
	T5	-0.050	-0.050
	T6	-0.050	-0.050

The maximum decrease in organic carbon percentage was noticed in the rice-rice-rice sequence, followed by fallow-rice-rice and sweet potato-rice-rice sequence. The decrease in organic carbon was found to be very negligible at the end of two years in the sequence cowpea-rice-rice.

The daincha-rice-rice sequence has shown the highest gain in organic carbon status of the soil after 2 years of the sequence.

Over-all analysis of the summary Table-77 reveals that the operation of the various sequences for a period of two years results in a slight decrease in organic carbon level of the rice-rice-rice, fallow-rice-rice and sweet potato-rice-rice sequence. Maintenance of the organic carbon level in the cowpea-rice-rice sequence and an over all increase in the organic carbon level in the daincha-rice-rice sequence has been observed. Though the above is the broad picture that emerged, there are fluctuations in the organic carbon level after each component crop. Thus, the <u>in situ</u> ploughing of the daincha in summer in the sequence daincha-rice-rice, the incorporation in soil of the vine and leaves of sweet potato-rice-rice and the addition of the haulm and leaves of cowpea crop after harvest adds on organic matter to the soil. In consequence, after the summer sweet potato, cowpea and daincha crop due to incorporation of organic matter in the soil, a slight increase in organic carbon level in the soil has been observed, though after the sweet potato and pulse crops the addition of organic matter is not as significant in quantity as in the incorporation of the green manure, the daincha crop. In consequence immediately after 1981 and 1982 summer crop in these sequences, the organic carbon level increased initially during the virippu and decreased subsequently during the mundakan. However, in the case of the daincha-rice-rice the addition of the organic matter is sufficient enough to maintain a higher level of organic carbon after six crops. The difficulty in maintaining and building up organic carbon level in tropical soils is well known. However, after the addition of organic matter and at the end of the summer crop, a waterlogged situation is brought about by the South West monsoon during the virippu season. This slows down the decomposition of the incorporated organic matter.

T2 and T3, in general, decreased the organic carbon level in the sequences than other treatments. Both these treatments have decreased the level of all the three nutrients, N, P and K. It is possible that to meet the requirements of microorganisms and crop species competing for nitrogen and nutrients, mineralisation of organic matter is required to take place. In similar sequences but from other situations, a nalgogous findings have been observed by Sahu et al., (1988).

Tables 78 to 80 present the changes in total N per cent of the soil consequent to the growing of various component crops in the cropping sequences under experimentation.

The results show that the sequences have a significant effect on the percent of total nitrogen in the soils. The treatmentshave no significant effect. Between periods and treatments, there is a significant effect.

The data indicate that the sequences have significant effect on soil N. The sequence daincha-rice-rice (A4) is the best in maintaining a higher total N percentage in soil after six continuous crops. The next best sequence is cowpea-rice-rice. This is followed by fallow-rice-rice and rice-rice-rice.

The sequence sweet potato-rice-rice has comparatively lower percentage of nitrogen in the soil after continuous cropping. The treatmentshave no significant effect in maintaining the total N percentage of the soil. However,

Table-78

Changes in total nitrogen content (in percentage) after each cropping sequence

Sequence	Treat-ment	Initial status (C0)	Period 1981 After summer (C1)	After virippu (C2)	After mundakan (C3)	1982 After summer (C4)	After virippu (C5)	After mundakan (C6)
Rice-rice-rice (A1)	T_1	0.161	0.160	0.159	0.158	0.157	0.157	0.156
	T_2	0.161	0.160	0.159	0.158	0.157	0.156	0.155
	T_3	0.161	0.160	0.159	0.157	0.157	0.156	0.155
	T_4	0.161	0.160	0.159	0.158	0.157	0.156	0.155
	T_5	0.161	0.160	0.159	0.158	0.157	0.157	0.156
	T_6	0.161	0.160	0.159	0.158	0.157	0.157	0.155
Sweet potato-rice-rice (A2)	T_1	0.161	0.161	0.160	0.159	0.158	0.158	0.158
	T_2	0.161	0.160	0.159	0.158	0.158	0.158	0.157
	T_3	0.161	0.160	0.159	0.158	0.158	0.157	0.157
	T_4	0.161	0.161	0.160	0.159	0.158	0.158	0.157
	T_5	0.161	0.161	0.160	0.159	0.158	0.158	0.158
	T_6	0.161	0.160	0.160	0.159	0.158	0.158	0.158

(Contd.....2)

Sequence	Treatment	Initial status (C0)	Period 1981 After summer (C1)	1981 After virippu (C2)	1981 After mundakan (C3)	1982 After summer (C4)	1982 After virippu (C5)	1982 After mundakan (C6)
Cowpea-rice-rice (A3)	T_1	0.161	0.162	0.160	0.158	0.158	0.157	0.155
	T_2	0.161	0.161	0.159	0.157	0.158	0.158	0.154
	T_3	0.161	0.161	0.159	0.157	0.157	0.158	0.154
	T_4	0.161	0.161	0.159	0.157	0.158	0.157	0.154
	T_5	0.161	0.162	0.160	0.158	0.158	0.157	0.154
	T_6	0.161	0.162	0.160	0.158	0.158	0.159	0.154
Daincha-rice-rice (A4)	T_1	0.161	0.164	0.162	0.161	0.165	0.165	0.164
	T_2	0.161	0.164	0.162	0.161	0.163	0.161	0.162
	T_3	0.161	0.163	0.162	0.161	0.163	0.162	0.161
	T_4	0.161	0.164	0.162	0.161	0.163	0.162	0.162
	T_5	0.161	0.162	0.160	0.161	0.165	0.165	0.164
	T_6	0.161	0.162	0.160	0.161	0.165	0.165	0.164
Fallow-rice-rice (A5)	T_1	0.161	-	0.160	0.159	-	0.159	0.158
	T_2	0.161	-	0.160	0.159	-	0.158	0.157
	T_3	0.161	-	0.160	0.158	-	0.157	0.156
	T_4	0.161	-	0.160	0.159	-	0.158	0.158
	T_5	0.161	-	0.160	0.159	-	0.158	0.158
	T_6	0.161	-	0.160	0.159	-	0.158	0.157

CD A = 0.015
CD B = 0.009
(5% level)

CD C = 0.009
CD AT = 0.02
CD AC = 0.02

treatment T1 with the recommended dose of NPK maintains a higher N percentage in the soil after its application in six seasons.

The result indicates that the period has a significant effect in the percentage of total nitrogen in soil.

The result is indicative of the effect of each component crop on the initial N level in the soil. The result indicates that the period has a significant effect on the percentage of total nitrogen in soil.

Table 78 indicates that there is a significant effect on the percentage of total nitrogen in the soil between periods and sequences. Thus, the sequence daincha-rice-rice (A4) shows less decrease in total nitrogen percentage of soil due to continuous cropping. This is followed by the sequence cowpea-rice-rice (A3). It can also be seen that the sequence A4 and A1 are on par. This is immediately followed by the sequence A5 ie. fallow-rice-rice. This again is on par with rice-rice-rice sequence (A1). The sequence A5 and A3 are also on par with the sequence cowpea-rice-rice in maintaining the total N percentage in the soil. The highest nitrogen per cent in the soil is noted in the sequence sweet potato-rice-rice sequence.

Table-79

Available nitrogen content in ppm after each cropping sequence

Sequence	Treatment	Initial status (C0)	1981 After summer (C1)	1981 After virippu (C2)	1981 After mundakan (C3)	1982 After summer (C4)	1982 After virippu (C5)	1982 After mundakan (C6)
Rice-rice-rice (A1)	T1	25	24	23	22	21	20	19
	T2	25	23	22	21	20	19	18
	T3	25	22	21	20	19	18	17
	T4	25	23	22	21	20	19	18
	T5	25	24	23	22	21	20	19
	T6	25	24	23	22	21	20	19
Sweet potato-rice-rice (A2)	T1	25	22	21	20	19	18	17
	T2	25	21	20	19	18	17	16
	T3	25	20	19	18	17	16	15
	T4	25	21	20	19	18	17	16
	T5	25	22	21	20	19	18	17
	T6	25	22	21	20	19	18	17
Pulse-rice-rice (A3)	T1	25	27	26	25	26	25	24
	T2	25	26	25	24	25	24	23
	T3	25	25	24	23	24	23	22
	T4	25	26	25	24	25	24	23
	T5	25	27	26	25	26	26	25
	T6	25	27	26	25	26	26	25

(Contd....2)

Sequence	Treatment	Initial status (C0)	Period					
			1981			1982		
			After summer (C1)	After viripPu (C2)	After mundakan (C3)	After summer (C4)	After viripPu (C5)	After mundakan (C6)
Daincha-rice-rice (A4)	T1	25	26	25	24	25	24	23
	T2	25	25	24	23	24	23	22
	T3	25	24	23	22	23	22	21
	T4	25	25	24	23	24	23	22
	T5	25	26	25	24	25	24	23
	T6	25	26	25	24	25	24	23
Fallow-rice-rice (A5)	T1	25	25	24	23	23	22	21
	T2	25	25	23	22	22	21	20
	T3	25	25	22	21	21	20	19
	T4	25	25	23	22	22	21	20
	T5	25	25	24	23	23	22	21
	T6	25	25	24	23	23	22	21

(5% level) CD A = 0.25 CD T = 0.19 CD C = 0.20

CD A T = 0.43 CD A C = 0.45

Between periods and treatments there is significant effect with respect to total N present in the soil under all the sequences studied.

There is a close relationship between the observed trends in the organic carbon levels in soil and the total nitrogen levels as a result of cropping sequences.

In fact the Tables 75 to 78 present this data clearly. Thus the cropping sequences daincha-rice-rice, and pulse-rice-rice have a much higher total nitrogen in soils than the rice-rice-rice or sweet potato-rice-rice sequence. This is on account of the leguminous, green manure and pulse crops grown in summer in the sequences, A3 and A4 and the consequent fixation of atmospheric nitrogen by the rhizhobial associations. The sweet potato crop being an exhaustive crop removes nitrogen as well as other nutrients. The low nitrogen status in the sequence is due to the removal of nitrogen by this crop. Sasidhar and Sadanandan (1977) have also found that sweet potato-rice-rice is a nutrient depleting sequence. Other workers like Yadav and Singh (1986) also found daincha-rice-rice and pulse-rice-rice to be a nitrogen building or at least nitrogen maintaining cropping sequence.

Table 79 presents the available nitrogen in ppm of the soil after each component crop of the various sequences.

The results indicate that the sequences, treatments and, period are significant.

The data show that the sequence cowpea-rice-rice (A3) is the best in maintaining a higher available nitrogen status. This is closely followed by daincha-rice-rice (A4), fallow rice-rice (A5) and rice-rice-rice sequence. The sequence sweet potato-rice-rice exhausts the soil to a greater extent and decreases the soil of its available N status.

The treatments also have a significant effect in maintaining the available N status of the soil. The treatment T1 provided highest available N status to the soil followed by T6, T5 and T4 which were on par. The treatment T3 which included the three major nutrients at half the recommended doses could not maintain the available N status of the soil. The treatments T5 and T4 were on par. It is seen that in the treatment T1 which received the full recommended dose of nitrogen had the highest available N status maintained, followed by T6 and T5 which also included the full dose of nitrogen. They were also on par in providing available N status of the soil in the sequence.

The available N of the soil significantly decreases from the initial status throughout the cropping sequence

Table-80

Summary table showing change in available nitrogen in soil (ppm)

Sequence	Treatment	Increase or decrease over initial status 1981-82	1982-83
i) After summer			
Rice-rice-rice (A1)	T1	-1	-4
	T2	-2	-5
	T3	-3	-6
	T4	-2	-5
	T5	-1	-4
	T6	-1	-4
Sweet potato-rice-rice (A2)	T1	-3	-6
	T2	-4	-7
	T3	-5	-8
	T4	-4	-7
	T5	-3	-6
	T6	-3	-6
Pulse-rice-rice (A3)	T1	+2	-1
	T2	+1	+0
	T3	+0	-1
	T4	+1	+0
	T5	+2	+1
	T6	+2	+1
Daincha-rice-rice (A4)	T1	+1	+0
	T2	+0	-1
	T3	-1	-2
	T4	+0	-1
	T5	+1	+0
	T6	+1	+0
Fallow-rice-rice (A5)	T1	+0	-2
	T2	+0	-3
	T3	+0	-4
	T4	+0	-3
	T5	+0	-2
	T6	+0	-2

(Contd....2)

Sequence	Treat-ment	Increase or decrease over initial status	
		1981-82	1982-83
ii) <u>After virippu</u>			
Rice-rice-rice (A1)	T1	-2	-5
	T2	-3	-6
	T3	-4	-7
	T4	-3	-5
	T5	-2	-4
	T6	-2	-4
Sweet potato-rice-rice (A2)	T1	-4	-7
	T2	-5	-8
	T3	-6	-7
	T4	-5	-8
	T5	-4	-7
	T6	-4	-7
Pulse-rice-rice (A3)	T1	+1	+0
	T2	+0	-1
	T3	-1	-2
	T4	+0	-0
	T5	+1	+0
	T6	+1	+0
Daincha-rice-rice (A4)	T1	+0	-1
	T2	-1	-2
	T3	-2	-4
	T4	-1	-2
	T5	+0	-1
	T6	+1	+0
Fallow-rice-rice (A5)	T1	-1	-3
	T2	-2	-4
	T3	-3	-5
	T4	-2	-4
	T5	-1	-3
	T6	-1	-3

(Contd.....3)

Sequence	Treat-ment	Increase or decrease over initial status	
		1981-82	1982-83
iii) After mundakan			
Rice-rice-rice (A1)	T1	-3	-6
	T2	-4	-7
	T3	-5	-8
	T4	-4	-7
	T5	-3	-6
	T6	-3	-6
Sweet potato-rice rice (A2)	T1	-5	-8
	T2	-7	-9
	T3	-7	-10
	T4	-8	-9
	T5	-5	-8
	T6	-5	-8
Pulse-rice-rice (A3)	T1	+0	-1
	T2	-1	-2
	T3	-2	-3
	T4	-1	-2
	T5	+0	+0
	T6	+0	+0
Daincha-rice-rice (A4)	T1	-1	-2
	T2	-2	-3
	T3	-3	-4
	T4	-2	-3
	T5	-1	-2
	T6	-1	-2
Fallow-rice-rice (A5)	T1	-2	-4
	T2	-3	-5
	T3	-4	-6
	T4	-2	-4
	T5	-2	-4

The total nitrogen content of a soil is a measure of overall soil fertility. The contribution of various cropping systems in increasing the soil fertility can be assessed by finding out the percentage of nitrogen in the soil before and after each crop and at the end of each of the cropping sequences.

From the table, it is clear that in all the treatments and in all the sequences a decrease in total nitrogen takes place. The sequence cowpea-rice-rice and daincha-rice-rice, however, show an increase in total nitrogen content of the soil immediately after the summer crop. There was maximum decrease in total nitrogen at the end of two years in the sequences rice-rice-rice and sweet potato-rice-rice. The same is true of available nitrogen status of the soil. The summary table 90 reveals that there is a slight gain in available nitrogen status in the cowpea-rice-rice and daincha-rice-rice sequences immediately after the summer crop.

The gain in total nitrogen status of soil can take place due to the addition of fertilizers, plant residues and organic matter or by rain water as well as by the activities of non-symbiotic nitrogen fixing bacteria or blue green algae. Symbiotic nitrogen fixation by root nodules of leguminous plants also contributes towards increased nitrogen in the soil. A decrease or loss nitrogen status of the soil can occur due to crop removal, by leaching, by erosion, by solubilisation etc. The increase in total nitrogen and available nitrogen content of the soil after cowpea-rice-rice and daincha-rice-rice sequences may be due to the residual effect of the organic matter incorporated coupled with the additional fixation of nitrogen in the root nodules of these crops. The judicious inclusion of legumes and green manures in the cropping sequences is found to be desirable by Merchandani and Khan (1953). Legumes have been found to increase the organic matter status of soils by several workers like Jones, (1942), Moore, (1962), Watson, (1963), Rixon, (1966). This has been attributed to the profuse rooting pattern and their resistance to easy decomposition. A well developed root system of legumes favours accumulation of humus in soil even during the growth of plants due to the continuous sloughing off of root tissue. The increase in nitrogen content of cowpea as compared to that of daincha in the present study may be due to the comparatively higher accumulation of organic

Table-81

Changes in total 'P' (ppm e) from the initial status after each component in the different cropping sequences

Sequence	Treatment	Initial status (C0)	Periods 1981-82 After Summer (C1)	After virippu (C2)	After mundakan (C3)	1982-83 After Summer (C4)	After virippu (C5)	After mundakan (C6)
Rice-rice-rice- (A1)	T1	900	905	910	915	920	925	928
	T2	900	903	908	913	918	922	926
	T3	900	902	906	912	916	920	923
	T4	900	906	910	917	921	925	925
	T5	900	904	907	914	917	923	926
	T6	900	905	911	916	922	924	927
Sweet potato-rice-rice (A2)	T1	900	903	909	913	916	921	926
	T2	900	903	906	911	913	919	923
	T3	900	901	904	912	912	917	922
	T4	900	904	907	915	915	920	927
	T5	900	902	905	911	914	918	924
	T6	900	905	908	914	917	919	925

(Contd...2)

Sequence	Treatment	Initial status (Co)	Periods					
			1981-82			1982-83		
			After summer (C1)	After Viripppu (C2)	After Mundakan (C3)	After Summer (C4)	After Viripppu (C5)	After Mundakan (C6)
Cowpea-rice-rice (A3)	T1	900	902	907	913	914	917	923
	T2	900	902	905	911	916	917	920
	T3	900	901	903	909	914	913	919
	T4	900	904	906	914	917	918	924
	T5	900	902	904	910	915	914	921
	T6	900	903	906	912	918	916	922
Daincha-rice-rice (A4)	T1	900	899	904	909	912	918	923
	T2	900	896	902	906	911	916	921
	T3	900	898	901	905	910	914	920
	T4	900	899	905	909	914	917	922
	T5	900	898	903	907	912	916	921
	T6	900	899	906	908	915	919	924
Fallow-rice-rice (A5)	T1	900	900	905	910	916	920	925
	T2	900	900	903	908	913	918	922
	T3	900	900	902	907	912	917	921
	T4	900	900	905	909	914	921	924
	T5	900	900	904	908	913	919	923
	T6	900	900	907	911	915	922	926

CD-A = 4.69 CD-T = 3.59 CD-C = 1.81 CD-AT = 8.041 CD-AC=4.05

(5% level)

matter after the decay of crop residues and also due to the higher fixation of nitrogen by the daincha spp. The fixation of nitrogen by cowpea was estimated by Mutomon (1971) at 73.24 kg per annum. The addition of green manure also increases the total nitrogen in soil as reported by Sahu et al., (1988). The treatments have an effect in increasing the total available nitrogen status of the soil. T1, T5 and T6 are found to be better.

The observation that there was a decrease in total and available nitrogen of the soil in a continuous cropping sequence is in agreement with the findings of several workers. Racho and De Dutta (1968) observed that application of fertilizer nitrogen to rice, irrespective of rates of application, had no residual value for the succeeding crop. Ghosh and Kanzaria (1964) found that a purely cereal rotation is inferior in all respects especially regarding residual nitrogen in soil. The higher decrease of total nitrogen after a rice crop may be due to the higher rate of oxidation of nitrogen in summer season and subsequent loss due to leaching with the onset of monsoon. The results of the present investigation is in agreement with the above findings.

Table-81 presents the changes in total P (in ppm) from the initial status after the cultivation of each component crop included in the sequence. The result shows that sequence, treatment and periods have a significant effect on the total P status of the soil. The sequence cowpea-rice-rice (A3) is the best sequence in maintaining a higher total P status of the soil, out of the five cropping sequences studied. This was closely followed by daincha-rice-rice (A4) sequence. The rice-rice-rice and sweet potato-rice-rice were the sequences that maintained a poor total 'P' status of the soil. The T1 and T6 are the best treatments for maintaining a high total 'P' status of the soil. This was followed by T5. It has to be noted that these treatments were maintaining the full recommended doses of P. The lowest level of P was incidently maintained in treatment T3 where only 50 per cent of the recommended doses of P had been applied.

In general, a tendency to increase the total phosphorus content in the soil over the initial level is seen in all the sequences. Thus, after the experiment the soil maintains an increased level of total 'P' in all the sequences. The sequence itself has an influence in determining the total P status of the soil. The P status of the soil in the pulse-rice-rice and daincha-rice-rice was higher because of the incorporation of green matter to the soil by these crops.

Table-82

Changes in available 'P' (in ppm) in soil over initial status due to different cropping sequences

Sequence	Treat-ment	Initial status (CO)	Period 1981-82 After summer (C1)	After virippu (C2)	After mundakan (C3)	1982-83 After Summer (C4)	After Virippu (C5)	After mundakan (C6)
Rice-rice-rice (A1)	T1	16	18	20	22	23	24	25
	T2	16	17	19	21	22	23	24
	T3	16	16	18	20	21	22	23
	T4	16	18	20	22	23	24	26
	T5	16	17	19	21	22	23	24
	T6	16	18	20	22	23	24	26
Sweet potato-rice-rice (A2)	T1	16	15	16	18	14	16	18
	T2	16	12	14	16	12	14	16
	T3	16	10	12	14	20	12	14
	T4	16	14	16	18	14	16	18
	T5	16	12	14	16	12	14	16
	T6	16	14	16	18	14	16	18

(Contd...2)

Sequence	Treatment	Initial status (C0)	Period 1981-82 After summer (C1)	1981-82 After Virippu (C2)	1981-82 After Mundakan (C3)	1982-83 After Summer (C4)	1982-83 After Virippu (C5)	1982-83 After Mundakan (C6)
Cowpea-rice-rice (A3)	T1	16	18	21	23	25	27	29
	T2	16	16	18	20	22	24	26
	T3	16	14	16	18	20	22	24
	T4	16	18	21	23	25	27	29
	T5	16	16	18	20	22	24	26
	T6	16	18	21	23	25	27	29
Daincha-rice-rice (A4)	T1	16	15	18	22	18	22	24
	T2	16	15	16	20	17	21	23
	T3	16	15	14	18	16	19	21
	T4	16	15	16	20	18	22	24
	T5	16	15	16	20	17	21	23
	T6	16	15	18	22	18	22	24
Fallow-rice-rice (A5)	T1	16	16	18	20	20	22	24
	T2	16	16	17	19	19	21	23
	T3	16	16	16	18	18	20	22
	T4	16	16	16	20	20	22	24
	T5	16	16	18	19	19	21	23
	T6	16	16	20	20	20	22	24

(5% level) CD-A = 0.28 CD-T = 0.13 CD-C = 0.11 CD-AT= 0.31 CD-AC= 0.25

Table-83

Changes in available P in ppm over the initial status due to different cropping sequences

Sequence	Treat-ment	After Summer (C1)	After Virippu (C2)	After Mundakan (C3)	After Summer (C4)	After Virippu (C5)	After Mundakan (C6)
Rice-rice-rice (A1)	T1	+2	+4	+6	+1	+2	+3
	T2	+1	+3	+5	+1	+2	+3
	T3	+0	+2	+4	+1	+2	+3
	T4	+2	+4	+6	+1	+2	+3
	T5	+1	+3	+5	+1	+2	+3
	T6	+2	+4	+6	+1	+2	+3
Sweet potato-rice-rice (A2)	T1	-1	-0	+2	-2	-2	+2
	T2	-4	-2	+0	-4	-2	+0
	T3	-6	-4	-2	-4	-2	-2
	T4	-2	+0	+2	-4	-2	+2
	T5	-4	-2	+0	-4	-2	+0
	T6	-2	-0	+2	-4	-2	+2

(Contd....2)

Sequence	Treatment	After Summer (C1)	After Virippu (C2)	After Mundakan (C3)	After Summer (C4)	After Virippu (C5)	After Mundakan (C6)
Cowpea-rice-rice (A3)	T1	+2	+5	+7	+2	+4	+6
	T2	+0	+2	+4	+2	+4	+6
	T3	+2	+0	+0	+2	+4	+6
	T4	+2	+5	+5	+2	+4	+6
	T5	+0	+2	+2	+2	+4	+6
	T6	+2	+5	+5	+2	+4	+6
Daincha-rice-rice (A4)	T1	−1	+2	+6	−4	+0	+2
	T2	−1	+0	+4	−3	+1	+3
	T3	−1	−2	+2	−2	+1	+3
	T4	−1	+0	+4	−2	+2	+4
	T5	−1	+0	+4	−3	+1	+3
	T6	−1	+2	+6	−4	+0	+2
Fallow-rice-rice (A5)	T1	+0	+2	+4	+0	+2	+4
	T2	+0	+1	+3	+0	+2	+4
	T3	+0	+0	+2	+0	+2	+4
	T4	+0	+0	+4	+0	+2	+4
	T5	+0	+2	+3	+0	+2	+4
	T6	+0	+4	+4	+0	+2	+4

Table-82 presents the change in available 'P' status of the soil after each component crop in the cropping sequence. This is given in summary Table 83. From the results, it can be seen that sequence, treatment and periods have an effect in determining the available 'P' status of the soil. The available 'P' status was high in daincha-rice-rice and pulse-rice-rice (A3) and they were found to be on par. This was followed by the sequence fallow-rice-rice (A5). The least available P status was shown by rice-rice-rice and sweet potato-rice-rice (A2). Among the treatments tried, T6 and T1 are found to be the best ones and are on par. The next best treatments are T4 and T5. The treatments T1 and T6 were incidentally the treatments with full doses of P. T4 and T5 were with 75 per cent of the recommended dose of P. The lowest level of P was noted for treatment which T3, incidentally received only 50 per cent of the recommended doses of P. The rate of increase in available P, status of the soil was noted to be maximum for daincha-rice-rice (A4).and cowpea-rice-rice. The rice-rice-rice and sweet potato-rice-rice sequences maintained a lower level of available 'P' status in soil.

So, from the table it is clear that there was an increase in available P content of the soil after daincha and cowpea. The cultivation of the rice crop in all the seasons decreases the available 'P' status of soil. This may be attributed to the legume effect which may be due to the humic substance produced by the legume residue, solubilising effect of soil microflora and the CO_2 regimes produced by the micro-organisms which solubilises insoluble phosphates. So, the cowpea crop is capable of converting the unavailable phosphates of soil into available form (Raheja 1966). The unique ability of legumes to fix nitrogen and mineralise soil phosphate leads to release of incorporated P when applied as green manure. The decomposition of the green manure in soil thus produces the organic acids which solubilises the fixed form of 'P' in the soil soluble forms. Further mineralisation of the organic P occurs. This has been reported by Mahendra Singh and Jaiprakash (1968), Ghosh and Kanzaria (1964).

At the end of a rice-rice-rice sequence, the soils contain less available P than other sequences. This is due to the continuous waterlogging of the soil in all the three sequences. This leads to release of available P which is taken up, by the rice crop.

The uptake of P by rice crop also is higher than in other crops and this would have been one of the reasons

TABLE-84

Changes in total 'K' from initial status (Percentage) after each component crop in the different sequences

Sequence	Treat-ment	Initial status (C0)	Periods 1981-82 After Summer (C1)	After Virippu (C2)	After Mundakan (C3)	1982-83 After Summer (C4)	After Virippu (C5)	After Mundakan (C6)
Rice-Rice-Rice (A1)	T1	0.120	0.119	0.117	0.116	0.115	0.113	0.112
	T2	0.120	0.118	0.116	0.115	0.114	0.112	0.111
	T3	0.120	0.118	0.115	0.115	0.113	0.111	0.111
	T4	0.120	0.119	0.117	0.116	0.115	0.113	0.112
	T5	0.120	0.119	0.117	0.116	0.115	0.113	0.112
	T6	0.120	0.118	0.116	0.115	0.114	0.112	0.111
Sweet potato-rice-rice (A2)	T1	0.120	0.117	0.115	0.114	0.111	0.109	0.108
	T2	0.120	0.117	0.115	0.114	0.110	0.109	0.108
	T3	0.120	0.116	0.114	0.113	0.110	0.108	0.107
	T4	0.120	0.117	0.115	0.114	0.111	0.109	0.108
	T5	0.120	0.117	0.115	0.114	0.111	0.109	0.108
	T6	0.120	0.117	0.115	0.114	0.110	0.109	0.108

(Contd.....2)

Sequence	Treatment	Initial status (C0)	1981-82 After Summer (C1)	1981-82 After Virippu (C2)	1981-82 After Mundakan (C3)	1982-83 After Summer (C4)	1982-83 After Virippu (C5)	1982-83 After Mundakan (C6)
Cowpea-rice-rice (A3)	T1	0.120	0.119	0.118	0.118	0.117	0.116	0.115
	T2	0.120	0.119	0.118	0.117	0.116	0.115	0.114
	T3	0.120	0.118	0.117	0.116	0.116	0.115	0.114
	T4	0.120	0.119	0.118	0.117	0.117	0.117	0.115
	T5	0.120	0.119	0.118	0.117	0.117	0.116	0.115
	T6	0.120	0.118	0.118	0.116	0.116	0.115	0.114
Daincha-rice-rice (A4)	T1	0.120	0.118	0.117	0.116	0.114	0.113	0.112
	T2	0.120	0.118	0.117	0.116	0.114	0.113	0.112
	T3	0.120	0.118	0.117	0.116	0.116	0.115	0.114
	T4	0.120	0.117	0.116	0.115	0.113	0.112	0.111
	T5	0.120	0.118	0.117	0.116	0.114	0.113	0.112
	T6	0.120	0.118	0.117	0.116	0.114	0.113	0.112
Fallow-rice-rice (A5)	T1	0.120	0.120	0.119	0.117	0.116	0.115	0.114
	T2	0.120	0.120	0.118	0.116	0.115	0.114	0.113
	T3	0.120	0.120	0.118	0.116	0.115	0.114	0.113
	T4	0.120	0.120	0.119	0.117	0.116	0.115	0.114
	T5	0.120	0.120	0.119	0.117	0.116	0.115	0.114
	T6	0.120	0.120	0.118	0.116	0.115	0.114	0.113

CD-A = 8.8 CD-T = 3.8 CD-C = 1.34 CD-AT = 8.5 CD-AC = 3.01

(5% level)

Table-85

Change in exchangeable 'K' (in ppm) after each cropping sequence over initial status due to different cropping sequence

Sequence	Treatment	Initial status	Period 1981-82 After summer	1981-82 After Virippu	1981-82 After Mundakan	1982-83 After Summer	1982-83 After Virippu	1982-83 After Mundakan
Rice-rice-rice (A1)	T1	90	80	75	70	65	60	55
	T2	90	77	73	68	62	58	53
	T3	90	72	68	63	60	57	51
	T4	90	77	73	67	63	59	54
	T5	90	80	75	70	65	60	55
	T6	90	77	72	67	62	58	52
Sweet potato-rice-rice (A2)	T1	90	75	70	65	60	55	50
	T2	90	72	67	62	58	52	48
	T3	90	69	64	60	55	51	46
	T4	90	72	67	62	58	52	50
	T5	90	75	70	65	60	55	50
	T6	90	72	67	62	58	52	58

(Contd......2)

Sequence	Treatment	Initial status	Period					
			1981-82			1982-83		
			After Summer	After Virippu	After Mundakan	After Summer	After Virippu	After Mundakan
Cowpea-rice-rice (A3)	T1	90	87	82	77	72	68	63
	T2	90	84	80	75	70	66	61
	T3	90	81	77	72	68	65	58
	T4	90	87	82	78	73	67	62
	T5	90	87	82	76	72	68	64
	T6	90	84	80	75	70	66	60
Daincha-rice-rice- (A4)	T1	90	85	92	85	80	85	70
	T2	90	82	89	82	87	72	67
	T3	90	79	86	79	74	69	64
	T4	90	75	92	85	80	75	70
	T5	90	85	92	85	80	75	70
	T6	90	82	89	82	77	72	67
Fallow-rice-rice (A5)	T1	90	90	85	80	80	75	70
	T2	90	90	82	77	77	72	67
	T3	90	90	79	74	74	69	64
	T4	90	90	85	80	80	75	70
	T5	90	90	85	80	80	75	70
	T6	90	90	82	77	77	72	67

CD-A=0.52 CD-T = 0.25 CD-C = 0.20 CD-AT = 0.60 CD-AC = 0.51

(5% level)

Table-86

Changes in exchangeable 'K' status of soil in ppm over initial status due to different cropping

Sequence	Treatment	1981-82 After Summer	1981-82 After Virippu	1981-82 After Mundakan	1982-83 After Summer	1982-83 After Virippu	1982-83 After Mundakan
Rice-rice-rice (A1)	T1	-10	-15	-20	-5	-10	-15
	T2	-13	-17	-22	-6	-10	-15
	T3	-18	-22	-27	-3	-6	-12
	T4	-13	-17	-23	-4	-8	-13
	T5	-10	-15	-20	-5	-10	-15
	T6	-13	-18	-23	-5	-9	-15
Sweet potato-rice-rice (A2)	T1	-15	-20	-25	-5	-10	-15
	T2	-12	-13	-18	-4	-10	-14
	T3	-21	-26	-30	-5	-9	-14
	T4	-12	-23	-28	-4	-10	-12
	T5	-15	-20	-25	-5	-10	-15
	T6	-18	-23	-28	-4	-10	-4

(Contd......2)

Sequence	Treatment	Period					
		1981-82			1982-83		
		After Summer	After Virippu	After Mundakan	After Summer	After Virippu	After Mundakan
Cowpea-rice-rice (A3)	T1	-3	-8	-13	-5	-9	-14
	T2	-6	-10	-15	-5	-9	-14
	T3	-9	-13	-18	-4	-7	-12
	T4	-3	-8	-12	-5	-11	-16
	T5	-3	-8	-12	-4	-10	-12
	T6	-6	-10	-15	-5	-9	-15
Daincha-rice-rice (A4)	T1	-5	+2	-5	-5	+0	-15
	T2	-8	-1	-3	-5	-10	-15
	T3	-11	-4	-11	-5	-10	-15
	T4	-5	-2	-5	-5	-10	-15
	T5	-5	+2	-5	-5	-10	-15
	T6	-8	-1	-8	-5	-10	-15
Fallow-rice-rice (A5)	T1	+0	-5	-10	+0	-5	-10
	T2	+0	-8	-13	-0	-5	-10
	T3	+0	-11	-16	+0	-5	-10
	T4	+0	-5	-10	+0	-5	-10
	T5	+0	-5	-10	+0	-5	-10
	T6	+0	-8	-13	+0	-5	-10

for the observed decrease in available 'P' status. Further soil samples collected when dried leads to a decrease in their available P status.

Table-84 presents the changes in total K after each component crop of the cropping sequence and Table-85 presents the changes in exchangeable K after each component crop of the cropping sequence. This is also summarised in Table-86.

From the results, it is clear that all crops decrease the exchangeable K level in soil. The sequence and treatments have an effect on the exchangeable K status of the soil. The sequence daincha-rice-rice was found to be the best in maintaining the exchangeable K status of the soil. The cowpea-rice-rice is also able to maintain exchangeable K levels next only to daincha-rice-rice. The sweet potato-rice-rice and rice-rice-rice sequence was less efficient in maintaining exchangeable K status of the soil. The T1, T4 and T5 wherein the full recommended doses of K fertilisers had been applied maintained high exchangeable K status in all the crops studied. The treatments T2 and T3 incidentally contained only half and three fourth of the recommended K fertilizer dose and are found to be least efficient in maintaining the exchangeable K levels.

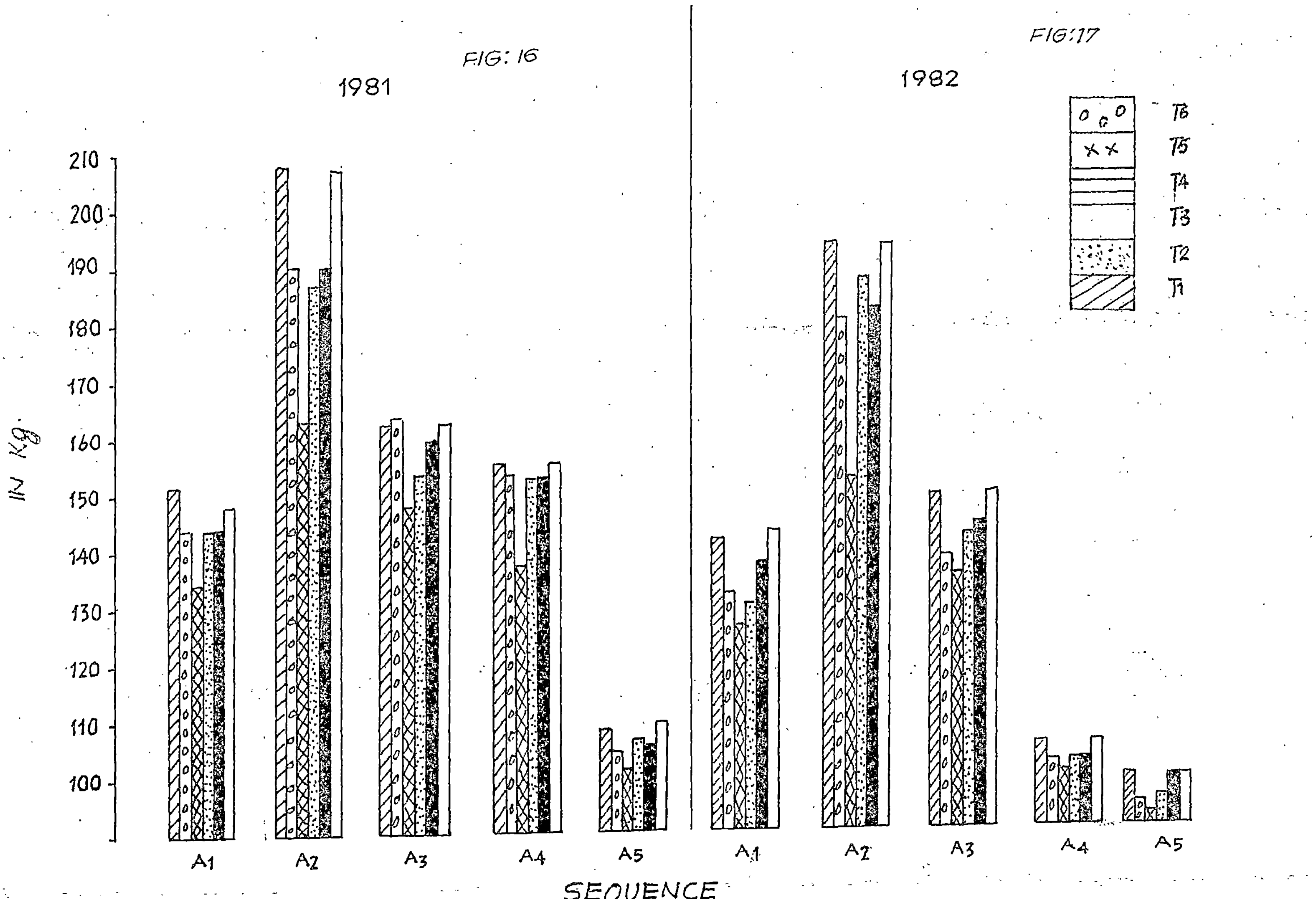
Table-87

Uptake of nitrogen (in kg ha^{-1}) by various crops in the cropping sequences during 1981

Sequence	Treatments	Summer Rice Grain	Summer Rice Straw	Summer Rice Total	Virippu Rice Grain	Virippu Rice Straw	Virippu Rice Total	Mundakan Rice Grain	Mundakan Rice Straw	Mundakan Rice Total	Total N removed in kg after one year
I Rice-rice-rice (A1)	T1	25.09	20.49	45.58	27.96	20.31	48.27	27.84	29.84	57.68	151.53
	T2	23.52	19.27	42.79	26.81	19.47	46.28	26.48	28.59	55.07	144.14
	T3	22.25	18.13	40.38	25.19	18.27	43.46	24.54	26.49	51.03	134.87
	T4	23.09	18.90	41.99	27.00	19.62	46.62	26.73	28.90	55.63	144.24
	T5	22.24	17.72	39.96	27.17	19.74	46.91	26.73	28.90	55.63	144.05
	T6	23.13	19.15	42.28	27.84	20.22	48.06	27.63	29.83	57.46	147.08
		Sweet potato			**Rice**			**Rice**			
		Tuber	Vine	Total	Grain	Straw	Total	Grain	Straw	Total	Total
II Sweet potato-rice-rice (A2)	T1	55.00	51.00	106.00	27.07	19.61	46.68	26.78	29.00	55.78	208.46
	T2	47.50	44.21	91.71	26.29	18.06	44.35	26.12	28.20	54.32	190.38
	T3	34.77	32.36	67.13	25.42	17.65	43.07	25.46	27.50	52.96	163.16
	T4	46.38	43.63	90.51	26.29	19.04	45.33	24.20	27.85	52.05	187.89
	T5	46.49	43.09	90.39	26.29	19.04	45.33	26.34	28.31	54.34	190.37
	T6	54.69	50.90	105.59	27.07	19.61	46.68	26.78	28.08	55.06	207.08

Sequence	Treatments	Summer Cowpea Grain	Summer Cowpea Haulm	Summer Cowpea Total	Virippu Rice Grain	Virippu Rice Straw	Virippu Rice Total	Mundakan Rice Grain	Mundakan Rice Straw	Mundakan Rice Total	Total N removed in kg after one year
III Cowpea-rice-rice (A3)	T1	28.99	16.15	45.14	31.40	22.82	54.22	30.49	32.92	63.41	162.77
	T2	24.71	13.87	38.58	30.40	22.11	52.51	29.74	32.13	61.87	162.98
	T3	24.11	13.57	37.68	28.92	21.03	49.95	29.01	31.33	60.34	147.97
	T4	25.21	14.23	39.44	29.55	21.48	51.03	29.34	31.64	60.98	153.08
	T5	28.49	16.19	44.68	30.49	22.17	52.66	29.97	32.20	62.21	159.55
	T6	28.60	16.13	44.73	31.15	22.65	53.80	30.53	32.99	63.52	162.05
		Daincha Green matter		Total	Rice Grain	Rice Straw	Rice Total	Rice Grain	Rice Straw	Rice Total	Total
IV. Daincha-rice-rice (A4)	T1		37.76	37.06	31.40	22.82	54.22	30.49	32.92	63.71	155.63
	T2		39.09	39.09	30.40	22.11	51.51	29.74	32.13	61.89	153.49
	T3		37.42	37.42	28.92	21.03	49.96	29.01	31.33	60.34	137.72
	T4		40.10	40.10	29.55	21.48	51.03	29.34	31.64	60.98	152.01
	T5		38.20	38.20	30.49	22.17	52.66	29.91	32.30	62.21	152.07
	T6		38.43	38.43	31.15	22.65	53.16	30.53	32.99	63.52	155.72
		Fallow			Rice Grain	Rice Straw	Rice Total	Rice Grain	Rice Straw	Rice Total	Total
V. Fallow-rice-rice (A5)	T1		..		28.74	20.91	49.65	28.19	30.45	58.64	108.29
	T2		..		27.99	20.36	48.35	27.25	28.99	56.24	104.59
	T3		..		27.25	19.83	47.08	26.43	28.35	54.78	101.86
	T4		..		28.19	20.37	50.00	25.45	29.17	54.62	104.62
	T5		..		28.19	20.52	48.71	27.59	29.78	57.37	106.08
	T6		..		29.15	21.21	50.36	28.33	30.58	58.91	109.27

FIG. UPTAKE OF N IN kg. ha⁻¹ OF EACH COMPONENT CROPE IN THE CROPPING SEQUENCES



From the results it is clear that daincha and cowpea sequences maintain comparatively better exchangeable K status in soil when compared to other sequences. This is because both these crops add green manure to the soil. The decomposition of these green manure crops and similar plants have resulted in increasing the exchangeable K status in these sequences by solubilising non-exchangeable K (Verma and Verma, 1988); Hanway (1962) and Nair et al., (1973).

The paddy crop is cultivated under submerged conditions. This results in increased availability of potash (Ponnamperuma 1965). This enables the rice crop to utilise the maximum quality of potash and leaching losses will be more. In the rice-rice-rice sequence, a lower exchangeable K status has always been noticed by other workers also. (Lal 1973), Verma and Verma 1988).

C. Crop uptake

Tables 87 and 88 as well as Figs. 16 and 17 present the data on the uptake of N in kg ha^{-1} by the various component crops of the different cropping sequences during the years 1981 and 1982. In the rice-rice-rice sequence, the summer rice crop (Variety - Triveni) on an average removes 20-25 kg of N by way of the grain and 18 to 21 kg of N through the straw with a total removal of around 40 to 46 kg.

Table-88

Uptake nitrogen (in $kg ha^{-1}$) by various crops in the cropping sequence 1982

Sequence	Treatment	Summer Rice			Virippu Rice			Mundakan Rice			Total N removed in kg after one year
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Total
I Rice-rice rice (A1)	T1	26.15	21.79	47.94	27.22	19.74	46.96	27.29	19.70	46.99	141.89
	T2	23.81	19.89	43.76	25.26	18.34	43.60	26.21	18.97	45.18	132.54
	T3	23.04	19.20	42.24	24.00	17.41	41.41	25.00	18.10	43.01	126.75
	T4	24.28	20.24	44.52	24.87	18.01	42.88	25.30	17.96	43.26	130.66
	T5	23.76	21.27	45.03	27.58	20.01	47.59	26.36	19.72	46.08	138.07
	T6	26.14	21.78	47.92	28.04	20.34	48.38	27.30	19.76	47.06	143.36
		Sweet potato			Rice			Rice			
		Tuber	Vine	Total	Grain	Straw	Total	Grain	Straw	Total	Total
II Sweet potato-rice-rice (A2)	T1	53.67	49.61	103.28	26.56	19.34	45.90	26.27	19.00	45.27	194.45
	T2	47.92	44.20	92.12	25.63	18.67	44.03	25.45	18.54	43.99	180.41
	T3	34.32	31.65	65.97	24.64	17.95	42.59	24.75	18.43	43.18	151.74
	T4	47.53	53.81	101.34	25.04	18.27	43.31	25.57	18.36	43.87	188.52
	T5	47.99	44.21	92.02	25.64	18.07	44.31	25.82	18.36	44.64	181.15
	T6	53.44	49.30	102.74	26.67	19.93	46.06	26.32	19.20	44.52	194.80

(Contd.....2)

Sequence	Treat-ment	Summer Cowpea Grain	Haulm	Total	Virippu Rice Grain	Straw	Total	Mundakan Rice Grain	Straw	Total	Total N removed in kg after one year Total
III Cowpea-rice-rice (A3)	T1	28.79	16.10	44.89	30.65	22.23	52.88	30.09	21.72	51.81	149.58
	T2	24.56	13.22	37.78	29.69	21.51	51.02	29.06	20.90	40.96	138.94
	T3	23.86	13.40	37.26	28.81	21.02	49.83	28.06	20.36	48.43	135.52
	T4	25.05	14.07	39.12	29.63	21.49	51.12	28.98	21.03	50.01	141.25
	T5	28.33	15.90	44.23	29.51	19.94	49.45	29.28	21.26	50.54	144.22
	T6	28.45	15.96	44.41	30.65	22.21	52.86	29.99	21.76	51.75	149.02
		Daincha Green matter		Total	Rice Grain	Straw	Total	Rice Grain	Straw	Total	Total
IV Daincha-rice-rice (A4)	T1	39.80		39.80	30.57	22.18	52.75	30.40	22.08	52.48	105.23
	T2	38.99		38.99	30.24	21.95	52.19	29.75	21.56	51.31	103.05
	T3	36.72		36.72	28.85	21.30	50.15	28.94	21.02	49.96	100.11
	T4	39.47		39.47	29.67	21.52	51.19	29.63	21.53	51.16	102.35
	T5	38.00		38.00	29.95	21.72	51.67	29.63	21.57	51.20	102.87
	T6	41.20		41.20	30.52	22.11	52.63	30.65	22.25	52.90	105.53
		Fallow			Rice Grain	Straw	Total	Rice Grain	Straw	Total	Total
V Fallow-rice-rice (A5)	T1				28.57	20.75	49.32	28.30	20.53	48.83	98.15
	T2				27.17	19.72	46.89	27.28	19.78	47.06	93.95
	T3				26.55	19.29	45.54	26.35	19.25	45.06	91.44
	T4				27.17	19.74	46.91	27.36	19.85	47.21	94.12
	T5				27.57	20.02	47.59	27.63	20.04	57.67	95.26
	T6				28.84	20.93	49.97	28.18	20.44	48.62	98.59

The maximum of 46 kg being for T1 and 40 kg being for T3 where in maximum and minimum nitrogen respectively had been applied. For the summer rice crop, the maximum nitrogen applied was 70 kg and minimum was 30 kg. Inspite of this the removal had been 40-45 kg per hectare. The efficiency of N utilisation was around 45 to 65 per cent. In the virippu crop (Variety Jaya) the average removal of N per hectare was around 43 to 45 $kgha^{-1}$ with the efficiency between 45 to 55 per cent. In the mundakan crop, however, the removal of nitrogen for the same variety Jaya varied from 51 to 58 $kgha^{-1}$ with a nitrogen utilisation efficiency 55-65 per cent. It is significant to note that for the summer and mundakan crop the nitrogen utilisation efficiency was higher than for the virippu crop. The total N removal for the sequence of crops rice-rice-rice in 1981 comes to 135 to 152 kg of N ie. treatments T1 and T3 respectively with the values for other treatments occupying intermediary position between them. The lack of considerable difference between maximum and minimum removal of nitrogen indicates the mobilisation of soil nitrogen from the less available sources according to the needs and occasioned by low application rates of fertilizers in the various treatments.

The results presented in Table 68 for the same sequence in 1982 shows an average removal between 127 to 144 kg.

The trend in the efficiency of utilisation, pattern of removal by grain and straw for the three crops in the sequence is more or less similar to the pattern earlier, discussed for 1981.

From Table-87, the removal of N for sweet potato-rice-rice sequence during the year 1981 and from Table-88 the removal in 1982 become evident. The sweet potato crop in 1981 removed 67 to 106 kg of nitrogen in treatments T3 and T1 respectively with the removal of N in other treatments lying between these 181-194 kg values. In 1982, the removal was 66 to 103 kg of N and this also followed the earlier trends. It may be noted that the removal of nitrogen by the tuber and vines is equal in both the years. The efficiency of utilisation of N by this tuber crop grown in summer is about 80-85 per cent. The virippu and mundakan rice crop had very nearly the same pattern of removal of N as in other sequences and treatment-wise. The sequence sweet potato-rice-rice had removed 164 to 209 kg of nitrogen, while the fertiliser nitrogen applied was to a maximum 305 kg in treatment T1 and 152.5 kg in T3. The ploughing under of the vines after harvest of the economic produce namely the tuber and resulted in the addition of 30 to 50 kg of N to the soil. Taking this also into consideration, it may be noted that the sequence was highly nutrient exhaustive especially in terms of nitrogen and this was mainly due to the summer sweet potato crop. The data presented in Table-88 of 1982 also follows the same trend for the sequence sweet potato-rice-rice.

The results on the removal of nitrogen by cowpea in 1981 and 1982 are presented in Tables 87 and 88. From the results, it can be seen that the cowpea crop on an average removes 38 to 45 kg of nitrogen in the treatments T3 and T4 respectively. In the other treatments the values lie between these extremes. It may be noted that the maximum and minimum quantities of nitrogen applied was 20 and 10 kg respectively. This obviously means that the cowpea crop has been able to utilise a maximum quantity of nitrogen of about 25 to 30 kg. The crop takes up nitrogen only from the booster dose of fertiliser applied and not from the N reserves of the soil. The same trend is followed by the cowpea crop of 1982. The virippu and mundakan rice variety Jaya removes on an average 49-55 kg and 60-64 kg of nitrogen in the virippu and mundakan season respectively and 49 to 53 kg and 48 to 52 kg of N for the virippu and mundakan season of 1982. The over-all removal of nitrogen falls in the narrow range of 148 to 163 kg in 1981 and 153 to 155 kg in 1982. It may be remembered that nearly 1/3 of the total nitrogen removed by the cowpea crop namely 13 to 16 kg of nitrogen is in fact added back to the soil in the form of haulms. Thus, the effect of treatments are not much significant compared to the effect of the sequence itself.

The result of the daincha-rice-rice sequence indicate that the removal of N is 110 to 118 kg in 1981 and 100 - 106 kg in 1982. The daincha crop, a totally unfertilised crop, removes on an average 35 to 40 kg of nitrogen. It removes from the soil only marginal amounts of nitrogen and fixes through the root nodule association most of the requirements of the crop. The contribution of the nitrogen fixing mechanism is about 25 to 30 kg of nitrogen out of the total removal of 110 to 118 kg of nitrogen by the sequence as a whole in 1981 which is more or less idential to the N removal by the same sequence in 1982 as presented in the Table 88.

The fallow-rice-rice sequence the nitrogen removal ranges from 101 to 110 kg. The fallow-rice-rice sequence removes the lowest quantity of nitrogen from the soil while sweet potato-rice-rice removes the highest amount of nitrogen from the soil.

TABLE -89

Uptake of phosphorus (in kg ha^{-1}) by various crops included in the cropping sequence during 1981

Sequence	Treatment.	Summer Rice			Viruppu Rice			Mundakan Rice			Total P removed in kg after one year.
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Total.
I Rice-rice-rice. (A1)	T1	5.75	3.18	8.93	6.31	4.47	10.78	5.37	3.98	9.35	29.06
	T2	5.39	2.98	8.37	5.09	3.77	9.68	6.06	3.81	9.87	27.72
	T3	5.10	2.80	7.90	5.76	3.62	9.38	6.62	3.53	9.15	26.43
	T4	5.30	2.92	8.22	6.10	3.89	9.99	6.19	3.87	10.05	28.27
	T5	5.10	2.74	7.84	6.20	3.91	10.11	6.12	3.86	9.98	27.93
	T6	5.35	2.96	8.31	6.37	4.01	10.38	6.33	3.98	10.31	29.00
		Sweet Potato			Rice			Rice			
		Tuber	Vine	Total	Grain	Straw	Total	Grain	Straw	Total	Total
II Sweet potato-rice-rice. (A2)	T1	9.94	18.52	28.46	6.14	3.90	10.04	6.99	4.39	11.38	49.88
	T2	5.24	17.15	22.39	6.03	3.59	9.62	6.82	4.29	10.11	43.12
	T3	8.92	15.35	24.27	5.82	3.51	9.33	6.55	4.08	10.73	44.22
	T4	5.04	17.05	22.09	6.62	3.79	10.41	6.72	4.23	10.95	44.45
	T5	15.37	18.79	24.06	6.02	3.79	9.81	7.73	4.31	12.04	45.91
	T6	9.77	17.37	27.14	6.21	3.90	10.11	6.86	4.02	10.88	48.11

(Contd.....2)

Sequence	Treatment	Summer			Virippu			Mundakan			Total P removed in kg after one year
		Cowpea			Rice			Rice			
		Grain	Haulm	Total	Grain	Straw	Total	Grain	Straw	Total	Total
III Cowpea-rice-rice (A3)	T1	4.43	2.25	6.68	7.03	4.42	11.45	6.97	4.38	11.35	29.15
	T2	3.77	1.90	5.67	6.64	4.19	10.83	6.58	4.12	10.70	26.80
	T3	3.67	1.87	5.54	6.77	3.79	10.56	6.44	4.05	10.54	22.64
	T4	3.85	1.86	5.71	6.42	3.84	10.26	6.59	4.11	10.70	26.67
	T5	4.35	2.25	6.60	6.64	9.16	10.80	6.19	4.16	10.35	27.75
	T6	4.29	2.22	5.57	6.94	4.37	11.31	6.97	4.39	11.36	28.24
		Daincha			Rice			Rice			
		Green	matter	Total	Grain	Straw	Total	Grain	Straw	Total	Total
IV Daincha-rice-rice (A4)	T1	7.99	7.99	7.99	7.19	4.53	11.72	6.47	4.06	10.53	30.24
	T2	8.28		8.28	6.97	4.38	11.35	6.26	3.85	10.11	29.79
	T3	4.70		4.70	6.63	4.17	11.33	6.06	3.79	9.85	25.88
	T4	8.49		8.49	6.78	4.26	11.04	5.83	3.89	9.72	29.25
	T5	8.00		8.00	6.99	4.37	11.36	6.33	3.98	10.31	29.67
	T6	8.14		8.14	7.16	4.49	11.65	6.50	4.88	11.38	31.17
		Fallow			Rice			Rice			
					Grain	Straw	Total	Grain	Straw	Total	Total
V Fallow-rice-rice (A5)	T1				6.50	4.15	10.65	6.41	3.87	10.28	20.93
	T2				6.43	4.04	10.47	5.99	4.28	10.27	20.79
	T3				6.26	3.93	11.19	5.85	4.18	10.03	21.22
	T4				6.34	4.04	10.38	5.05	4.24	9.29	19.67
	T5				6.47	6.06	10.53	6.02	4.31	10.33	20.86
	T6				6.67	4.20	10.87	6.14	4.40	10.54	21.41

TABLE - 90

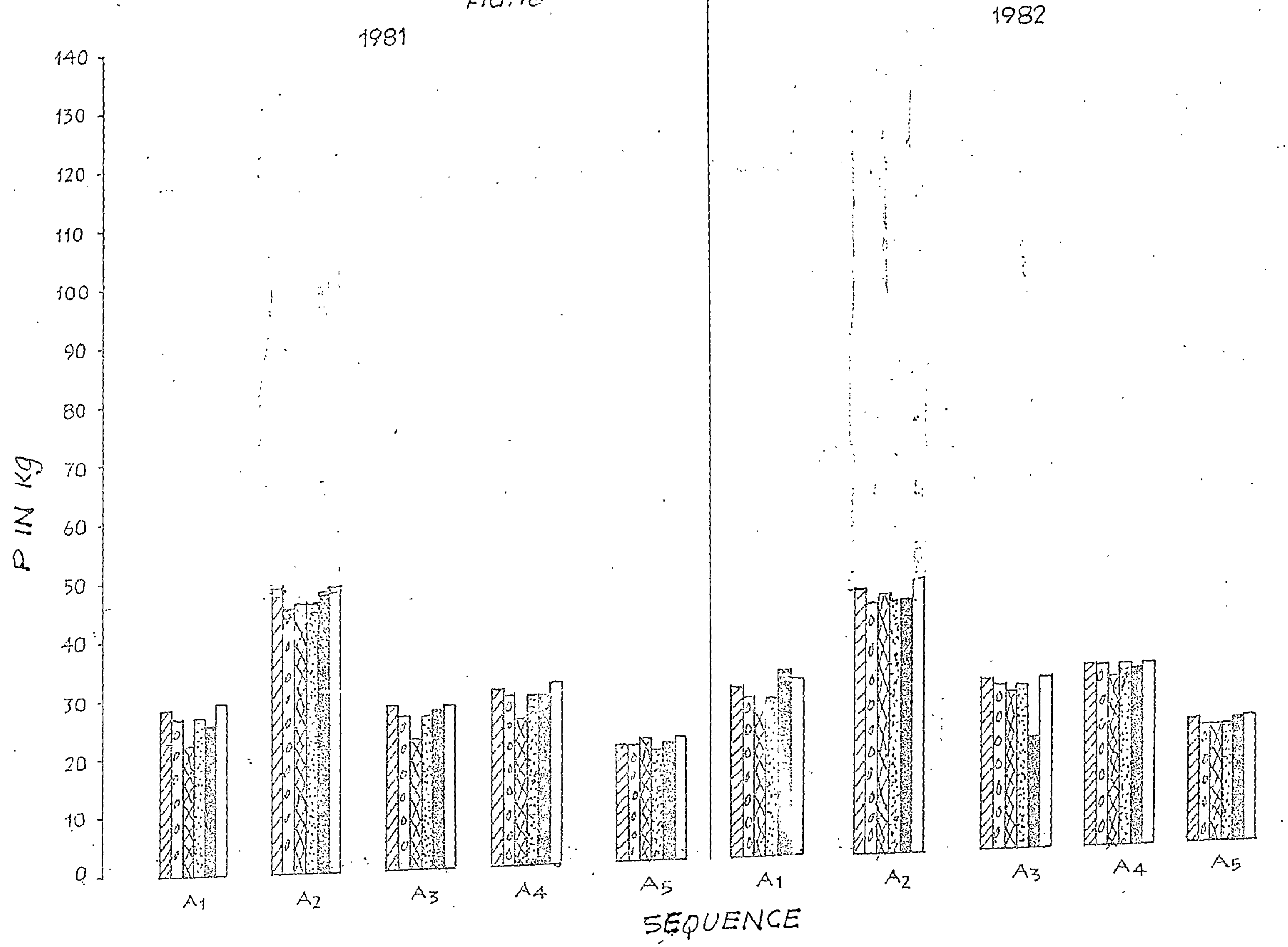
Uptake of Phosphorus (in kg ha^{-1}) by the various crops included in the cropping sequences during 1982.

Sequence	Treatment.	Summer Rice			Virippu Rice			Mundakan Rice			Total P removed in kg after one year.
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Total
I. Rice-rice-rice. (A1)	T1	6.12	3.32	9.44	6.23	3.91	10.14	6.24	3.91	10.15	29.73
	T2	5.58	3.04	8.62	5.78	3.14	8.92	5.99	3.76	9.75	27.29
	T3	5.39	2.93	7.32	5.45	3.45	8.90	5.67	3.59	9.26	25.48
	T4	5.56	3.09	8.65	5.69	3.57	9.26	5.78	3.56	9.34	27.25
	T5	8.44	3.24	11.68	6.23	3.97	10.20	6.03	3.91	9.94	31.82
	T6	6.12	3.37	9.49	6.43	4.04	10.47	6.24	3.92	10.16	30.12
		Sweet potato			Rice			Rice			
		Tuber	Vine	Total	Grain	Straw	Total	Grain	Straw	Total	Total
II Sweet Potato-rice-rice (A2)	T1	9.18	18.06	27.24	6.08	3.82	9.90	6.02	3.75	9.77	46.91
	T2	6.05	17.49	23.53	5.87	3.41	9.28	5.75	3.67	9.42	42.23
	T3	8.65	16.20	24.85	5.65	3.83	9.48	5.67	3.65	9.32	43.65
	T4	5.80	17.70	23.05	5.75	3.92	9.67	5.84	3.67	9.51	42.23
	T5	6.37	17.15	23.57	5.88	3.97	9.85	5.92	3.72	9.64	42.06
	T6	9.25	17.24	26.49	6.12	4.16	10.28	6.86	3.79	10.65	47.42

Sequence	Treatment	Summer			Virippu			Mundakan			Total P removed in kg after one year
		Cowpea			Rice			Rice			
		Grain	Haulm	Total	Grain	Straw	Total	Grain	Straw	Total	Total
III Cowpea-rice-rice (A3)	T1	4.56	2.22	6.78	7.01	4.40	11.41	6.85	4.31	11.16	29.35
	T2	4.23	2.10	6.33	6.93	4.26	11.19	6.61	4.15	10.76	28.28
	T3	3.86	1.80	5.66	6.60	4.16	10.76	6.42	3.99	10.41	26.83
	T4	4.14	2.10	6.24	6.78	4.26	11.04	6.67	3.78	10.45	27.73
	T5	4.42	2.24	6.66	6.75	4.29	11.04	6.70	4.21	10.91	18.61
	T6	4.51	2.21	6.72	7.01	8.40	11.41	6.86	4.31	11.17	29.30
		Daincha			Rice			Rice			
		Green mater		Total	Grain	Straw	Total	Grain	Straw	Total	Total
IV Daincha-rice-rice (A4)	T1	8.45		8.45	7.21	4.40	11.61	6.97	4.38	11.35	31.41
	T2	8.37		8.37	6.99	4.36	11.30	6.82	4.27	11.09	30.76
	T3	7.81		7.81	6.62	4.23	10.85	6.64	4.17	10.81	28.97
	T4	8.41		8.41	6.80	4.28	11.08	6.80	4.27	11.07	30.56
	T5	8.10		8.10	6.87	4.37	11.24	6.79	4.27	11.06	30.40
	T6	8.77		8.77	7.00	4.39	11.39	6.46	4.42	10.88	31.04
		Fallow			Rice			Rice			
					Grain	Straw	Total	Grain	Straw	Total	Total
V Fallow-rice-rice (A5)	T1				6.56	4.13	10.69	6.49	4.07	10.56	21.25
	T2				6.24	3.92	10.16	6.25	3.93	10.18	20.34
	T3				5.95	3.83	9.78	6.04	3.82	9.86	19.64
	T4				6.22	3.92	10.14	6.27	3.99	10.21	20.35
	T5				6.35	3.98	10.33	6.34	3.98	10.32	20.65
	T6				6.11	4.16	10.27	6.46	4.06	10.52	20.79

FIG. UPTAKE OF P (kg. ha⁻¹) OF EACH COMPONENT CROP IN THE CROPPING SEQUENCES.

FIG: 18 FIG: 19



From the results, it can be concluded that sweet potato-rice-rice sequence removes the highest amount of nitrogen while the lowest removal of nitrogen is by daincha-rice-rice followed by cowpea-rice-rice and fallow-rice-rice. Among these in the first two named sequences either N is not added as in the daincha-rice-rice or only marginally added as a booster dose in the cowpea-rice-rice sequences. Some of these observations are in agreement with the earlier findings.

Table-89 and Fig. 18 present the uptake of P in kg ha^{-1} of the component crops of the different sequences in 1981 while Table 90 and Fig. 19 present the data by the same sequences in 1982. The data show that in the rice-rice-rice sequence, the rice crop variety in summer season viz. Triveni and variety Jaya in virippu and mundakan season on an average removes- 7-8 kg, 9-10 kg and 9-10 kg. respectively. The total removal of P_2O_5 by the rice-rice-rice sequence in 1981 comes to between 25 to 29 kg. The same sequence in 1982 has removed about 26-32 kg of P_2O_5.

From these results it will be worth while to examine the efficiency of P utilisation under Kerala rice farming situations. In the summer season the efficiency of utilization of P thus is, about 27 per cent but the same in virippu and mundakan seasons are only 20-25 per cent.

In the sweet potato-rice-rice system the component crop of rice during virippu and mundakan season removes only about 10 kg of P_2O_5 as already described under rice-rice-rice sequence. While the sweet potato crop removes about 23 to 28 kg under T2 and T1. The other treatments occupy intermediary positions. In general, all crops in the sequence together remove to 43 to 49 kg of P_2O_5. This is several foid higher than the removal under rice-rice-rice system. Inspite of the fact that the vines and leaves are ploughed back into soil and they remove 15-18 kg of P_2O_5 from the soil. This can be substracted from the total removal of nutrients to get the not removal of P_2O_5. It has to be noted that the net removal of P_2O_5 is around 21-27 kg which, however, is higher than the rice-rice-rice system.

The cowpea-rice-rice and daincha-rice-rice system also removes 25 to 30 kg of P_2O_5. Both in the cowpea-rice-rice and daincha-rice-rice a part of the P_2O_5 removed is returned by ploughing under the haulms of the cowpea and the entire daincha crop into the soil. The lowest removal of P_2O_5 naturally happens in the fallow-rice-rice which incidentally was lower in cropping intensity than other cropping sequence.

Table-91

Uptake of K (in kg ha^{-1}) by various crops included in the sequence 1981

Sequence	Treatment	Summer Rice			Virippu Rice			Mundakan Rice			Total potash removed in kg after one year
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Total
I Rice-rice-rice (A1)	T1	11.58	36.20	47.78	13.20	41.57	54.77	12.85	37.66	50.51	153.06
	T2	10.86	34.04	44.90	12.65	39.80	52.45	12.22	39.08	51.30	148.56
	T3	10.27	32.93	43.20	11.88	37.35	49.23	11.33	36.20	47.53	139.93
	T4	10.66	33.39	44.05	12.75	40.10	52.85	12.42	39.74	52.16	149.06
	T5	10.27	31.29	61.56	11.83	40.34	52.17	12.83	39.49	52.32	146.05
	T6	10.76	33.83	54.69	13.14	41.33	54.47	12.75	40.76	53.51	161.87
		Sweet potato			Rice			Rice			
		Tuber	Vine	Total	Grain	Straw	Total	Grain	Straw	Total	Total
II Sweet potato-rice-rice (A2)	T1	78.85	130.24	203.09	12.79	39.74	52.53	14.12	39.56	53.68	309.30
	T2	62.48	113.16	175.64	12.42	36.60	49.02	13.32	38.56	52.38	277.04
	T3	45.73	82.82	128.55	12.01	35.77	47.78	13.32	39.60	53.10	229.43
	T4	61.66	111.47	173.13	12.52	38.59	51.01	13.24	38.09	51.33	275.47
	T5	61.14	113.22	174.36	12.42	38.59	51.01	13.39	38.72	52.11	277.48
	T6	71.94	130.28	202.22	12.79	39.74	52.53	14.14	39.44	53.58	308.33

(Contd....2)

Sequence	Treatment	Summer			Virippu			Mundakan			Total potash removed in kg after one year
		Cowpea			Rice			Rice			
		Grain	Haulm	Total	Grain	Straw	Total	Grain	Straw	Total	Total
III Cowpea-rice-rice (A3)	T1	9.80	35.77	45.57	14.70	44.89	59.69	13.84	43.09	56.93	162.19
	T2	9.10	33.15	42.25	14.24	43.44	57.68	13.37	41.59	54.96	154.89
	T3	8.30	30.30	38.60	13.82	42.45	56.27	12.98	40.40	53.38	148.25
	T4	8.88	32.40	41.28	14.21	43.39	57.60	12.21	41.72	53.93	152.81
	T5	9.48	35.00	44.48	14.15	43.21	57.36	12.68	42.16	54.84	156.68
	T6	9.68	35.12	44.80	14.70	44.85	59.55	13.06	43.17	56.23	160.58
		Daincha			Rice			Rice			
		Green matter		Total	Grain	Straw	Total	Grain	Straw	Total	Total
IV Daincha-rice-rice (A4)	T1	148.29		148.29	14.68	46.09	60.77	14.26	48.08	59.34	268.40
	T2	153.55		153.55	14.22	44.63	58.85	13.91	43.91	57.82	267.36
	T3	147.24		147.24	13.53	42.46	55.99	13.57	42.80	56.37	260.60
	T4	157.51		157.51	13.81	43.37	57.18	13.72	43.26	56.98	271.67
	T5	150.05		150.05	14.26	44.77	59.03	13.99	44.43	58.42	267.50
	T6	150.93		150.93	14.57	45.73	60.30	14.28	45.12	59.40	270.63
		Fallow			Rice			Rice			
					Grain	Straw	Total	Grain	Straw	Total	Total
V Fallow-rice-rice (A5)	T1				13.37	42.27	55.64	13.26	41.05	54.31	109.95
	T2				12.72	40.15	52.87	12.70	39.56	52.26	105.13
	T3				12.42	39.26	51.68	12.32	38.49	50.81	102.49
	T4				12.72	40.19	52.91	12.79	39.69	52.48	105.39
	T5				12.91	40.76	53.67	12.92	40.08	53.00	106.67
	T6				13.49	42.62	56.11	13.18	40.89	54.07	110.18

Table-92

Uptake of K (in $kg ha^{-1}$) by various crops included in the sequence 1982

Sequence	Treat-ment	Summer Rice			Virippu Rice			Mundakan Rice			Total Potash removed in kg after one year
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Total
I Rice-rice rice (A1)	T1	12.33	38.57	50.90	13.47	40.19	53.62	13.67	39.71	53.38	158.00
	T2	11.25	35.19	56.46	12.76	37.33	49.79	12.38	38.23	50.61	156.84
	T3	10.86	33.96	54.82	11.84	35.44	47.28	11.98	36.44	48.42	150.52
	T4	11.44	35.81	57.25	12.27	36.65	48.92	12.12	39.75	51.87	157.04
	T5	11.20	37.64	58.84	13.61	40.72	53.33	12.63	39.75	52.38	164.55
	T6	12.83	38.55	51.38	13.84	41.39	55.23	13.08	39.84	52.92	159.53
		Sweet potato			Rice			Rice			
		Tuber	Vine	Total	Grain	Straw	Total	Grain	Straw	Total	Total
II Sweet potato-rice-rice (A2)	T1	71.60	128.94	200.54	12.48	37.97	50.46	12.33	38.08	50.41	301.41
	T2	61.70	115.12	176.82	12.05	36.66	48.71	11.94	37.15	49.05	274.62
	T3	45.40	82.40	127.80	11.58	35.26	46.84	11.62	36.93	48.55	223.19
	T4	60.82	140.01	200.83	11.78	35.78	47.65	11.97	36.80	48.77	297.25
	T5	61.00	115.13	176.13	12.05	35.46	47.51	12.12	37.71	49.83	273.47
	T6	71.00	128.41	199.41	12.54	39.14	51.68	12.35	38.47	50.82	301.91

(Contd.....2)

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Sequence	Treatment	Summer Cowpea			Virippu Rice			Mundakan Rice			Total Potash removed in kg after one year
		Grain	Haulm	Total	Grain	Straw	Total	Grain	Straw	Total	Total
III Cowpea-rice-rice (A3)	T1	9.79	35.70	45.49	14.70	44.89	59.59	13.84	43.69	57.53	162.51
	T2	9.10	33.15	42.25	14.24	43.44	57.68	13.37	41.59	54.96	154.89
	T3	8.30	30.30	38.60	13.82	42.45	56.27	12.98	40.39	53.37	148.24
	T4	8.88	32.30	41.18	14.21	43.39	57.60	12.21	41.72	53.93	152.71
	T5	9.48	34.86	44.34	14.15	43.21	57.36	12.68	42.16	54.84	156.54
	T6	9.68	35.29	44.97	14.70	44.85	59.55	13.06	43.17	56.23	160.75
		Daincha			Rice			Rice			
		Green matter		Total	Grain	Straw	Total	Grain	Straw	Total	Total
IV Daincha-rice-rice (A4)	T1	156.47		156.47	14.37	44.37	58.74	14.19	44.13	58.32	273.53
	T2	153.29		153.29	14.22	43.84	58.06	13.89	43.08	56.97	268.32
	T3	144.35		144.35	13.56	42.56	56.12	13.50	42.00	55.50	255.07
	T4	155.45		155.45	13.95	42.98	56.93	13.83	43.03	56.86	769.24
	T5	149.42		149.42	14.08	43.39	57.47	13.83	42.99	56.82	263.71
	T6	161.98		161.98	14.35	44.17	58.52	14.31	44.47	58.78	279.28
V Fallow-rice-rice (A5)		Fallow			Rice			Rice			
					Grain	Straw	Total	Grain	Straw	Total	Total
	T1				14.37	44.31	58.68	14.19	44.13	58.32	117.00
	T2				14.22	43.84	58.06	13.89	43.08	56.97	115.03
	T3				13.56	42.56	56.12	13.51	42.00	55.51	111.63
	T4				13.98	42.98	56.93	13.83	48.03	56.86	113.79
	T5				14.08	43.39	57.47	13.83	42.99	56.82	114.29
	T6				14.35	44.14	58.49	14.10	44.47	58.57	117.06

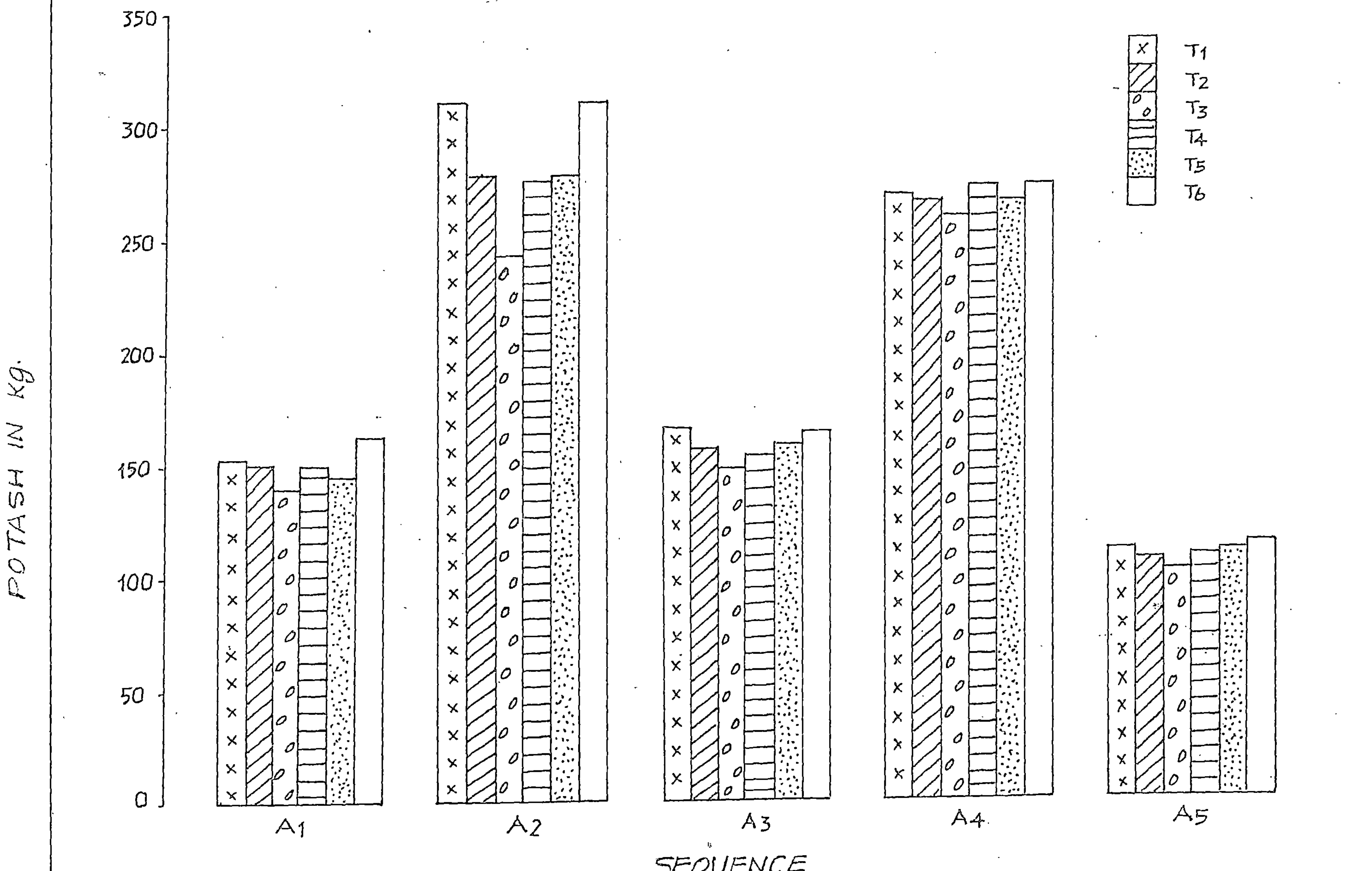
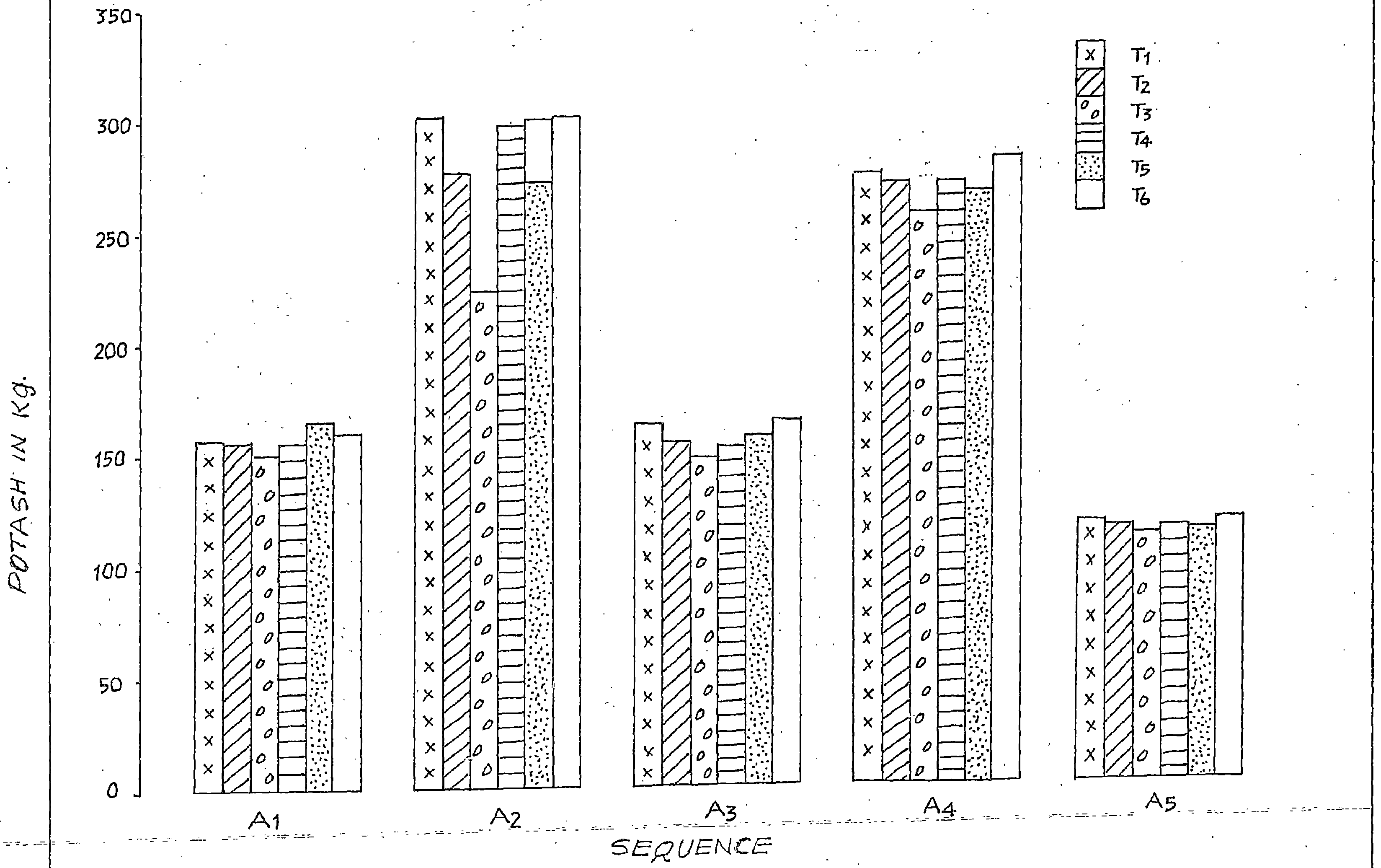


FIG.20 UPTAKE OF POTASH ($kg.ha^{-1}$) OF EACH COMPONENT CROPS OF THE SEQUENCE -1981

FIG_21 UPTAKE OF POTASH (kg. ha^{-1}) OF EACH COMPONENT CROP OF THE SEQUENCES-1982



From the result, it can be summarised that the efficiency of 'P' utilisation of rice under waterlogged conditions of the experimentation for both virippu and mundakan rice is around 20-24 per cent and for summer short duration irrigated rice is about 24-27 per cent. The 'P' utilisation efficiency for summer sweet potato and cowpea varies from 60-80 per cent and 20-25 per cent respectively. Considering all the sequences, sweet potato-rice-rice is the most exhaustive with respect to P_2O_5. The daincha-rice-rice is able to recycle about 10 kg of P_2O_5 absorbed by the daincha crop back into the soil. In the cowpea rice-rice-rice sequence also, there is recycling of P_2O_5 through the return of the haulms of the cowpea to the soil. The treatments do not have any effect on the removal of phosphate by any of the component crops in any sequence. A similar trend is noticed in 1982 also. The daincha-rice-rice and cowpea-rice-rice sequences have been reported to be capable of maintaining 'P' fertility in soils by workers such as Gill et al., (1987) and Sadanandan and Mahapatra (1972c).

Table 91 and Fig. 20 and Table 92 and Fig. 21 present the data on potash removal by various component crops in the various cropping sequences for 1981 and 1982 respectively. In the rice-rice sequence, on an average, the summer rice (short duration variety Triveni), virippu and mundakan rice (medium duration Jaya) removes on an average 47-54, 50-55 and 50-53 kg of K respectively. The maximum K uptake was noticed in the virippu and mundakan seasons. The total removal of K in the sequence rice-rice-rice is about 140-162 kg. There is not much difference between treatments. It means that under the low level of fertilisation (T3), the uptake was also less. The maximum uptake results in treatments T1 and T6 where the full dose of fertiliser had been applied and with these treatments, the highest yields were obtained. In 1982 also, rice-rice-rice sequence follows the same trend in uptake. The maximum uptake of K obtained were for T1 and T5. T1 and T5 happened to be the treatments with full dose of fertiliser potash. The uptake was between 158 and 196 for T1 and T5 respectively. Treatment T3 recorded the least uptake in the sequence.

In the case of sweet potato-rice-rice sequence, the summer sweet potato crop removes 128-203 kg of potash leading in consequence to a total removal of 210 to 310 kg of K_2O by all the component crops in the sequence. This obviously makes the sweet potato-rice-rice to be a nutrient exhausting sequence. However, the fact that the vines of sweet potato have been ploughed into the soil causes the removal of 82-130 Kg of potash per hectare. The virippu rice and mundakan rice recorded the removal of 47-52 Kg and 51-53 Kg of K_2O per hectare respectively in 1981. A similar trend was followed in 1982 also.

In the dainacha-rice-rice sequence the uptake of potash was between 268 to 271 kg. The green matter of daincha summer crop actually gets recycle into the soil. The uptake the two rice crops in the sequence thereby comes to about 115 Kg. The T1 and T5 are considered to be the treatments contributing towards macimum K uptake in these soils. Between treatments, there is only slight difference. Thus T3 is the treatment wherein the least K uptake had resulted. It is also the treatments where only 50 per cent recommended dose has been applied. The same is the trend by the pulse crop where the same level of K has been applied. Further in this sequence, the haulms of the pulse crop are added back to the soil. A similar trend is noticed in 1982 results also as shown in Table 92. Among all the sequences studied, the maximum removal of K_2O is by the sweet potato -rice-rice. The rice-rice-rice sequence stands next in order in removal of potash.

Table-93

Balance sheet of nitrogen (in kg ha^{-1}) in the various cropping sequence 1981

Sequences	Treat-ment	Initial status	Addition of nitrogen fertilisers				Uptake of 'N'	Actual balance	Expected bala-nce	Net loss or gain in
			Rice	Rice	Rice	Total				
Rice-rice-rice (A1)	T1	3622.0	70.0	90.0	90.0	250.0	151.5	3567.0	3720.5	-153.2
	T2	3622.0	52.5	67.5	67.5	187.5	144.1	3558.3	3665.4	-107.1
	T3	3622.0	35.0	45.0	45.0	125.0	134.9	3553.8	3612.1	-58.4
	T4	3622.0	52.5	67.5	67.5	187.5	144.2	3558.3	3665.3	-107.0
	T5	3622.0	70.0	90.0	90.0	250.0	144.5	3567.3	3727.5	-160.3
	T6	3622.0	70.0	90.0	90.0	250.0	147.8	3567.8	3724.2	-156.5
			Sweet potato	Rice	Rice	Total				
Sweet potato-rice-rice (A2)	T1	3622.0	125.0	90.0	90.0	305.0	208.5	3581.0	3718.5	-137.0
	T2	3622.0	93.8	67.5	67.5	228.8	190.4	3575.0	3660.4	-85.0
	T3	3622.0	12.5	45.0	45.0	152.5	163.2	3570.0	3611.3	-21.4
	T4	3622.0	93.8	67.5	67.5	228.8	187.9	3575.0	3662.6	-87.6
	T5	3622.0	125.0	90.0	90.0	305.0	190.4	3581.8	3726.6	-144.9
	T6	3622.0	125.0	90.0	90.0	305.0	207.9	3579.5	3714.1	-134.6

(Contd.....2)

Sequences	Treatment	Initial status	Addition of nitrogen fertilisers				Uptake of 'N'	Actual balance	Expected balance	Net loss or gain in
			Cowpea	Rice	Rice	Total				
Cowpea-rice-rice (A3)	T1	3622.0	20.0	90.0	90.0	200.0	162.8	3556.0	3659.2	-103.2
	T2	3622.0	15.0	67.5	67.5	150.0	163.0	3544.0	3609.0	-68.0
	T3	3622.0	10.0	45.0	45.0	100.0	148.0	3538.0	3674.0	-136.0
	T4	3622.0	15.0	67.0	67.5	150.0	153.0	3544.0	3619.0	-75.0
	T5	3622.0	20.0	90.0	90.0	200.0	159.6	3556.0	3662.5	-106.5
	T6	3622.0	20.0	90.0	90.0	200.0	162.0	3566.0	3660.0	-104.0
			Daincha	Rice	Rice	Total				
Daincha-rice-rice (A4)	T1	3622.0	0	90.0	90.0	180.0	119.0	3640.0	3683.0	-43.8
	T2	3622.0	0	67.5	67.5	135.0	114.0	3636.0	3612.0	+26.0
	T3	3622.0	0	45.0	45.0	90.0	100.0	3627.0	3587.1	+40.0
	T4	3622.0	0	67.5	67.5	135.0	112.0	3620.0	3605.8	+20.0
	T5	3622.0	0	90.0	90.0	180.0	114.0	3540.0	3688.9	-48.0
	T6	3622.0	0	90.0	90.0	180.0	116.6	3640.0	3686.3	-26.0
			Fallow	Rice	Rice	Total				
Fallow-rice-rice	T1	3622.0	-	90.0	90.0	180.0	108.0	3594.0	3694.0	-100.0
	T2	3622.0	-	67.5	67.5	135.0	104.0	3580.0	3654.0	-74.0
	T3	3622.0	-	45.0	45.0	90.0	101.0	3571.0	3611.0	-50.0
	T4	3622.0	-	67.5	67.5	135.0	104.0	3583.0	3696.5	-71.0
	T5	3622.0	-	90.0	90.0	180.0	106.0	3585.0	3698.0	-113.0
	T6	3622.0	-	90.0	90.0	180.0	109.0	3585.0	3701.0	-116.0

Table-94

Balance sheet of nitrogen (in $kgha^{-1}$) in the various cropping

Sequence 1982

Sequences	Treatment	Initial status	Addition of nitrogen fertilisers				Uptake of N	Actual balance	Expected balance	Net loss or gain in
			Rice	Rice	Rice	Total				
Rice-rice-rice (A1)	T1	3567.25	70.00	90.00	90.00	25.00	151.89	3512.00	3666.00	-154.00
	T2	3558.25	52.50	67.50	67.50	187.50	132.54	3494.00	3613.00	-119.00
	T3	3553.75	35.00	45.00	45.00	125.00	126.75	3489.00	3552.00	-63.00
	T4	3558.25	52.50	67.50	67.50	187.50	130.66	3500.00	3613.00	-195.00
	T5	3567.25	70.00	90.00	90.00	250.00	138.70	3510.00	3653.00	-143.00
	T6	3567.75	70.00	90.00	90.00	250.00	143.36	3508.00	3658.00	-150.00
Sweet potato-rice-rice (A2)	T1	3581.75	125.0	90.00	90.00	305.00	194.45	3568.00	3692.00	-124.00
	T2	3575.00	93.7	67.50	67.50	228.75	180.41	3561.00	3623.00	-162.0
	T3	3590.00	125.0	45.00	45.00	152.50	151.74	3557.00	3590.00	-34.0
	T4	3575.00	93.7	67.50	67.50	228.50	188.52	3562.00	3615.02	-153.0
	T5	3581.75	125.0	90.00	90.00	305.00	181.15	3558.00	3615.60	-147.0
	T6	3579.50	125.0	90.00	90.00	305.00	197.80	3565.20	3686.70	-121.0

(Contd.....2)

Sequences	Treatment	Initial status	Addition of nitrogen fertilisers				Uptake of N	Actual balance	Expected balance	Net loss or gain
			Rice	Rice	Rice	Total				
Cowpea-rice-rice (A3)	T1	3556.00	20.00	90.00	90.00	200.00	149.58	3707.00	3607.00	-100.00
	T2	3544.00	15.00	67.50	67.50	150.00	138.94	3635.00	3555.06	-80.00
	T3	3538.00	10.00	45.00	45.00	100.00	135.52	3534.00	3502.48	-32.00
	T4	3544.00	15.00	67.50	67.50	150.00	141.25	3621.00	3548.75	-73.00
	T5	3556.00	20.00	90.00	90.00	200.00	144.22	3733.00	3506.98	-127.00
	T6	3556.00	20.00	90.00	90.00	200.00	149.02	3733.00	3606.98	-127.00
Daincha-rice-rice (A4)	T1	3640.00	0	90.00	90.00	180.00	65.60	3709.00	3754.40	-45.00
	T2	3636.00	0	67.50	67.50	135.00	75.59	3726.00	3696.41	-31.00
	T3	3627.00	0	45.00	45.00	90.00	63.20	3648.00	3653.80	-25.00
	T4	3620.00	0	67.50	67.50	135.00	62.00	3665.00	3703.00	-38.00
	T5	3640.00	0	90.00	90.00	180.00	64.87	3725.00	3755.00	-30.00
	T6	3640.00	0	90.00	90.00	180.00	64.33	3726.00	3755.00	-29.00
Fallow-rice-rice (A5)	T1	3594.00	0	90.00	90.00	180.00	98.15	3572.00	3676.00	-104.35
	T2	3580.00	0	67.50	67.50	135.00	93.95	3549.00	3622.00	-73.00
	T3	3521.00	0	45.00	45.00	90.00	91.44	3465.00	3520.00	-55.00
	T4	3583.00	0	67.50	67.50	135.00	94.12	3573.00	3542.00	-75.00
	T5	3585.00	0	90.00	90.00	180.00	95.00	3560.00	3678.00	-110.00
	T6	3585.00	0	90.00	90.00	180.00	98.60	3551.00	3667.00	-116.00

Critical examination reveals that the sweet potato is a soil K exhaustive crop and this high removal is only because of the high tuber and vine yield. However, the ploughing in of the vine to the soil returns part of the K removed. The K removed by the sweet potato crop has been higher than by other component summer crops in other sequences. The daincha-rice-rice and pulse-rice-rice also returns back to the soil the haulm (cowpea) and green matter (daincha) thereby causing lower net removal of K by these two sequences. In order to maintain a good fertility status, the daincha or a pulse should be included in the sequence. These results are in agreement with the findings of Nair et al., (1973a) and Singh and Ramamoorthy (1974).

Tables 93 to 98 present the balance sheet of plant nutrients in the various cropping sequences.

Tables 93 and 94 present the balance sheet of total nitrogen in each cropping sequences for the year 1981 and 1982. From the results it is clear that there has been a heavy loss of nitrogen in the cropping sequence rice-rice-rice (A1). This is closely followed by sweet potato-rice-rice (A2) as shown by the nutrient balance sheet table in 1981 and 1982. From these results, it is to be noted that there has been a slight gain in nitrogen in the cropping sequences coqpea-rice-rice (A3) and daincha-rice-rice sequences during both the years.

There has been a net loss of nitrogen from the rice-rice-rice sequence which comes to about 155-160 kg ha^{-1} in the first year and 155-160 kg ha^{-1} in the second year. Corresponding loss of nitrogen for the sweet potato-rice-rice sequence was found to be 87 + 37 kg ha^{-1} and 80-124 kg ha^{-1} in 1981 and 1982 respectively. The sequence cowpea-rice-rice and daincha-rice-rice (A3) and fallow-rice-rice are better in maintaining the total nitrogen status of the soil. The fallow-rice-rice also shows decrease in total nitrogen status of the soil for both the years.

Treatments also have a clear cut effect in maintaining the total nitrogen status of the soil. Treatments T1, T5 and T6 maintain a higher total nitrogen status of the soil. Treatment T3 has been found to be the lowest in maintaining the total nitrogen status of soil. Thus T3 is the treatment wherein 50 per cent of the recommended dose of total nitrogen has been applied.

From the results, it is clear that there was a gain in total nitrogen status of the soil in the cowpea-rice-rice and daincha-rice-rice sequences and the maximum gain was noticed in treatments T1 and T6 where the full dose of nitrogen was applied. The treatment T3 was found to be less effective. It may be noted that there is a net loss of nitrogen in most of the sequences and in all the treatments. Only in daincha-rice-rice (A4) and cowpea-rice-rice (A3), irrespective of treatment, a slight gain in total nitrogen has been observed. This will be around 100 kg T1 and about 80-32 kg/ha for T2, T5, T3 for every year. The cowpea-rice-rice and daincha-rice-rice also removed more nitrogen than was added. This clearly indicates that these crops utilised atmosphere nitrogen in addition to that taken up from the soil.

The balance sheet brought out the following points:-

1. The crop usually removes only a part of nitrogen applied to the soil the lowest uptake was noticed in the case of daincha-rice-rice and cowpea-rice-rice sequence.

2. The treatments T1, T5 and T6 were the best followed by T4. The treatments T1 and T6 included the full recommended dose of nitrogen. The treatment T3 is the lowest one in maintaining fertility of the soil and included only 50 per cent of recommended levels of N, P and K.

3. The continuous cropping causes the loss of nitrogen from the soil.

Table-95

Balance sheet of available phosphorus (in $kg\,ha^{-1}$) over initial status due to different cropping sequences 1981

Sequence	Treat- ment	Initial status	Addition of phosphorus fertilisers				Uptake	Expected balance	Actual balance	Net loss or gain
			Rice	Rice	Rice	Total				
Rice-rice-rice (A1)	T1	36	35.00	45.00	45.00	125.00	29	132	50	-82
	T2	36	26.25	33.75	33.75	84.25	27	92	47	-35
	T3	36	17.50	22.50	22.50	62.50	26	72	45	-27
	T4	36	35.00	45.00	45.00	125.00	28	133	50	-83
	T5	36	26.25	33.75	33.75	83.25	27	92	47	-45
	T6	36	35.00	45.00	45.00	125.00	29	132	50	-82
			Sweet potato	Rice	Rice	Total				
Sweet potato-rice-rice (A2)	T1	36	80	45.00	45.00	170	51	155	41	-114
	T2	36	60	33.75	33.75	127	46	117	36	- 61
	T3	36	40	22.50	22.50	85	39	89	31	- 58
	T4	36	80	45.50	45.00	170	48	154	41	-114
	T5	36	60	33.00	33.00	127	47	116	36	- 80
	T6	36	80	45.00	45.00	170	51	155	41	-114

(Contd....2)

Sequence	Treat-ment	Initial status	Addition of phosphorus fertilisers				Uptake in	Expected balance	Actual balance	Net loss or gain
			Cowpea	Rice	Rice	Total				
Cowpea-rice-rice (A3)	T1	36	30	45.00	45.00	120.00	27	127	51	-34
	T2	36	25	33.75	33.75	92.50	26	102	49	-53
	T3	36	15	22.50	22.50	60.00	25	71	45	-26
	T4	36	30	45.00	45.00	120.00	25	129	51	-36
	T5	36	25	33.75	33.75	92.50	27	191	49	-54
	T6	36	30	45.00	45.00	120.00	28	126	51	-35
				Rice	Rice	Total				
Daincha-rice-rice (A4)	T1	36	0	45.00	45.00	90.00	22	104	50	-54
	T2	36	0	33.00	33.75	67.50	21	82	45	-37
	T3	36	0	22.50	22.50	45.00	20	86	40	-16
	T4	36	0	45.00	45.00	90.00	21	105	45	-60
	T5	36	0	33.75	33.75	67.50	21	82	45	-37
	T6	36	0	45.00	45.00	90.00	23	103	50	-53
				Rice	Rice	Total				
Fallow-rice-rice (A5)	T1	36	0	45.00	45.00	90.00	21	105	45	-60
	T2	36	0	33.75	33.75	67.50	20	83	42	-41
	T3	36	0	22.50	22.50	45.00	21	85	40	-17
	T4	36	0	45.00	45.00	90.00	19	107	45	-62
	T5	36	0	33.75	33.75	67.50	20	83	42	-41
	T6	36	0	45.00	45.00	90.00	21	108	45	-63

Table-96

Balance sheet of available phosphorus (in $kgha^{-1}$) over initial status due to different cropping sequences 1982

Sequence	Treat-ment	Initial status	Addition of phosphorus fertilizers Rice	Rice	Rice	Total	Uptake $kgha^{-1}$	Expected balance	Actual bala-nce	Net loss or gain
Rice-rice-rice (A1)	T1	50.00	35.00	45.00	45.00	125.00	29.00	146.00	58.00	-88.00
	T2	47.00	26.25	33.75	33.75	83.25	27.00	103.00	54.00	-47.00
	T3	45.00	17.50	22.50	22.50	62.50	25.00	81.00	52.00	-29.00
	T4	50.00	35.00	45.00	45.00	125.00	27.00	148.00	58.00	-90.00
	T5	47.00	26.75	33.75	33.75	83.25	31.00	99.00	54.00	-44.00
	T6	50.00	35.00	45.00	45.00	125.00	30.00	145.00	58.00	-87.00
			Sweet potato	Rice	Rice	Total				
Sweet potato-rice-rice (A2)	T1	41.00	80.00	45.00	45.00	170.00	48.00	177.00	41.00	-136.00
	T2	36.00	60.00	33.75	33.75	127.00	45.00	118.00	36.00	- 92.00
	T3	31.00	40.00	22.50	22.50	85.00	37.00	79.00	31.00	- 48.00
	T4	41.00	80.00	45.00	45.00	170.00	45.00	174.00	41.00	-133.00
	T5	36.00	60.00	33.00	33.00	127.00	46.00	137.00	36.00	-101.00
	T6	41.00	80.00	45.00	45.00	120.00	50.00	161.00	41.00	-120.00

Sequence	Treatment	Initial status	Addition of phosphorus fertilizers				Uptake	Expected balance	Actual balance	Net loss or gain
			Cowpea	Rice	Rice	Total				kg ha^{-1}
Cowpea-rice-rice (A3)	T1	51.00	30.00	45.00	45.00	120.00	27.00	144.00	65.00	-29.00
	T2	49.00	15.00	33.75	33.75	92.00	26.00	115.00	58.00	-57.00
	T3	45.00	15.00	22.50	22.50	60.00	25.00	80.00	54.00	-26.00
	T4	51.00	30.00	45.00	45.00	120.00	25.00	146.00	65.00	-81.00
	T5	49.00	15.00	33.75	33.75	92.00	26.00	115.00	58.00	-57.00
	T6	51.00	30.00	45.00	45.00	120.00	27.00	144.00	65.00	-79.00
				Rice	Rice	Total				
Daincha-rice-rice (A4)	T1	50.00	0	45.00	45.00	90.00	23.00	117.00	54.00	-63.00
	T2	45.00	0	33.75	33.75	67.50	22.00	85.00	51.00	-34.00
	T3	40.00	0	22.50	22.50	45.00	21.00	64.00	47.00	-17.00
	T4	45.00	0	45.00	45.00	90.00	22.00	113.00	54.00	-59.00
	T5	45.00	0	33.75	33.75	67.50	22.00	85.00	51.00	-34.00
	T6	50.00	0	45.00	45.00	90.00	23.00	117.00	54.00	-63.00
				Rice	Rice	Total				
Fallow-rice-rice (A5)	T1	45.00	0	45.00	45.00	90.00	21.00	114.00	54.00	-60.00
	T2	42.00	0	33.75	33.75	67.50	20.00	89.00	52.00	-37.00
	T3	40.00	0	22.50	22.50	45.00	19.00	66.50	50.00	-26.00
	T4	45.00	0	45.00	45.00	90.00	20.00	113.00	54.00	-59.00
	T5	42.00	0	33.75	33.75	67.50	20.00	89.00	52.00	-24.00
	T6	45.00	0	45.00	45.00	90.00	20.00	114.00	54.00	-60.00

4. The inclusion of legumes like daincha or cowpea in the sequence will be beneficial in maintaining the total nitrogen status of the soil.

The tables 95 and 96 present the balance sheet of available phosphorus in the soil for the year 1981 and 1982 respectively. For this calculation all the manures added are considered as extractable P. From the table it was noted that the extractable P in all the cropping pattern decreases after each component crops. The magnitude of decrease varies from 15.93 kg ha^{-1} during 1981 and from 30-105 kg ha^{-1} for 1982, respectively. The main reasons for the decrease in extractable 'P' or available P was partly due to fixation of the phosphorus released from the applied phosphates and partly due to its revival by the crop.

The amount of phosphorus removed by various crops was relatively low although, a large quantity of phosphorus was added through manures and fertilisers, Among the various crops sweet potato removed the maximum quantity of phosphorus and as such the sweet potato-rice-rice sequence takes up a maximum quantity of phosphorus in both the years. The sequences daincha-rice-rice and cowpea-rice-rice sequence were found to maintain a sufficiently higher available

Table-97

Balance sheet of exchangeable K (in $kg\,ha^{-1}$) in the various cropping sequences 1981

Sequence	Treat-ment	Initial status	Addition of potassic fertilisers				Uptake of K	Expected balance	Actual bala-nce	Net loss of gain
			Rice	Rice	Rice	Total				
Rice-rice-rice (A1)	T1	202.00	85.00	45.00	45.00	125.00	153.00	174.00	157.00	-17
	T2	202.00	26.25	33.75	33.75	93.25	150.00	159.00	145.00	-8
	T3	202.00	17.50	22.50	22.50	62.50	134.00	130.00	141.00	-11
	T4	202.00	35.00	45.00	45.00	125.00	149.00	178.00	150.00	-28
	T5	202.00	35.00	45.00	45.00	125.00	145.00	182.00	157.00	-25
	T6	202.00	26.25	33.75	33.75	125.00	161.00	166.00	150.00	-16
			Sweet Potato	Rice	Rice	Total				
Sweet potato-rice-rice (A2)	T1	202.00	125.00	45.00	45.00	215.00	179.00	238.00	146.00	-92
	T2	202.00	93.75	33.75	33.75	161.25	163.00	200.00	139.00	-61
	T3	202.00	62.50	22.50	22.50	107.50	147.00	162.00	135.00	-27
	T4	202.00	125.00	45.00	45.00	215.00	163.00	254.00	139.00	-115
	T5	202.00	125.00	45.00	45.00	215.00	162.00	255.00	140.00	-115
	T6	202.00	93.75	33.75	33.75	161.25	178.00	185.00	139.00	-46

(Contd....2)

Sequence	Treat-ment	Initial status	Addition of potassic fertilisers				Uptake of K	Expe-cted bala-nce	Actual bala-nce	Net loss or gain
			Cowpea	Rice	Rice	Total				
Cowpea-rice-rice (A3)	T1	202.00	60.00	45.00	45.00	150.00	127.00	255.00	173.00	-52
	T2	202.00	45.00	33.75	33.75	712.50	122.00	192.00	168.00	-24
	T3	202.00	30.00	22.50	22.50	75.00	118.00	159.00	162.00	+3
	T4	202.00	60.00	45.00	45.00	150.00	121.00	236.00	175.00	-51
	T5	202.00	65.00	45.00	45.00	150.00	122.00	235.00	171.00	-55
	T6	202.00	45.00	33.75	33.75	112.50	126.00	158.00	168.00	-70
			Daincha	Rice	Rice	Total				
Daincha-rice-rice (A4)	T1	202.00	0	45.00	45.00	90.00	120.00	172.00	191.00	+19
	T2	202.00	0	33.75	33.75	67.50	109.00	160.00	184.00	+24
	T3	202.00	0	22.50	22.50	45.00	113.00	121.00	177.00	+56
	T4	202.00	0	45.00	45.00	90.00	115.00	177.00	191.00	+14
	T5	202.00	0	45.00	45.00	90.00	115.00	154.00	191.00	+25
	T6	202.00	0	33.75	33.75	67.50	121.00	174.00	184.00	+10
			Fallow	Rice	Rice	Total				
Fallow-rice-rice (A5)	T1	202.00	0	45.00	45.00	90.00	109.00	173.00	180.00	+7
	T2	202.00	0	33.75	33.75	67.50	105.00	164.00	173.00	+8
	T3	202.00	0	22.50	22.50	45.00	102.00	145.00	166.00	+21
	T4	202.00	0	45.00	45.00	90.00	105.00	187.00	180.00	+7
	T5	202.00	0	45.00	45.00	90.00	106.00	186.00	180.00	+6
	T6	202.00	0	33.75	33.75	67.5	110.00	159.00	173.00	-4

Table-98

Balance sheet of exchangeable K (in $kg ha^{-1}$) in the various cropping sequences 1982

Sequence	Treatment	Initial status	Addition of potassic fertilisers Rice	Rice	Rice	Total	Uptake of K	Expected balance	Actual balance	Net loss or gain
Rice-rice-rice (A1)	T1	157.00	85.00	45.00	45.00	125.00	158.00	124.00	123.00	-1
	T2	145.00	26.25	33.75	33.75	93.75	156.00	82.00	119.00	+37
	T3	141.00	17.50	22.50	22.50	62.50	150.00	113.00	114.00	+1
	T4	150.00	85.00	45.00	45.00	125.00	157.00	132.00	121.00	-11
	T5	159.00	35.00	45.00	45.00	125.00	164.00	118.00	123.00	-5
	T6	150.00	26.25	23.75	33.75	125.00	159.00	116.00	117.00	-1
			Sweet potato	Rice	Rice	Total				
Sweet potato-rice-rice (A2)	T1	146.00	125.00	45.00	45.00	215.00	173.00	188.00	112.00	-76
	T2	139.00	93.75	33.75	33.75	161.25	160.00	140.00	108.00	-32
	T3	135.00	62.50	22.50	22.50	107.50	140.00	98.00	103.00	-5
	T4	139.00	125.00	45.00	45.00	215.00	157.00	197.00	112.00	-85
	T5	140.00	125.00	45.00	45.00	215.00	158.00	197.00	112.00	-85
	T6	139.00	93.75	33.75	33.75	161.25	172.00	128.00	108.00	-20

(Contd.....2)

Sequence	Treatment	Initial status	Addition of potassic fertilisers				Uptake of K	Expected balance kg/ha	Actual balance	Net loss or gain
			Cowpea	Rice	Rice	Total				
Cowpea-rice-rice (A3)	T1	173.00	60.00	45.00	45.00	150.00	127.00	124.00	141.00	+11
	T2	168.00	45.00	33.75	33.75	112.50	122.00	66.00	137.00	+71
	T3	162.00	30.00	22.50	22.50	75.00	118.00	119.00	130.00	+11
	T4	175.00	60.00	45.00	45.00	150.00	120.00	205.00	139.00	-65
	T5	171.00	60.00	45.00	45.00	150.00	122.00	198.00	144.00	-54
	T6	168.00	45.00	33.75	33.75	112.50	115.00	165.00	135.00	+35
			Daincha	Rice	Rice	Total				
Daincha-rice-rice (A4)	T1	191.00	0	45.00	45.00	90.00	117.00	156.00	157.00	+1
	T2	160.00	0	33.75	33.75	67.50	115.00	112.00	150.00	+38
	T3	121.00	0	22.50	22.50	45.00	111.00	55.00	144.00	+89
	T4	177.00	0	45.00	45.00	90.00	114.00	153.00	157.00	+4
	T5	154.00	0	45.00	45.00	90.00	115.00	129.00	157.00	+28
	T6	174.00	0	33.75	33.75	67.50	118.00	76.00	150.00	+74
			Fallow	Rice	Rice	Total				
Fallow-rice-rice (A5)	T1	180.00	0	45.00	45.00	90.00	117.00	153.00	157.00	+4
	T2	173.00	0	33.75	33.75	67.50	115.00	125.00	150.00	+25
	T3	166.00	0	22.50	22.50	75.00	111.00	130.00	144.00	+14
	T4	180.00	0	45.00	45.00	90.00	113.00	157.00	151.00	-6
	T5	180.00	0	45.00	45.00	90.00	114.00	156.00	157.00	+1
	T6	173.00	0	33.75	33.75	67.50	117.00	127.00	150.00	+23

P level than other sequences. The treatments, however, had no significant effect in maintaining the extractable P level of the soil.

Tables 97 and 98 presents the balance sheet of potash in soil after each component crop during the year 1981 and 1982. The balance sheet clearly reveals that the added K fertilizers from the soil have been removed by th the crops completely. The uptake of nutrients shows that rice-rice-rice sequence taking up about 134-160 Kg of K_2O/ha during the sequence of crops in 1981 and in 1982 also about 160 kg of K_2O/ha have been taken up by rice-rice. The sweet potato-rice-rice sequence takes up about 140-172 kg/ha of K_2O in 1981 and 160-200 kg K_2O in 1982. The other sequence fallow-rice-rice shows a decrease in soil total K_2O content in 1981 and in 1982. The decrease was however, found to be very negligible. This shows that the sequence maintained a balance in the extractable K status of the soil.

The daincha-rice-rice sequence and cowpea-rice-rice showed an increase in available K status of soil after the completion of the sequence in two years. This may be due to the incorporation of the haulms and green matter of the cowpea and daincha into the soil and recycling the nutrient K.

Table-99

Cost of cultivation per hectare of crops included in the cropping sequences (in Rupees)

Crops	Preparatory cultivation	Seeds and sowing	Manures and fertili-sers	After culti-vation charges	Harvesting and Threshing etc.	Total
1. a. Rice Summer	800	700	T1 750			3450.00
			T2 400			3100.00
			T3 325	700	500	2825.00
			T4 455			3155.00
			T5 625			3325.00
			T6 750			3450.00
b. Rice (Virippu Mundakan)	800	700	T1 855			3555.00
			T2 475			3175.00
			T3 334	700	500	3034.00
			T4 735			3435.00
			T5 805			3505.00
			T6 833			3533.00
2. Sweet potato (Summer)			3050			
	750	600	T1 815			3865.00
			T2 458			3408.00
			T3 690	1100	600	3710.00
			T4 705			3755.00
			T5 772			3822.00
			T6 783			3833.00

(Contd....2)

Crops	Preparatory cultivation	Seeds and sowing	Manures and Fertilisers		After cultivation charges	Harvesting and Threshing etc.	Total
3. Cowpea (Summer)	650	450	T1	625			2475.00
			T2	363			2223.00
			T3	392	300	450	2242.00
			T4	567			2417.00
			T5	625			2432.00
			T6	625			2475.00
4. Daincha	100	50	-	-	-	-	150.00
5. Fallow	100	-	-	-	-	-	100.00

<u>Note</u> <u>Rates used in calculation</u>

1. Wages — Male Rs.24/- day; Female Rs.20/- day
2. Manures and fertilisers — Urea - Rs.2400/- ton; M.Phos Rs.750/- ton; Muriate of Potash Rs.1500/- ton
3. Ploughing — Rs.50 per pair of bullocks
4. Cost of seed and produce
   Rice — Rice : Rs.200/quintal; Straw: Rs.100/quintal; Sweet potato Tuber Rs.60/quintal; Cowpea: Grain Rs.500/quintal

The treatments also show a significant effect on the extractable K status of the soil. With decrease in K level, the status of extractable K in soil also decreases. The treatment T1 and T5 are found to be better in maintaining the extractable K status of the soil. The treatment T3, wherein, the K applied has been halved, revealed maximum decrease in extractable K in all the sequences.

In general, the results show that irrespective of the sequences, the soils maintain almost the same extractable K status without any significant decrease from the initial level. It is also noted that the potasium loss from the soil is negligible. Wherever the decrease is noted it may be due to the uptake of potassium by weeds, the root stubbles etc. which were not counted for estimation.

D. Economics

Table-99 present; the data on the cost of cultivation per hectare of the component crops included in the various crop sequences. The data shows that the cost of cultivation of sweet potato is high viz. about Rs.3863/- while that of rice on an average is at Rs.3500/-.only. The cowpea crop has an average cost of Rs.2475/-. From the table it is clear that the fertilizer cost comes to about Rs.750/- to Rs.855/- for each of the component crops. The treatments

Table-100

Cost of cultivation and net profit per hectare of the cropping sequences for the year 1981-82 and 1982-83 (in rupees)

Cropping sequences	Crops	Treat-ments	Cost of cultivation 81-82	Cost of cultivation 82-83	Produce Grain $kgha^{-1}$ 81-82	Produce Grain $kgha^{-1}$ 82-83	Tuber 81-82	Tuber 82-83	Straw/haulm 81-82	Straw/haulm 82-83	Pooled value of produce 81-82 and 82-83	Net profit for two years	Average net profit per year
I Rice-rice rice	a. Rice (Summer)	T1	3450	3450	1998	2126	-	-	2155	2296	11362	4438	2219.0
		T2	3100	3100	1873	1940	-	-	2026	2095	10716	4516	2258.0
		T3	2825	2825	1771	1873	-	-	1906	2022	10234	4584	2292.0
		T4	3155	3155	1839	1974	-	-	1989	2132	9965	3655	1822.5
		T5	3325	3325	1771	1932	-	-	1863	2241	10484	3834	1917.0
		T6	3450	3450	1856	2126	-	-	2014	2295	11195	4295	2147.5
	b. Paddy (Virippu)	T1	3555	3555	2288	2227	-	-	2471	2405	12687	5577	2788.5
		T2	3175	3175	2193	2067	-	-	2369	2234	11972	5627	2813.0
		T3	3034	3034	2058	1964	-	-	2223	2121	11302	5234	2617.0
		T4	3435	3435	2210	2035	-	-	2387	2193	11925	5055	2522.5
		T5	3505	3505	2224	3257	-	-	2401	2432	12590	5580	2790.0
		T6	3533	3533	2278	2295	-	-	2460	2477	12848	5782	2891.0
	c. Rice (Mundakan)	T1	3555	3555	2278	2227	-	-	2442	2399	12640	5530	2765.0
		T2	3175	3175	2166	2139	-	-	2340	2310	12097	5143	2521.5
		T3	3034	3034	2008	2041	-	-	2168	2205	11422	5354	2627.0
		T4	3435	3435	2003	2065	-	-	2380	2187	11961	5091	2545.5
		T5	3505	3505	2167	2151	-	-	2365	2402	12205	5195	2597.0
		T6	3533	3533	2261	2229	-	-	1441	2407	12616	5550	2775.0

(Contd....2)

Cropping sequences	Crops	Treat-ment	Cost of cultivation 81-82	Cost of cultivation 82-83	Produce Grain kgha-1 81-82	Produce Grain kgha-1 82-83	Tuber 81-82	Tuber 82-83	Straw/haulm 81-82	Straw/haulm 82-83	Pooled value of produce 81-82 and 82-83	Net profit for2 years	Average net profit per year
II Sweet potato-rice-rice	a. Sweet potato (Summer)	T1	3865	3865	–	–	11880	11718	–	–	14158	6428	3214.0
		T2	3408	3710	–	–	10260	10462	–	–	12403	4983	2491.5
		T3	3710	3408	–	–	7509	7492	–	–	9000	2184	1092.0
		T4	3755	3755	–	–	10125	10378	–	–	12301	4791	2395.5
		T5	3822	3822	–	–	10040	10479	–	–	12311	4667	2333.5
		T6	3833	3833	–	–	11812	11670	–	–	14089	6423	2211.5
	b. Rice (Virippu)	T1	3555	3555	2217	2342	–	–	2394	2704	14216	7106	3553.0
		T2	3175	3175	2153	2227	–	–	2205	2617	13582	7232	3616.0
		T3	3034	3034	2082	2176	–	–	2155	2557	9308	3240	1620.0
		T4	3435	3435	2153	2261	–	–	2325	2614	13767	6897	3448.0
		T5	3505	3505	2153	2361	–	–	2325	2603	13956	6946	3473.0
		T6	3533	3533	2217	2364	–	–	2394	2702	14258	7192	3596.0
	c. Rice (Mundakan)	T1	3555	3555	2193	2151	–	–	2375	2307	13370	6260	3130.0
		T2	3175	3175	2139	2084	–	–	2309	2310	13065	6715	3357.5
		T3	3034	3034	2085	2028	–	–	2252	2265	12963	6895	3447.5
		T4	3435	3435	2162	2089	–	–	2281	2187	12970	6100	3050.0
		T5	3505	3505	2149	2115	–	–	2319	2402	13249	6149	3023.5
		T6	3533	3533	2193	2156	–	–	2362	2407	13467	6401	3260.5

(Contd....3)

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Cropping sequences	Crops	Treatment	Cost of cultivation 81-82	Cost of cultivation 82-83	Produce Grain kgha^{-1} 81-82	Produce Grain kgha^{-1} 82-83	Tuber 81-82	Tuber 82-83	Straw/haulm 81-82	Straw/haulm 82-83	Pooled value of produce 81-82 and 82-83	Net profit for two years	Average net profit per year
III Cowpea-rice-rice	a. Cowpea (Summer)	T1	2475	2475	780	826	-	-	8030	-	8030	3080	1540.0
		T2	2223	2223	681	767	-	-	-	-	7240	2794	1397.0
		T3	2242	2242	662	700	-	-	-	-	6810	2326	1163.0
		T4	2417	2417	695	749	-	-	-	-	7220	2371	1185.5
		T5	2432	2432	786	799	-	-	-	-	7925	3061	1530.5
		T6	2475	2475	789	816	-	-	-	-	3025	3075	1532.5
	b. Rice (Virippu)	T1	3555	3555	2511	2564	-	-	2711	2704	15565	8445	4222.5
		T2	3175	3175	2379	2426	-	-	2569	2617	14796	8446	4223.0
		T3	3034	3034	2453	2354	-	-	2325	2557	14496	8432	4216.0
		T4	3435	3435	2295	2421	-	-	2356	2614	14392	7532	3766.0
		T5	3505	3505	2362	2411	-	-	2551	2603	14700	7690	3845.0
		T6	3533	3533	2480	2504	-	-	2679	2704	15351	8285	4142.5
	c. Rice (Mundakan)	T1	3555	3555	2490	2446	-	-	2689	2642	15203	8093	4046.5
		T2	3175	3175	2349	2362	-	-	2536	25-50	14508	8158	4079.0
		T3	3034	3034	2301	2294	-	-	2485	2477	14152	8088	4044.0
		T4	3435	3435	2335	2369	-	-	2522	2588	14518	7648	3824.0
		T5	3505	3505	2362	2394	-	-	2550	2558	14620	7610	3805.0
		T6	3533	3533	2494	2451	-	-	2693	2647	15230	8164	4082.0

(Contd...4)

Cropping sequences	Crops	Treatments	Cost of cultivation 81-82	Cost of cultivation 82-83	Produce Grain $kg ha^{-1}$ 81-82	Produce Grain $kg ha^{-1}$ 82-83	Tuber 81-82	Tuber 82-83	Straw/haulm 81-82	Straw/haulm 82-83	Pooled value of produce 81-82 and 82-83	Net profit for two years	Average net profit per year
IV Daincha-rice-rice													
	a) Daincha (Summer)		150	150	-	-	-	-	500	500	1000	700	350.0
	b) Rice (Virippu)	T1	3555	3555	2571	2174			2777	2347	14614	7504	3752.0
		T2	3175	3175	2490	2099	-	-	2689	2266	14133	7783	3891.5
		T3	3034	3034	2369	2018	-	-	2588	2179	13391	7323	3661.5
		T4	3435	3435	2419	2052	-	-	2613	2217	13772	6902	3451.0
		T5	3505	3505	2497	2100	-	-	2697	2193	14044	7034	3017.0
		T6	3533	3533	2557	2185	-	-	2755	2419	14658	7592	3796.0
	c) Rice (Mundakan)	T1	3555	3555	2288	2490	-	-	2695	2689	14940	7830	3915.0
		T2	3175	3175	2191	2436	-	-	2631	2625	14514	8164	4082.0
		T3	3034	3034	2058	2376	-	-	2566	2560	1394	4674	2332.0
		T4	3435	3435	2218	2403	-	-	2591	2622	14445	6870	3430.0
		T5	3505	3505	2224	2450	-	-	2645	2620	14613	7903	3957.5
		T6	3533	3533	2278	2500	-	-	2702	2700	14958	7892	3946.0

(Contd....5)

Cropping sequences	Crops	Treatment	Cost of cultivation 81-82	Cost of cultivation 82-83	Produce Grain $kgha^{-1}$ 81-82	Produce Grain $kgha^{-1}$ 82-83	Tuber 81-82	Tuber 82-83	Straw/haulm 81-82	Straw/haulm 82-83	Pooled value of produce 81-82 and 82-83	Net profit for two years	Average net profit per year
V. Fallow-rice-rice													
	a) Fallow (Summer)		100	100								-200	-100.0
	b) Rice (Virippu)	T1	3555	3555	2355	2342	-	-	2544	2531	14469	7359	3679.5
		T2	3175	3175	2295	2227	-	-	2477	2404	13895	7545	3777.5
		T3	3034	3034	2234	2176	-	-	2412	2351	13583	7515	3757.5
		T4	3435	3435	2264	2227	-	-	2478	2407	13867	6997	3498.5
		T5	3505	3505	2311	2261	-	-	2496	2441	14081	7071	3535.5
		T6	3533	3533	2389	2364	-	-	2579	2552	14637	7571	3785.5
	c) Mundakan	T1	3555	3555	2288	2490	-	-	2695	2689	14940	7830	3915.0
		T2	3175	3175	2193	2436	-	-	2631	2625	14514	8164.	4082.0
		T3	3034	3034	2058	2376	-	-	2506	2560	13994	7794	3897.0
		T4	3435	3435	2218	2403	-	-	2591	2622	14455	7585	3792.5
		T5	3505	3505	2224	2450	-	-	2645	2620	14613	7603	3801.5
		T6	3533	3533	2278	2500	-	-	2702	2700	14958	7892	3946.0

in the present study consist of various doses of N.P.K. for each crop. A part of the study also explores the possibility of decreasing the fertilizer schedule for a particular sequence. So in Table 99, treatment-wise cost of fertilizers have been calculated and included. This also shows that fertilizer reduction to the extent of 25 per cent can save about Rs.300-400/- every season and thereby the cost of cultivation also comes down to a lower level. It was on this basis that the cost of cultivation and net profit per hectare of the component crops were calculated.

The economics of the cropping sequences have been studied in detail to find out the most profitable cropping sequence. The acceptance of any cropping sequence, by a farmer depends on the net profit. The farmer will not accept a cropping sequence even if it gives a higher yield, or maintains or builds up soil fertility unless it gives a higher net profit. The cost of cultivation, gross income and net profit were calculated on the basis of yield and the prevailing market rates for the produce during the years 1981 and 1982.

Table 100 presents the cost of cultivation and net profit per hectare of the cropping sequences for the year 1981-82 and 1982-83. From the table, it is clear that sweet potato-rice-rice showed the maximum yield and the net profit per year of Rs.9887/- followed by cowpea-rice-rice Rs.9809/- rice-rice-rice, fallow-rice-rice and daincha-rice-rice sequences.

The treatments have a significant role in deciding not only yield but also the cost of cultivation of crop. T1 generally being the full recommended dose results in the highest cost, even though the yield is higher from the economic point of view the net profit is lower. The net profit will not fetch enough return for the investment on fertilizer when compared to other treatments. The treatment T2 where the fertilizer dose is only 75 per cent of the recommended level and T3 where it has been halved had lower investment cost. On comparing these different treatments with different cropping sequences, it was noted that T2 and T6 gave the highest net profit. In treatment T2, all the N, P and K were applied at 75 per cent of the recommended dose and T6 only K has been applied as 75 per cent of the recommended dose, while N and P have been applied of full recommended dose.

In short, the table reveals that the sweet potato-rice-rice gave the highest net profit from one hectare of land, followed by cowpea-rice-rice, rice-rice-rice.

As the sweet potato is a nutrient exhaustive crop and net investment for the crop is very high, it is better to adopt a cowpea-rice-rice sequence. It has also given a net profit all most as near as the sweet potato-rice-rice. More over, from the soil studies, it was made clear that the legume introduction in cropping sequence increases the soil fertility. Among the treatment studied, it also came out that even with 75 per cent of the recommended dose of N P and K.the higher yields can be obtained for rice. But long-term application of reduced doses of fertilizer will affect crop growth deleteriously because the soils status and the balance sheet of NPK reveals that in these soils for these component crops, fertilizer reduction is impossible. If fertilizer are applied at lower doses, it will seriously affect the soil fertility on a long term. So, the present recommended dose of fertilizer cannot be minimised for these crops in the sequences studied.

Overall, it may be seen that the two sequences which are suitable under Kerala rice farming situations are sweet potato-rice-rice and pulse-rice-rice. Though the farmer has a higher net profit with the former, both the sequences can be advocated under Kerala situations.

In fact, a third sequence which is being practiced is the rice-rice-rice sequence. This study has also shown that this sequence is good though slightly deleterious to soil fertility. This makes one suggest that in a given rice farming area of a ribbon valley in the mid lands of Kerala or the flood plains of the major rivers as in Palghat, lower regions of the paddy area or Ela are suitable for rice-rice-rice. The fringes of these regions which have more elevated plots with a water scarcity in summer rendering them unsuitable for rice cropping in summer, gives as an alternative a summer fallow. In such situations a sweet potato or a pulse crop can suitably be tailored for these regions with the available residual moisture or with a life saving marginal irrigation where ever feasible.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

An experiment consisting of five cropping sequences viz. rice-rice-rice (A1), sweet potato-rice-rice (A2), cowpea-rice-rice (A3), daincha-rice-rice (A4) and fallow-rice-rice (A5) and six treatments with varying doses of N P and K was conducted to study the performance of the sequences in relation to the nutrients required for optimising the output from the sequences.

The field experiment was laid out at R.R.S., Pattambi in 1980-81 and the experiment was conducted for two consecutive years ie. for six seasons. The experiment commenced with the summer crops of 1981, namely summer-rice (Triveni) sweet potato, cowpea, daincha and a summer fallow-wherein the land was ploughed twice and left as such without any crops. The component crops were raised with five treatments modified from the recommended doses for each.

The biometric observations like plant height in cm and tiller number at successive stages of growth, length of main shoots of sweet potato, number of branches and height of cowpea etc. were recorded. The crops were harvested at maturity and their yield noted. The soils were analysed for N P and K before the initial crop and after each successive crops. The plants removal of nutrients from the soil were analysed and computed. The balance sheet of the nutrients N P and K were worked out. An analysis of the net profit per hectare was made. The results are summarised as under and the salient conclusions highlighted.

(1) Height of summer rice plant was significantly affected by the treatments. The treatment with the full recommended dose of N P and K as per package of practices was found to be better.

(2) In summer rice, the tiller number was influenced by the treatments. Treatments with the full recommended dose (T1) and the treatment with full dose of N and P and 3/4 K (T1) were better.

(3) In summer cowpea again T1 and T6 gave the highest plant height.

(4) The observation on number of branches at successive stages of plant growth also revealed that the treatments have a significant effect on cowpea.

(5) The number of pods per cowpea plant, length of pods and 100 seed weight were enhanced by application of full dose of P and K for the cowpea crop. The results show that T_1 is the best treatment.

(6) Length of the main shoots of sweet potato revealed that treatments had a significant effect on its growth. Treatments T1 and T6 gave the highest response.

(7) The number of branches of sweet potato at different stages of growth indicated the significance of treatments on growth of sweet potato. The treatment T4 (full dose of P and K and 3/4 of N) and T6 (full dose N and P and 3/4 K) gave the highest response.

(8) The height of daincha plants observed in 1982 reveals that the differences observed in height of plant was related to the differential treatment received by the plots in the previous mundakan and virippu crops.

(9) The height of rice plants (Jaya) in cm at successive stages of growth for the virippu 1981 shows that the sequence daincha-rice-rice (A5) and fallow-rice-rice (A5) recorded the highest plant height and were on par, followed by the sequence pulse-rice-rice (A3). The sequences A4 and A3 were on par. The least plant height was indicated by rice-rice-rice (A1). The combination between treatments and sequences reveals that among the sequence-daincha-rice-rice recorded the maximum plant height in all treatments, followed by the sequence commencing with pulse-rice-rice. The treatments T1 and T6 recorded maximum plant height in all the sequences.

(10) The height of plants in cm at successive stages of growth of rice during mundakan 1981 also indicates that the sequence daincha-rice-rice (A4) and fallow-rice-rice (A5) recorded plant height on a par. This was closely followed by pulse-rice-rice (A3). The treatments have a significant effect in enhancing plant height.

(11) The plant height in cm at successive stages of growth of rice in virippu 1982 also indicates that the maximum plant height in the sequence fallow-rice-rice (A5), daincha-rice-rice (A4) and pulse-rice-rice (A3) sequences and were on a par. The maximum plant height were noticed on T1 and T6.

(12) The plant height in cm at successive stages of growth of paddy, mundakan 1982, also indicates that the sequences A3 and A4 recorded the maximum plant height and the treatments T1 and T6 gave the maximum height of plant.

(13) The mean number of tillers in the rice crop for the virippu 1981 shows that the sequence daincha-rice-rice (A4) and the sequence fallow-rice-rice (A5) recorded the heighest mean tiller number and were on a par. The maximum tiller number has been recorded by T1 and T6.

(14) The mean number of tillers in the rice crop for the mundakan 1981 also indicates that the sequence daincha-rice-rice (A4) and the pulse-rice-rice (A3) recorded the highest

number of tillers and the treatments T1 and T6 have the highest tiller numbers in all the sequences.

(15) The result on the mean number of tillers for the virippu 1982 and mundakan 1982 indicates that the sequence daincha-rice-rice and pulse-rice-rice gave the highest tiller number and the treatments T1 and T6 gave the highest tiller number in all the sequences.

(16) The yield of grain and straw in kg ha^{-1} in 1981 and 1982 summer indicates that treatments have got significant effect on the yield. The T1 and T6 gave maximum yield.

(17) The yield of sweet potato in summer 1981 and 1982 indicates that the treatments have a significant effect. The treatments T1 and T6 are the best.

(18) The yield or pulse in summer 1981 and 1982 indicates that the treatments have a significant effect on the yield. T1 and T6 are the best treatments for higher yield.

(19) The yield in kg ha^{-1} of the summer cowpea 1981 and 1982 showed that the treatments have significant effect and T1 and T6 are the best.

(20) The yield in kg ha^{-1} of the summer daincha 1981 and 1982 shows that there have been no significant difference in yield between treatments.

(21) The grain yield in Kg ha^{-1} of the virippu rice 1981 shows that only sequence have a significant effect. The sequence daincha-rice-rice (A4) recorded the highest yield followed by pulse-rice-rice (A3) and were on par with fallow-rice-rice (A5).

(22) The straw yield in kg ha^{-1} of the virippu rice 1981 shows that the sequences tried are not significant with respect to straw yield. Treatments however, have a significant effect. T1 and T6 are the best treatments.

(23) The grain yield in Kg ha^{-1} of the rice crop in mundakan in 1981 shows that both treatments and sequences have got significant effect. The sequence daincha-rice-rice gave the highest grain yield, followed by pulse-rice-rice and were on par. Among the treatments T1 and T6 gave the highest yield.

(24) The straw yield in kg ha^{-1} of the rice variety Jaya for mundakan 1981 shows that both sequences and treatments are significant. The sequence daincha-rice-rice gave the highest straw yield followed by pulse-rice-rice. Among the treatments T1 and T6 gave the highest yield.

(25) The grain yield in Kg ha^{-1} of the rice variety Jaya for the virippu 1982 shows that both sequences and treatment have a significant effect. Among the sequence daincha-rice-rice is the best followed by the sequence pulse-

rice-rice and fallow-rice-rice. The treatments T1 and T6 were the best.

(26) The straw yield in $kgha^{-1}$ of the rice variety Jaya for the virippu 1982 shows that both the treatments and sequences have a significant effect. The sequence daincha-rice-rice (A4) gave the highest straw yield and was followed by the sequence pulse-rice-rice (A3). Among the treatments T1 and T6 gave the highest yield.

(27) The grain yield in $kgha^{-1}$ of the rice variety for the mundakan 1982 shows that both sequence and treatments are significant. Here also the sequence (A4) gave the highest yield followed by the sequence (A3). The treatments T1 and T6 gave the highest yield.

The yield of straw in $kgha^{-1}$ for the rice variety Jaya in mundakan 1982 shows that both sequences and treatments have a significant effect. The sequence daincha-rice-rice (A4) and the sequence pulse-rice-rice gave the highest yield. The T1 and T6 are best treatments.

(28) The NPK content of both grain and straw in percentage at harvest of rice variety Triveni or Summer 1981 and 1982, the NPK content at harvest of grain, husk and haulm of summer cowpea 1981 and 1982, the NPK content in percentage at harvest of summer sweet potato 1981 and 1982, the NPK

content in percentage at harvest of the daincha crop for the year 1981 and 1982 and the NPK content of rice grain virippu and mundakan 1981 and 1982 and of the straw of the virippu and mundakan 1981 and 1982 show that there is no significant difference in the NPK content.

(29) The cultivation of various crops tends to change the soil pH. The sequence rice-rice-rice shows the highest decrease in soil pH. The sequences pulse-rice-rice and daincha-rice-rice show a lesser decrease in soil pH.

(30) The sequences have a significant effect on the organic carbon content of the soil. The sequence rice-rice-rice shows a high decrease in soil organic carbon after the crop, and this was followed by the sequences sweet potato-rice-rice and fallow-rice-rice. The sequence daincha-rice-rice has shown the highest gain in organic carbon status of soil after two years of cropping. The treatments T2 and T3 have shown the minimum level of organic carbon in the soil.

(31) The sequences have a significant effect in determining the total N per cent of the soil. The sequences daincha-rice-rice (A4) is found to be the best in maintaining a higher total N percentage in soil and was followed by pulse-rice-rice. The sweet potato-rice-rice maintains a

poor total N status of the soil. The same trend was noticed in the case of available N status of the soils also.

(32) The treatments and sequence have a significant effect on total P status of the soil. The sequence cow-pea-rice-rice (A3) is the best in maintaining a higher total P status of the soil followed by daincha-rice-rice (A4). The T1 and T6 are the best treatments maintaining a high total P status of the soil. A similar trend is observed for available P status also. The available 'P' status was high in daincha-rice-rice (A4) and cowpea-rice-rice sequences.

(33) Both sequences and treatments have a significant effect on total K status of the soil. The total K shows a decrease in all the sequences. The treatments T1 and T5 are found to be the best in maintaining total K status of the soil. Both sequences and treatments have a significant effect on the K status of the soil after two years of experiments. All sequences show a decrease in exchangeable K status of the soil. The daincha-rice-rice and cowpea-rice-rice are the best sequences in maintaining exchangeable K status of the soil. The T1 and T5 are the best treatment.

(34) The data on the uptake of N in kg ha^{-1} by the various component crops of the different cropping sequences during 1981 and 1982 show that the rice-rice-rice sequence removes about 126 to 143 kg of N, sweet potato-rice-rice removes about 181 to 194 kg, cowpea-rice-rice 138 to 149 kg, daincha-rice-rice 100-105 kg and fallow-rice-rice 91 to 98 kg of N from soil. The sequence sweet potato-rice-rice removes the maximum N from soil.

(35) The data on the uptake of phosphorus by the various component crops included in the cropping sequence during 1981 and 1982 shows that rice-rice-rice sequence removes about 26-30 kg of P_2O_5, sweet potato-rice-rice removes about 91-133 kg of P_2O_5, cowpea-rice-rice 22 to 27 kg of P_2O_5, daincha-rice-rice 25 to 31 kg of P_2O_5 and fallow-rice-rice 19 to 21 kg of P_2O_5 from the soil.

(36) The data on the uptake of exchangeable K by the various component crops of the cropping sequence for the year 1981 and 1982 shows that the rice-rice-rice sequence removes about 139 to 158 kg of K_2O, sweet potato-rice-rice about 229 to 309 kg, cowpea-rice-rice about 148 to 162 kg of daincha-rice-rice 260 to 279 kg and fallow-rice-rice 102 to 117 kg of K_2O from soil.

(37) From balance sheet of N in the various cropping sequences 1981 and 1982 shows that rice-rice-rice sequence shows a loss of 19 to 160 kg ha^{-1} sweet potato-rice-rice shows a loss of 21 to 162 kg ha^{-1} cowpea-rice-rice shows a loss of 32 to 127 kg ha^{-1} daincha-rice-rice shows a loss of 25 to 45 kg per hectare and fallow-rice-rice about 55 to 116 kg per hectare from the soil. The treatment have a significant effect. T1 and T6 are the best treatments.

(38) From balance sheet of available P (in kg ha^{-1}) over the initial status due to different cropping sequences for the year 1981 and 1982, it is observed that a net loss of 27 to 88 kg ha^{-1} in rice-rice-rice. The sequence sweet potato-rice-rice shows a net loss of 61 to 136 kg ha^{-1} cowpea-rice-rice shows a loss of 26 to 79 kg ha^{-1} daincha-rice-rice shows a net loss of 17 to 63 kg ha^{-1} and fallow-rice-rice shows a net loss of 15 to 63 kg ha^{-1} of available P. Treatments have a significant effect. The treatments T1 and T6 are the best.

(39) A slight decrease in exchangeable K status of the soil in the sequence rice-rice-rice has been observed. It shows a net loss of about 8 to 28 kg ha^{-1}. The sequence sweet potato-rice-rice shows a net loss of 27 to 115 kg ha^{-1}

cowpea-rice-rice shows a very negligible loss, daincha-rice-rice and fallow-rice-rice show, however, a small gain in exchangeable K status of the soil. The treatments have a significant effect.

(40) The highest cost of cultivation is for the sequence sweet potato-rice-rice, followed by rice-rice-rice, cowpea-rice-rice. The lowest is for the daincha-rice-rice and fallow-rice-rice. The lowest is for the daincha-rice-rice and fallow-rice-rice. The treatments T1 and T6 have the highest input cost.

(41) The net profit per hectare of the cropping sequence treatment-wise has been worked out. From the result it is clear that the sweet potato-rice-rice sequence gave the highest net profit per hectare followed by cowpea-rice-rice and rice-rice-rice sequences. Among the treatments full recommended dose gave the highest net profit. The lowest net profit per hectare was noticed for fallow-rice-rice and daincha-rice-rice which naturally had only two economic crops namely virippu and mundakan rice. The daincha crop in the sequence daincha-rice-rice had been raised with no monetary inputs.

(42) From the nutrient balance studies, it has to be stated that over a period of two years in all the sequences,

there has been a net loss of total N and available P. The efficiency of utilisation of these two nutrients are in the ranges 75-90 and 22-52. The total K levels are maintained fairly even in all the cropping sequences except daincha-rice-rice and cowpea-rice-rice wherein a slight increase has been observed.

REFERENCES

REFERENCES

Alice Abraham (1986). Release of soluble aluminium under submerged conditions and its influence on rice plant. Ph.D. thesis submitted to Kerala Agricultural University.

Allen, T.A. (1976). The effect of rates and dates of applying potassium on yields of cotton, winter wheat and maize. Agronomiya, 3: 80-81.

*Allen, A. (1986). The relationship between tuber size and tuber conservation of N P and K. J. Agric. Lebeneese (1): 503-505.

Ananthanarayana, R., Balakrishna Rao, K. and Mithyantha, M.S. (1988). Implications of changes in pH of some acid soils of Karnataka in different electrolytic solutions. J. Ind. Soc. Soil Sci., 30: 161-164.

Annual Report (1976). Report of Agricultural Research Station, Pattambi.

Annual Report (1977). Report of the All India Co-ordinated Rice Improvement Project. ICAR. Hyderabad.

Annual Report (1985). Report of the Agricultural Research Station, Kananady.

* Avokyan, S. (1972). Potential and amount of K in cultivated soils of Armenia and effectiveness of K fertilizers. Agri. Khimiya: 72: 327-329

Azam, A. (1986). Uptake of wheat plants and within soil fractions of residual nitrogen for leguminous plant materials and inorganic fertilization. Plant and Soil: 95 (1): 97-108.

Badiger, M.K., Subbareddy, N.P., Rosalind Michael and Shivaraj, B. (1982). Infülence of fertilizer potassium, sulphur and calcium on the yield and quality attributes of groundnut. J. Ind. Soc. Soil Sci., 3 (2): 166-169.

Bains, S.M. (1955). Efficiency of fertilizer nitrogen for rice. Fert. News. 16 (3): 30-32

Barnes, A. Greenwood, D.J. and Clever, T.J. (1986). A dynamic model for the effect of potassium and Nitrogen fertilizers on growth and nutrient uptake of crops. J. Agric. Sci. Camb. 76: 225-244

Battacharya, A.K. (1971). Mechanism of the formation of exchangeable ammoniacal nitrogen after waterlogging of rice soils. J. Indian Soc. Soil Sci. 19(2): 209-213

Basak, M.N., Bhattacharjee, P.K. and Sen, S.K. (1960). Effect of supplementary phosphate and potash with nitrogen on the yield of waterlogged rice. Indian J. Agri. Sci. 30: 272-280.

Bedřna, Z. (1974). Transformation of P and K fertilizer in the soil. Trans. 10th Int. Conf. Soil Sci., 4:327-333.

Black, C.A. (1985). Soil Plant relationships John Wiley and Sons Inc., New York PP 638.

Boyer, B. (1976). The effect of exchangeable aluminium on soil pH. J. Indian Soc. Soil Sci. 5 (2): 110-112.

*Brinkman, R. (1970). The fertility of paddy soils and fertilizer applications for rice. Geoderma. 3: 199-206.

Budhar, M.N., Kanda Swamy, O.S. and Narayanan, A. (1985). Double cropping system for dry land of Dharmapuri Dist. Madras. Agric. J., 72(8): 451-453.

Chandler, R.P. (1979). Rice in the tropics: A guide to the development of National Programmes. Westview Press, Soil Inc. Colorado.

Chang S.C. and Jackson M.L. (1958). Soil P fractions in some representative soils. J. Soil Sci. 9: 109-119.

Chiu, T.P. (1971). The fertility of paddy soils and fertilizer applications for rice. J. Taiwan Agric. Res. 20(1):1.

Chiu, T.P. and Li, L.J. (1965). Potash review: In the fertility of paddy soils and fertilizer application for rice. ASPAC. 1965.

Cholitkul, W., and Tyner, E.H. (1971). Inorganic phosphorus fractions and their relation to some chemical indices of phosphate availability for some low land rice soils of Thailand. Int. Symp. Soil Fert. Eval., New Delhi 2-20.

Chaudhury, M.S. and Vechami, M.V. (1985). Long term effect of ammonium sulphate on the productivity status of rice soil. Indian J. Agron. 10 (2): 145-152.

Clark, R.V. and Mack, A.R. (1974). Effect of growing barley continuously on yield, chemical constituents and disease prevelence. Canadian. J. Plant. Sci. 54(2): 307-314.

Dahiya, S.S. and Restogie, S.K. (1976). Nutrient removal by crops. Farmer and Parliament: 1: 160-162

Dasharthi, T.E. and Padmanabha, V. (1972). A brief note on the work done in the All India Co-ordinated project on tuber crops, Rajendra Nagar, Hyderabad, Andhra Pradesh. Paper presented at the third All India Workshop on tuber crops held at Trivandrum.

David, G. (1964). The time methods of phosphatic fertilizer application. Phosphorus in Agric. 4: 21-25.

De Datta, S.K. (1970). Fertilisers and soil amendments for tropical rice. Rice Production Manual (1970). IRRI: 114-120.

De Datta, S.K. and Surjith, K. (1981). Principles and Practices of rice production. John Wiley and Sons, Singapore PP 1-618.

Deka, J.C. and Singh, Y. (1984). Studies on rice-based multiple cropping sequences effect of crop rotation on fertility status of soil. Ind. J. Agron., 29(4): 441-447.

Dent, O. (1986). Acid Sulphate soils: a base line for research and development. International Institute for Land Reclamation and Improvement, Post Box 456700, AA, Wageningen, Netherlands.

Dickman, S.R. and Bray, R.H. (1940). Colorimetric determination of phosphate. Indus and Engin; Chem. Annual; Ed., 12: 665-668.

Didi Asde S. and wid Jafe, I.P.G. (1986). Residual effect of P fertilizer, lime and organic matter on soil fertility and soya bean yield on an Alfisols. J. Indian. Soc. Soil Sic. 32:517-521.

Digar, S. (1960). Manurial requirement of paddy in a laterite soil. J. Indian Soc. Soil. 8(1): 23-34.

Dillen, N.S. and Deve, G. (1986). Influence of various cropping sequences on P desorption in soil. J. Indian. Soc. Soil Sci. 34: 529-531.

Dubey, S.K. and Shinde, D.A. (1986). Effects of phosphate and potash application on pod yield and uptake of macro-nutrients by groundnut. J. Indian. Soc. Soil Sci. 34: 302-309.

Ebong, U.K. (1965). Cowpea production in Nigeria. Mem. Fed. Dep. Agric. Res. Fed. Rep. Nigeria. 80: 1-9.

Esakimuthu, N.K., Krishnamoorthy, K.K. (1977). Progressive changes in forms of nitrogen and potassium in soils during crop growth as influenced by application of nitrogen and potassium. Agriculture and Agro.industries Journal, Bombay. 9: 82-85.

Ezedimma, F.O.C. (1964). Effect of inoculation with local isolates of cowpea rhizobium and application of nitrage nitrogen on the development of cowpea. Trop. Agric. Tripaded. 41: 243-249.

Ganeshamoorthy, K. and Biswas, C.R. (1985). Non-exchangeable sources in soil to crops. J. Indian Soc. Soil Sci. 33: 60-66.

Gangwar, B. (1987). Rice-based crop sequences for the Andaman Islands. I.R.R.I. 12(2): 41-47.

Gajbhiye, K.S. (1985). Forms of potash in some Inceptisols and Entisols. J. Indian. Soc. Soil. Sci. 3(3): 412-415.

Ghosh, A.B. and Kanzaria, M.V. (1964). Soil fertility investigations under continuous manuring and cropping in Pusa permanent manurial experiments. Bull. Natl. Inst. Sci. India. 26: 245-259.

Ghosh, R.L.M., Chatge, M.B. and Subramonian, K. (1956). Rice in India., I.C.A.R., New Delhi.

Gill, M.P.S., Dhillen, N.S. and Dev, G.P.(1987). Nutrition of groundnut-wheat and green gram-wheat crop sequences in alluvial sandy loam. J. Indian. Soc. Soil Sci. 55: 420-431.

Girst, D.H. (1969). A rational system of rice nutrition Agric. Digest. 17: 20-28.

Godsase, A.N. and Dongale, J.H. (1984). Nutrient uptake pattern and yields of horsegram as influenced by N and P application J. Indian Soc. Soil Sci. 32: 387-389.

Goodfray - Sam Aggrey, W. (1976). Effect of potash fertilizers in Sweet potato in Sierraleone. Expt. Agric. 12 (1): 87-94.

* Hanway, P. (1962). 4th Annual, Fertilizer industry Representative Conference, IOWA, University.

Hati, N. and Ray, A.K. (1984). Legume cereal association in Pigion Pea - Finger millet. J. Indian Soc. Soil Sci 32: 183-185.

Helder, B.R. and Mandal, L.N. (1985). Lime requirement of acid soils in relation to pH, exchangeable Al content of soils and extractable acidity. J. Indian. Soc. Soil Sci. 33: 528-535.

* Huang, S.P. (1969). Experiment report on soils and fertilizers. Taiwan prov. Dept. Agric. and Fores. (in Chinese).

I.R.R.I. (1963). Annual Report of the International Rice Research Institute, Las Banos, Laguna.

Islam, A. and Bolton, J. (1970). The effect of soil pH on K in the release of non exchangeable K to rye grass. J. Agric. Soil Cant. 25: 571-576.

Jackson, M.L. (1974). Soil Chemical Analysis, Prentice Hall, Inc. New Jersey.

Jacquinot, L. (1967). Grain legumes of the low land tropics Advance in Agron. 26: 1-132.

Jain, V.K., Chauhan, Y.S. and Jain, P.C. (1986). Effect of different doses of phosphorus on growth, yield and quality of cowpea. Madras Agri. J. 73 (4): 199-202.

Jayarani, R. and Ramaiah.B(1980). Response of cowpea (Vigna sinensis.L) to phosphorus and growth regulators. Madras agric. J. 67(2): 102-105.

Jones, G.H.G. (1942). The effect of leguminous cover crops in building up soil fertility. East Agric. J. 8: 48-51.

Jhonson, W.A. and Ware, L.M. (1948). Effect of rates of nitrogen on relative yields of sweet potato vines and roots. Proc. Amer. Soc. Hort. Sci. 52:313-316.

Juco, A.S.R. and Lal, R. (1975). Effect of continuous cropping and residue management on chemical and physical properties of Alfisol in Southern Nigeria. Agron. Abst. 2:38.

Kabeerathumma, S. and Mohankumar, B. (1986). Efficiency of rock phosphate as a source of phosphate to sweet potato. J. Indian. Soc. Soil Sci. 34: 306-309.

Kanwar, J.S. (1974). Assessment of potassium fertilization in the tropics and sub tropic of Asia. Proceedings of the 10th Congress of the Int. Potash Inst. in Budapest, Hungary.

Kanwar, J.S. and Prihar, S.S. (1962). Effect of continuous application in the tropics and sub tropics of Asia. Proceedings of the 10th Congress of the Int. Potash Inst. in Budapest, Hungary.

Kapur, M.L. Singh, R. and Singh, S. (1984). Response of maize and wheat to K application in soils different in available K status. J. Indian. Soc. Soil Sci. 32: 442-444.

Kar, A.K. (1973). Availability of iron and aluminium of applied phosphates in acidic reactions in Indian acid soils. Technology (India) 10: 253-255.

Katua, R.B. and Sahu, B.F. (1970). Response of high yielding dwarf indica rice to different sources and levels Oryza., 7(1): 17-20.

*Kawaguchi, K. and Kawachi, J. (1966). Changes in the exchangeable cations in the course of drying of preliminary submerged soils. J. Sci. Soil. Manures. Tokyo 42: 177-18?

Kemmler, G. (1971). The fertility of paddy soils and fertilizer application for rice. Inst. Symp. Soil Fert. Eval. New Delhi.

Khanna, S.S. and Mahajan, K.K. (1971). A study of the behaviour of added phosphate in soils of variable physico-chemical properties. Int. Symp. Soil Fert. Eval. New Delhi, 725-736.

Khandkar, U.R., Shinde, D.A., Kondalkar, V..., Nigam, K.., and Jain, R.K. (1985). Response of Bengal gram to N and P fertilisation in a vertisol under rain fed condition. *J. Ind. Soc. Soil Sci.*, **34**: 803-85.

Krishnamoorthy, K., Manickam, T.S. and Kothandaraman, A.(1985). Influence of P and micronutrient on the yield and uptake to NPK in cowpea variety Co-3. *Madras Agric. J.* **72**(4): 181-184.

Kulkarni, C.S., Patil, A.V. and Krishnamoorthy, K. (1973). Response of cowpea (*Vigna Catjang*) to varying fertilizer levels. *Mysore J. Agric. Sci.* **7**: 170-174.

Lal, R.B. (1973). *Effect of different cropping intensities and irrigation methods on an economics of crop production.* Ph.D. thesis in Agronomy submitted the Faculty of the Post graduate school, I.A.R.I., New Delhi.

Landrau, P. and Samuels, G. (1957). The effect of fertilizer on the yield and quality of sweet potatos. *J. Agric. Univ. Proc.* **35** (2): 71-77.

Lenka, D. and Behera, P.C. (1967). Response of four Taiwan local varieties of paddy high levels of nitrogen. *Indian J. Agron.* **12**(4): 353-357.

*Lichner, J. (1979). Study of the relationship between potassium content of soil and dry matter of a grass weed. *Polnoho spodarstvo.* **22**(3): 205-213.

Lim, C.F. (1955). The relative effectiveness of organic ameleorates and their relation to production capacity of paddy Soil Fertil. Taiwan. 8-17.

Mahapatra, I.C. (1968). Effect of flooding on soil reaction and mobilisation of various nutrients. J. Indian. Soc. Soil Sci. 16: 149-153.

Mahapatra, I.C. and Patrik, J.W.H. (1969). Fertilizer needs of rice. Indian. Fmg. 18 (12): 21-27.

Mahapatra, I.C. and Rajendra Prasad.S.(1970). Response of rice to potassium in relation to transformation and availability under waterlogged condition. Fert. News. 15 (2):34.

Maharatra, P.K., Bhol, B.B. and Patnaik, R. (1987). Rice based crop rotation for upland fields. IRRN 12: (4).

Mahapatra, I.C., Patrick, J.W.H. and Singh, S. (1987). The fractions of soil nitrogen during different periods of submergence and their effect on yield and nutrition of wet land rice. Biology and fertilizer of soil. 6(1): 45-49.

Mahendra Singh,S. and Jai Prakash, R. (1968). Effect of fertilizers on mineralisation of nitrogen and phosphorus in manures. J. Ind. Soc. Soil Sci., 16(4): 405-408.

Mahimairaja, S. and Mayalagu, K. (1985). Available Fe in rice soils by varied levels of p x Fe under two irrigation regimes. Madras Agric. J. 72(2):113-115.

Mandal, B.C., Roy, A.B., Shah, M.N., and Mandal, A.K. (1984). Wheat yield and soil nutrient status as influenced by continuous cropping and manuring in a jute-rice-wheat rotation. J. Indian. Soc. Soil Sci. 32: 696-700.

Mandal, B.C., Mandal, A.K., Ghosh, A.B. (1982). Changes in organic carbon and total nitrogen in a Gangetic alluvium after five years of multiple cropping with rice-wheat. J. Indian Soc. Soil Sci. 30(1): 94-96.

Mandal, L.N. and Khan, S.K. (1977). Release of P from insoluble phosphate materials in acidic lowland and rice soils. J. Indian. Soc. Soil Sci. 20(1):19-25.

Mandal, R.C., Singh, K.D. and Magoon, M.L. (1968). Manurial spacking trial on sweet potato. Annual Report Central Tuber Crops Research Institute, Trivandrum. 25-26.

Mandal, R.C. and Mohankumar, C.R. (1971). Studies on production economics of high yielding varieties on sweet potato. Annual Report Central Tuber Crops Research Institute, Trivandrum. 23-24.

Martine, J.A. and Suarez, A. (1977). K supplying and fixing capacity of costs ricon latosols and andosols. Soil Sci. 123: 37-40

Mehrotra, L. and Crulae Singh, S. (1970). Nature and distributi of potassium in the surface soils of U.P. J. Indian Soc. Soil Sci. 15 (2): 90-94.

Matsushima, S. (1965). Nitrogen requirements at different stages of growth. The mineral nutrition of rice plant. The John Hopkins Press, Baltimore. Md. 219-242.

Merchandani, T.T. and Khan, A.R. (1953). Green manuring. Rev. Ser. Bull. 6

Mitsui, S. (1955). In organic nutrition, fertilization and soil amelioration for low land rice. Yokendo Ltd. Tokyo, Japan.

Mikkelsen, D.S. and Patrick.W.H. Jr. (1968). Changing pattern in fertilizer use. Soil Sci. Soc. Amer. Wisconsin, USA. 403-432.

Moore, A.W. (1962). The influence of legume on soil fertility under a grazed tropical pasture. Emp. J. Expt. Agric., 30: 239.

Moore, D.P. (1972). Micronutrients in agriculture. J.J. Mortvedt, P.M., Giordano, W.L., Lindsay eds. 171-198.

Morgan, N.D. (1934). Relation of fertilization to the yield and keeping quality of sweet potato. Proc. Amer. Soc. Hort. Sci. 37: 849-854.

Morita, T. (1967). Effect on application time of nitrogeneous fertilizers on top growth, tuber formation and developments of sweet potato. J. Jap. Soc. Hort. Sci. 369(4):21-26.

Mohankumar, C.R. and Singh, K.N. (1984). Studies on N. Water regimes and weed control in upland direct seeded rice. II Nitrogen recovery and productive efficiency. Indian J. Agron. 29(4): 453-458.

Mohand, ?. and Singh, R.A. (1968). Effect of cropping on agri- gation and some other aspects of physical properties of acidic soils of Kanke (Ranchi). J. Soil Wat. conserv. India. 17: 67-73.

Mutomon, L. (1971). Green manuare in combination with ferti- lizer Nitrogen in rice under multiple cropping system. Aust. J. Agric. Res., 12: 705-710.

Nad, R.K. and Goswami, N.N. (1984). Effect of long term application of phosphate on soil phosphorus status in a rice-wheat-rotation. J. Ind. Soc. Soil Sci. 32:(1) 288-291.

Nair, G.M., Sadanandan, N. and Nair, R.V. (1976). Effect of lime of application of nitrogen at different levels on the uptake of nitrogen by sweet potato varieties. J. Rootcrops. 2 (1):21-24.

Nair, P.K.R. and Singh, A. (1971). Production potential, economic feasibilities and input requirement of five high intensity crop rotations with rice (Oryza Sativa.L.) Indian. J. Agri. Sci. 41(10):807-815.

Nair, P.K.R., Singh, A. and Mododgal, S.C. (1973 a). Maintenance of soil fertility under intensive multiple cropping in Northern India. Indian. J. Agric. Sci. 43(3):250-255.

Nair, P.K.R., Singh, A., and Modgal, S.C. (1973 b). Maintenance of soil fertility under intensive multiple cropping in Northern India. Ind. J. Agric. Sci. 44(2): 200-205.

Nelliat, E.V., Bavappa, K.V. and Nair, P.K.R. (1974). Multi-storeyed cropping-a new Dimension in Multiple cropping for coconut plantations. World Crops. 10: 202-206.

Nijhawan, H.L. (1963). Role of groundnut in maintaining soil fertility. Ind. J. Agron. 7(3): 236-239.

Noshita.N. and Hang. R.M. (1986). Distribution of different forms of Nitrogen in some desert soils. Soil Sci. 116(1):-160-162.

Pande.N. Singh, R.S. and Singh, S. (1985). Effect of submergence on changes in soil properties and yield and nutrient uptake by rice with varying nutrio environment in low land rice soil. J. Indian Soc. Soil Sci. 33: 816-820.

Parr, C.H. and Bose, R.D. (1944). Phosphate manuring of legumes-1, Indian Fmg. 5: 156-162.

Parr, C.H. and Bose, R.D. (1945). Phosphate manuring legumes-II. Indian Fmg., 5:156-162.

Parr, C.H. and Sen, S. (1948). Phosphatic manuaring of legumes in relation to green manuring. Ind. Fmg., 9: 227-238.

Patel, B.P., Khade, V.N., Khanvikas, S.A., Dongale, J.H. (1987). Irrigated rice based cropping strategies in coastal Maharashtra, IRRN., 12 (1).

Patrick, W.H. and Mahapatra, I.C. (1968). Tranformation and availability to rice nitrogen and phosphorus in water-logged soils time of application. Advances in Agron., 20: 323-359.

Paul, E.A. and Myers, R.J.K. (1971). The effect of soil moisture stress on uptake and recovery of tagged nitrogen by wheat. Can. J. soil Sci., 51: 37-43.

Pillai, K.G., Rao, A.V., Sharma, Y.R.D. and Rao, N.S. (1976). Economics of nitrogen for dwarf rice variety. Fert. News: 21(2): 34-36.

Piper, C.S. (1950). Soil and Plant Analysis. University of Adelaide, Australia.

Ponnamperuma, F.N. (1955). The chemistry of submerged soils in relation to the growth and yield of rice. Ph.D. Thesis, Cornell Univ., Ithaca, New York.*

Ponnamperuma, F.N. (1964). Dynamic aspect of flooded soils and nutrition of rice plant. Proceedings of symposium on rice IRRI, Philippines, Manila.

Ponnamperuma, F.N. (1965). Dynamic aspects of flooded soils and the nutrition of the rice plant. The mineral nutrition of the rice Plant. The John Hopkine Press, Baltimore, Md.

Ponnamperuma, F.N. (1972). The chemistry of submerged soils. Advances in Agron. 24: 29-96.

Ponnamperuma, F.N. (1975). "Major Research in upland rice". IRRI, Los Banos, Philippines.

Ponnamperuma, F.N. (1979). Chemical changes in submerged soils and their effect on rice growth. Soils and Rice., 421-440.

Poyser, W.A., Holdin, R.M. and Ridley, A.O. (1957). The effect of farm and green manures on the fertility of black earth- Meadow Clay Soils. Canadian. J. Soil Sci., 37: 48-56.

Prasad, B. and Jha, J. (1973). Effect of continuous cropping of rice with high dose of fertilizer on the organic carbon status of soil. Indian. J. Agron. 18(1): 41-46.

Prasad, B., Singh, K.D.N. and Singh, B.P. (1986). Effect of long term use of fertilizer and manure on forms and availability of nitrogen in an acid soil under multiple cropping system. J. Indian Soc. Soil Sci. 34: 271-274.

Prasad, B., Sinha, K. and Sinha, N.P. (1982). Effect of continuous application of farm yard manure and fertilizers on available soil K and its uptake by potato. J. Indian. Soc. Agri. Sci., 30(2): 235-236.

Prasad, R. and Palaniappan, S.P. (1987). Pulse crop residue as nitrogen source in rice based cropping system. International Rice Research News letter T.N.A., 12 (1).

*PrimaVesi, A.M. and Primavesi, A. (1971). Differences in analytical results with try and wet soils. Agro.Chemicr., 15 (4-5): 454-460.

Purushothaman, S. (1979). Studies on rice based cropping. Ph.D. thesis submitted to the Tamil Nadu Agricultural University, Coimbatore.

Ruchie, K.C. and Robert, L.M. (1974). Grain legumes of the low land tropics. Advances in Agron., 26: 1-132.

Racho, V.V. and De Datta, S.K. (1968). Nitrogen economy of cropped and uncropped flooded rice soils under field conditions. Soil Sci. 105: 419-427.

Raghavalu, P. and Sreeramamoorthy, V. (1975). Production potential and economics of different crop sequences at Rudrur. Indian. J. Agron: 20(4):306-310.

Raheja, P.C. (1966). Soil Productivity And Crop growth. Asia Publishing House, Bombay.

Rajakannu, K., Balasubramonian, C.S. and Lekshmi Narayanan, C.K. (1970). Relationship of available K with soil reaction, available N, lime content and organic carbon in soils of Tamilnadu. Madras Agric. J. 57: 77-79.

Ram, P. and Singh, B. (1975). K in paddy in soils of Eastern U.P. Indian Soc. Soil Sci., 23: 222-226.

Ramanathan, K.M. and Subbiah, S. (1972). A study on the progressive uptake of potassium by finger millet. Indian. J. Agri. Res., 12: 15-18.

Ramanathan, K.M. (1978). An evaluation of potassium availability indices of some soils of South India. J. Indian. Soc. Soil Sci., 26(2): 198-202.

Ramaswamy, P.P., Oblisami, G. and Chellamuthu, S. (1985). Influence of N, P and inoculation on nodulation and yield in Black gram. Madras Agric. J., 72 (1): 658-660.

Rana, D.S., Singh, B., Kapur, M.L. and Bhandari, K.L. (1984). Crop yields and nutrient uptake in a cropping sequence under resource constraints. J. Indian Soc. Soil Sci., 32(2): 284-287.

Rao, J.S. and Ramanujam, K. (1971). Effect of nitrogen levels on the net assimilation rate and yield of A.B.T. -27 rice. Madras Agric. J. 58 (12): 898-900.

Rethinam, P., Kolandaswamy, S. and Sankaran, S. (1975). Studies on the comparative response of nitrogen. Madras Agric. J., 62(2):89-91.

* Rixon, A.J. (1966). Soil fertility changes in red brown earth under irrigated pastures 1. Change in organic carbon, C/N ratio, Cat-ion exchange capacity and pH. Australian. J. Agric. Res., 17: 303-316.

Robert, L. and Olsen, F.R. (1944). Influence of Phosphorus and potash on symbiotic nitrogen fixation. J. Amer. Soc. Agron., 36: 637-647.

Russel, E.W. (1961). Soil conditions and Plant growth. (Nineth edition). Longman's green and Co.Ltd., 48, Grosvenor Street, London-W1.

Schatschabel.P. (1971). Study of causes and native acidity of soils. J. Amer. Soc. Soil Sci. 5 (2): 125-132.

Sadanandan, N. and Mahapatra, I.C. (1972). Effect of various cropping patterns on pH of upland alluvial rice soils. Ind. J. Agron., 17 (1): 41-44.

Sadanandan, N. and Mahapatra, I.C. (1972a). A study of the changes in potassium status of soil due to multiple cropping. Agri. Res. J. Kerala 10 (1): 5-9.

Sadanandan, N. and Mahapatra, I.C. (1973). Studies on multiple cropping - balance sheet of total and available phosphorus in various cropping patterns, Indian J. Agron. 18 (4): 459-463.

Sadanandan, N. and Mahapatra, I.C. (1972c). Study on the soil available phosphorus as affected by multiple cropping. J. Indian Soc. Soil Sci., 20(4): 371-374.

Sadanandan, N. and Mahapatra, I.C. (1974b). Studies in multiple cropping-balance sheet of total and exchangeable potassium in soil in various cropping patterns. Indian J. Agron. 19(2): 138-140.

Sadanandan, N. and Mahapatra, I.C. (1975). A study on the effect of multiple cropping on the organic carbon status of upland alluvial soils. Agric. Res. J. Kerala. 13 (1): 33-38.

Sadasivan, R. (1985). Influence of NPK on growth and yield of rice. Madras Agric. J. 60(7): 610-630.

Sadayappan, S. and Kollendaiswamy, R. (1974). The influence of added nitrogen and its time of application on grain protein, phosphorus and potash. Madras Agri. J. 61(9): 646-647.

Sagar, S.G., Dev, G. and Meelu, O.P. (1986). Phosphorus fertilisation and its availability in wheat-rice-sequence. Ind. J. Agron. 31(4) 25-60.

Sahu, S. and Gupta, S.K. (1987). Fixation and relief of K in some alluvial soil. J. Indian. Soc. Soil Sci. 35: 29-34.

Sahu, B.N. and Lenka, D. (1966). Cultural-cum-manurial trials on paddy. Studies on the effect of dates of planting, spacing and levels of N and P on the yield of paddy. Indian. J. Agron. 11(2): 127-138.

Sahu, P.N., Padhi, A.K. and Hola, A.K. (1988). A rice grain legume cropping system from South coastal Orissa. I.R.R.N., 13 (6):46.

Salter, R.M. and Green, T.C. (1933). Factors affecting accumulation and loss of N and organic carbon in cropped soils. J. Amer. Soc. Agron. 25: 622-630.

Sanchez, S.L.F., Lopez, N.A. (1986). Low input systems and management fallows of acid soil in the humid tropics in soil management under humid conditions in Asia IBS RAM proceedings. International Board for Soil Research and Management. 353-360.

Sasidhar, V.K. (1979). Studies of the effect of multiple cropping on soil fertility and crop yields in wet land. Ph.D. thesis submitted to the Kerala Agricultural University.

Sasidhar, V.K. and Sadanandan, N. (1977). Studies on the effect of multiple cropping on soil fertility and crop yields in wet land. Agric. Res. J. Kerala., 2: 100-110.

Sasidhar, V.K. and Sadanandan, N. (1980). Comparative cropping and fertilizer use on organic and inorganic forms of P. In an aluvial soil. Madras Agri. J. 68(1):19-23.

Sarkar, S.K., Baser, U.H. and Dhua, S.P. (1986). Studies on the combined use of the chemical fertilizers.on yield and nitrogen uptake in a rice wheat sequence. J. Indian Soc. Soil Sci. 33: 187-199.

Schanderi, H. (1943). Studies of the nitrogen relations of legumes and non-legumes. Planta 33:424-437.

Scott, L.E. (1950). Potassium uptake by the sweet potato plants. Proc. Amer. Soc. Hort. Sci., 56: 248-252.

Selvaraj, K.V.R., Kulandaivelu, B., Rajakannu and Muthuvel (1988). Rice based cropping system in lower Bhavani project area in Tamilnadu IRRN., 13(3): 49.

Shapiro, R.E. (1958). Effect of flooding on the availability of phosphorus and nitrogen. Soil. Sci. 85:190-197.

Sharma, B.K. and Saxena, M.C. (1970). Balance of nitrogen in soil as affected by crop sequence and fertilization with nitrogen and phosphorus. Indian. J. Agric. Soil. 40(3):839-843.

Sharma, A.K. and Garg, K.P. (1975). Effect of phosphorus and molybdenum on growth and fodder yield of legumes. Indian J. Agron: 18: 1-5.

Sharma, C.K. and Tripathi, B.R. (1984). Phosphorus availability indices in relation to phosphorus fraction in some Himalayan acid soils of North India. J. Indian Soc. Soil Sci. 32: 292-298.

Sharma, M.L. and Mishra, V.K. (1985). Effect of inoculation levels of nitrogen on growth, yield and quality of wheat. Madras Agri. J. 73(2): 96-100.

Sharma, R.D. and Mishra, B. (1988). Availability of NPK and Si. in a Mollisol under flood rice. J. Indian Soc. Soil Sci. 36(1): 165-168.

Sharma, R.D., Mishra, B. and Singh, S, (1986). Residual effect of leguminous crop on some chemical and microbiological properties of soil. J. Indian Soc. Soil Sci. 34: 206-208.

Sharma, S.N., Prasad, R. and Singh, S. (1987). Legumes for nitrogen economy and double cropping under rainfed condition. Ind. J. Agri. Sci. 57(12): 899-904.

Sinha, S. (1957). The effect of continuous cropping on crop yields, nitrigying power of soil and nitrogen uptake by plants. J. Ind. Soc. Soil Sci., 5: 205-211.

Singh, K.D. and Moorthy, B. (1974). Choice of crop rotations in sustaining the productivity of crop land ecosystem of North-Western Indo Gangetic plains. Transections. 10th International Congress of Soil Science. 4: 41-49.

Singh, K.D. and Ramamoorthy. B. (1974). Choice of crop rotations in sustaining the productivity of crop land eco-system of North Western Indo-Gangetic plains. Transactions, 10th International Congress of Soil Science., 4: 41-50.

Singh, S. and Singh, S.S. (1976). Effect of waterlogging and organic matter on the inorganic P fractions of soil. J. Ind. Soc. Soil Sci. 24(1): 88-90.

Singh, V.P., Mahendra Singh,S. and Rajendra Singh.K.(1985). Forms of soil K in Western part of Haryana. J. Indian Soc. Soil Sci. Vol. 33: 284-291.

Singh, K.D., Prasad, B. and Chatterjee.L.(1986). Transformation of applied K in relation to its availability in Calcareous soil. J. Indian. Soc. Soil Sci. Vol. 34: 309-313.

Singhania, R.A. and Goswami, N.N. (1978). Relationship between available phosphorus and phosphate fraction in the soil, phosphorus in soils, crops and fertilizers. Bull. Indian. Soc. Soil Sci. 12: 377-385.

Singh, R., Jagrupsingh,S. and Bains, S.S. (1973). Response of rice to the sources, the rate and time of application of nitrogen under flooded condition. J. Res. Punjab. Agric. Uni. 15 (1): 8-44.

Singh, B. and Mondgal, N. (1978). Intensive cropping-rice-wheat cropping system. J. Res. Punjab. Agric. Univ. 10(1): 5-40.

Sreedevi, S. and Aiyer,R.S.(1976). Potassium status of acid rice soils of Kerala State. J. Indian. Soc. Soil Sci., 22(4) 321-328.

Srivasthava, O.P. and Pathak, A.N. (1971). Date of applied K in some soils of U.P. J. Ind. Soc. Soil Sci. 20(2): 103-109.

Sturgis, N.B. (1936). Changes in the oxidation, reduction equilibrium in soils as related to the physical properties of soil and growth of rice. La.Agri.Expt. Stn.Bull.271.

Sturgis, M.B. (1957). Soils. U.S.D.A. Year book: 658-663.

Subbarao, A. and Ghosh, A.B. (1983). Available potassium content in soil under indefinite fertilizer use as revealed by some soil test. Madras Agric. J. 70(1): 24-27.

SubbaRao, A. and Ghosh, A.B. (1981). Effect of the intensive cropping and fertilizer use on organic and inorganic forms of P. In an aluvial soil. Madras Agri. J. 68(1): 19-23.

Sudhir, K. Agarwal, I. Singh, P.A. and Bhardwaj, V. (1987). Inorganic soil P fractions and available P as effected by long term fertilization and cropping pattern in Nainital. Tarai. J. Indian. Soc. Soil Sci. 35: 25-28.

Subbiah, G.V. and Prasad Rao, B.M.V. (1983). Continuous cropping of rice influencing of temperature an uptake of NPK and Zn in rice. Agri. J. 70(3): 157-162.

Subramonian, A., Bala Subramonian, A. and Venkatachalam, C. (1977). Effect of varying levels of fertilizer and spacing on the yield of cowpea. Madras Agric. J. 64(9): 614-615.

Sukumaran, K., Nadarajarathinam, N. and Chandrababu, R. (1985). Effect of foliar application of K on carbon assimilation in greengram. Madras Agri. J. 72(8): 459-460.

Sushamakumari, P. (1981). Effect of different ratios and levels of N, P and K on maximisation of yield of rice. M.Sc. thesis division of Agronomy, College of Agriculture, Vellayani, Trivandrum.

Surendran, K. (1985). Nitrogen management in rice variety Lekshmi. M.Sc. (Ag.) Thesis division of Agronomy, College of Agriculture, Vellayani, Trivandrum.

Tiwari, G.P. (1965). Grain legumes of the low land tropics. Adv. Agron., 26: 1-132.

Tewari, A.M. and Thakur, C. (1976). Nutritional requirements of dwarf rices - I.R.8 and Jaya. Madras Agric. J. 63(2): 109-110.

Thakhur, R.S., Bisen, D.C. and Dubey, S.M. (1975). The transformations of applied P under waterlogged conditions in rice culture. J. Indian. Soc. Soil Sci. 23(4): 423-427.

Tanaka, A. and Yoshida, S. (1970). Nutritional disorders of rice in Asia. IRRI Tech. Bull. 10.

Thomas, K.M. (1964). "Studies on some forest soils of Kerala" M.Sc. (Ag.) Thesis, Univ. of Kerala. 1964.

Thomas, C.V. (1965). Studies on the response of certain varieties of sweet potatoes to fertilizer application. M.Sc. (Ag.) Thesis submitted to the University of Kerala.

Tilati, N.K., Mathew, S.K. and Attri, S.C. (1974). Behaviour of available and non exchangeable K in soil and its uptake in wheat crop. J. Indian Soc. Soil Sci. 22: 139-144.

Tripathi, [illegible], Bose, [illegible] and [illegible]nda, [illegible] (1973). [illegible] profitability of different multiple cropping patterns under lateritic tract of West Bengal. *Proceedings of the Symposium on Multiple Cropping held at Haryana Agricultural University, Hissar, India.* 168-171.

Tsuno, Y. and Fujise, K. (1964). Differences in distribution ratio of dry matter produced among some varieties. *Crop. Sci. Soc. Japan.* 32 (4): 297-31[illegible].

[illegible], [illegible], Khapatra, [illegible] Patro, G.K. and Patnaik, [illegible] (1986). [illegible]-based cropping system for optimum production under [illegible] constraints. *[illegible]* 12 (2): 19-89.

Uriyo, [illegible] (1973). Response of sweet potato to potassium fertilization in a red Oxisol in Tanzania. *Potassium in Tropical crops and soils, proceedings,* 10th Colloquium, *Int. Pot. Ins.* Abidjan: 495-497.

Venkata Rao, [illegible] and Padiger, N.N. (1971). Manuring of groundnut in Mysore-a review of experiments in past 30 years. *Oil Seeds J.* 4: 234-238.

Venkateswarlu, K. (1978). Effect of two forms of nitrogenous fertilizers at different levels in grain, straw yields and there contributing characters and recovery of applied Nitrogen in rice. *Andhra. Agric. J.* 25: 3-4.

Venkataraman, Bharadwaj, [illegible], Chan War and S.K., Bansal (1982). Available potassium changes in a soil under continuous rotational cropping of rice, wheat and cowpea. *J. Ind. Soc. Soil Sci.* 30 (1): 99-101.

Varma, [illegible] and Varma, [illegible] (1969). Factors affecting potash availability in soils. *Indian Potash J.* 11 (4): 2-11.

Verma, L.P., Dyadav, D.S. and Roomsingh, (1987). Effect of continuous cropping and fertiliser application on fertility status of soil. J. Indian Soc. Soil Sci. 35(1): 754-756.

Vedaprakash, P. Chauhan, V.S. and Tandon, J.P. (1982). Economics of rainfed upland rice based cropping system in the North West Himalaya. IRRN. 7(6): 5.

Vinodkumar, B.K., Bhatea and Maheendra Singh, S. (1985). Field response, uptake and distribution of Nitrogen in soyabean. J. Indian. Soc. field Sci. (33): 190-192.

Viswas, C.R., Chathopadhya, V.N., Chakrabarthy, P.K., Bandopadyay, A.K. and Ghosh, A. (1987). Rice based fish and vegetable cropping system in costal saline soils. IRRN 12(3).

Watson, E.R. (1963). The influence of Subterranean Coluer pastures on soil fertility-1, short term effects. Aust. J. Agric. Res., 14: 796-807.

Weber, E. (1930). Deleterious effect of salt-peter manuring of the assimilation of nitrogen by leguminaceae. Indian. J. Agron. 2: 27-33.

Wivutronguania, P., and Tiyawallee, B. (1984). Soil fertility changes under different multiple cropping systems. Proc. fifth Asian Soil Conference - Soil Science as a tool for rural Development Vol. I Bangkok, Thailand.

Worley, R.E., Hegwood, D.A. and Harmon, S.A. (1971). Grain legumes of the low land tropics. Advances in Agron. 26: 1-132.

Wu, T.V.(1960). Utilisation of exchangeable and non-exchangeable potassium by rice under upland and flooding conditions. B.S.Thesis, National Taiwan University.

Yaduvanshi, H.S., Tipathi, B.R. and Kanwar, B.S. (1985). Changes in inorganic P fraction under intensive cropping system in typic Hapludalf. J. Indian. Soc. Soil Sci. 33: 908-910.

Yamada, N. (1959). The fertility of paddy soils and fertilizer application for rice. AspAC, 202-210.

Yadav, D.S. and Singh, S.B. (1986). Studies on Nitrogen economy in legume based cropping system. Indian. J. Agron. 31 (4): 209-211.

Yadav, H.L. (1985). Changes in soil fertility as a result of different cropping system. Indian J. Agron. 31 (4): 310-317.

Yawalker, K.S. (1969). Vegetable crops of India. Agri. Horticultural publishing house, Nagpur-1, India.

Yuvan, P.C. (1964). Physiological basis and fertilizer practice on sweet potato for high yield production. Soil Sci. Soc. Amer. Proc. 24: 447-450.

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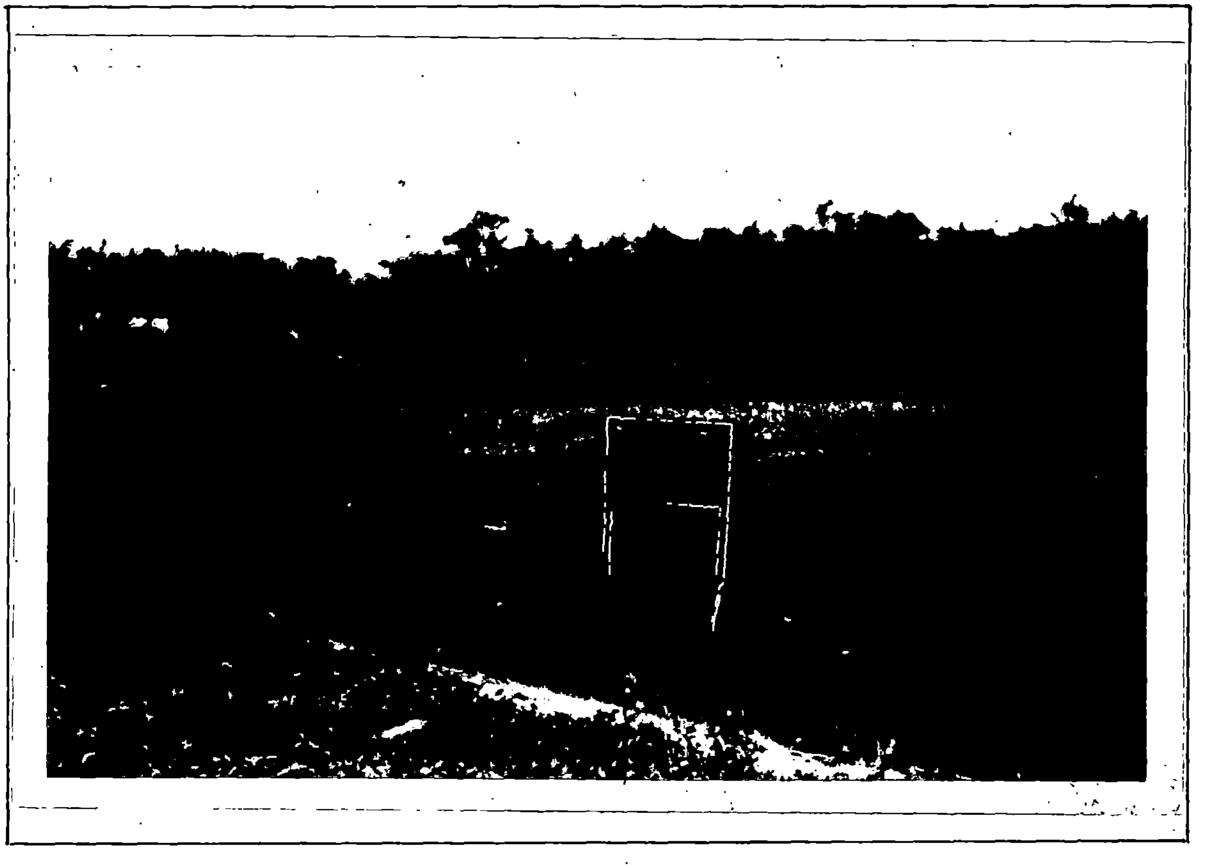
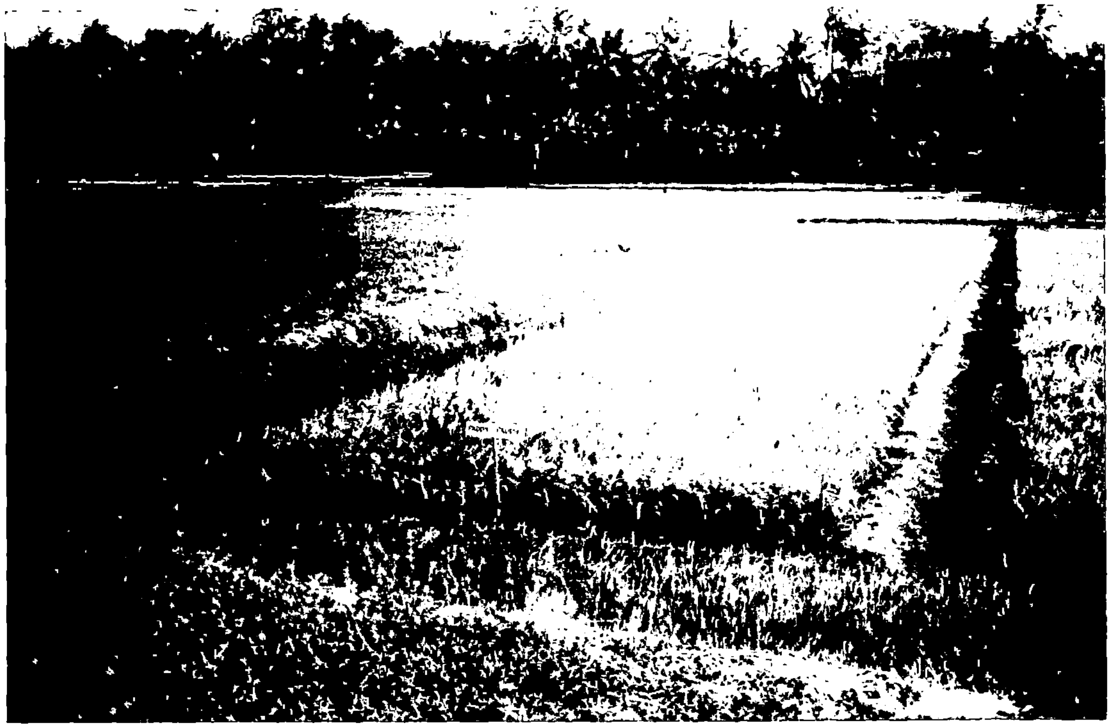


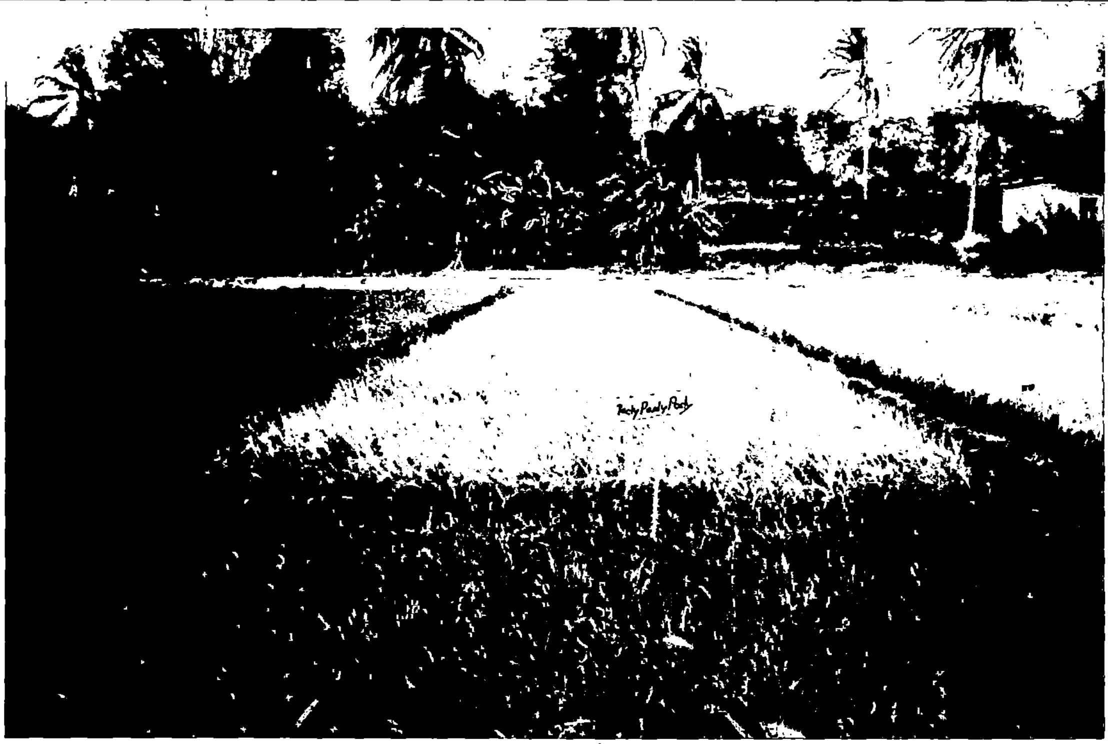
A VIEW OF THE EXPERIMENTAL PLOT

RICE-RICE-RICE SEQUENCE [A 1]

SUMMER -RICE



VIRIPPU - RICE



MUNDAKAN - RICE

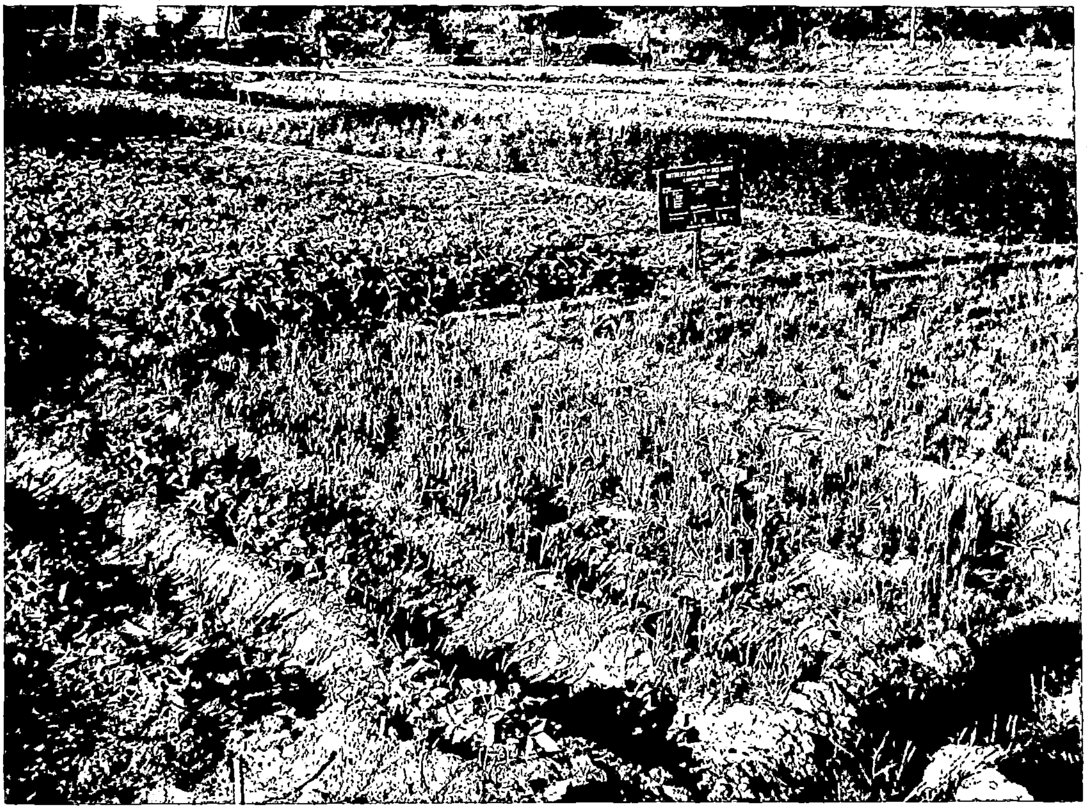
SWEET POTATO-RICE-RICE SEQUENCE [A2]

SUMMER - SWEET POTATO

VIRIPPU-RICE

MUNDAKAN-RICE

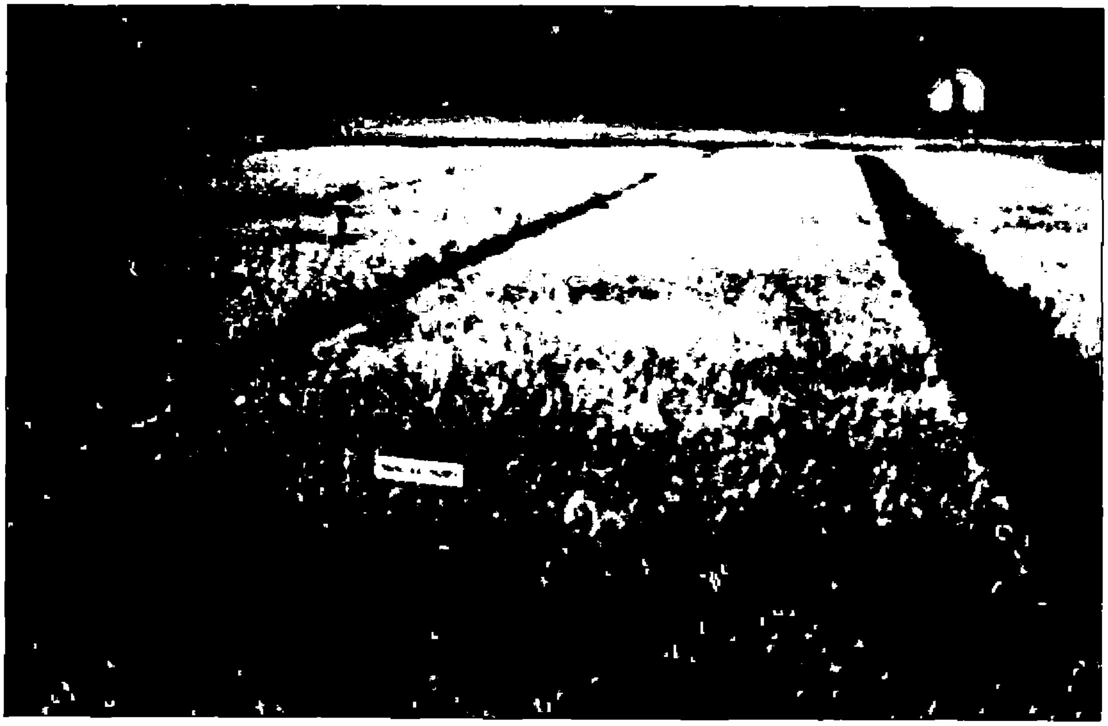
COWPEA-RICE-RICE SEQUENCE [A 3]



SUMMER- COWPEA

VIRIPPU-RICE

MUNDAKAN-RICE



VIRIPPU - RICE

MUNDAKAN - RICE

VIRIPPU - RICE

MUNDAKAN - RICE

FALLOW-RICE-RICE SEQUENCE [A 5]

SUMMER-FALLOW

NUTRIENT DYNAMICS IN THE RICE-BASED CROPPING SYSTEMS

BY

C. SUNDARESAN-NAIR

ABSTRACT OF A THESIS

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ABSTRACT

The experiment consisting of five cropping sequences viz. rice-rice-rice (A1), sweet potato-rice-rice (A2) cowpea-rice-rice (A3) daincha-rice-rice (A4) and fallow-rice-rice (A5) and six treatments with varying doses of N P and K were conducted to study the performance of the sequences in relation to the nutrients required for optimising the out put from the sequences.

The field experiment was laid out at R.R.S., Pattambi in 1980-81 and the experiment was conducted for two consecutive years ie. for six seasons. The experiment was started with the summer crop of 1981, namely summer rice (Triveni), sweet potato, cowpea, daincha and a summer fallow wherein the land was ploughed twice and left as such without any crops. The component crops were raised with five treatment variations modified from the recommended doses for each crop.

The biometric observations for the summer crops, virippu and mundakan crops were recorded. The indications were that treatments have a significant effect on summer crops virippu and mundakan rice crops of 1981 and 1982. The yield shows that both treatments

and sequences have a significant effect. The sequence daincha-rice-rice and the cowpea-rice-rice sequence gave the highest yield.

The chemical analyses of plant parts of the summer crops, virippu and mundakan rice crops of both 1981 and 1982 show that the treatments have no effect on the NPK content.

The soil study shows that the cropping sequences have a significant effect on soil pH. A pH decrease was noticed in all the sequences, the highest decrease being in the rice-rice-rice sequence. The organic carbon level of the soil is also affected due to the cropping sequence. The rice-rice-rice sequence shows a maximum decrease in organic carbon level and the daincha-rice-rice shows a gain in organic carbon level of the soil.

The total nitrogen of the soil shows a decrease in all the sequences and maximum decrease was noticed in sweet potato-rice-rice sequence. The available nitrogen level also was influence both by the sequences and treatments. A decrease in available nitrogen was noted to be a maximum in the rice-rice-rice sequence. The total P and available P levels show an increase in all the sequences and were high in daincha-rice-rice and cowpea-rice-

rice sequences. The treatments also have a significant effect in maintaining the P level in soils. The total K status of the soil as well as the exchangeable status of K shows a decrease after two year of cropping. The nutrient uptake studies reveal that the maximum NPK uptake takes place in the sequences sweet potato-rice-rice followed by rice-rice-rice and cowpea-rice-rice. The balance sheet of nutrients reveals that nitrogen and available phosphorus in all sequences show a decrease and increases with decrease in fertilizer levels. The balance sheet of K shows that the soil maintains K levels. The sequence daincha-rice-rice is the best in maintaining a high K status in the soil.

An ~~economic~~ analysis of the economics of cropping sequences reveal that the sequence sweet potato-rice-rice with full recommended dose of fertilizers gave the highest net return, which was followed by Cowpea-rice-rice and rice-rice-rice.

From nutrient balance studies, yield and economic analysis it is clear that any attempt in reducing the quantity of fertilizer for the component crops of the sequences affects the yield, besides deleteriously affecting the fertility of the soils. Any decrease in the fertilizer doses in the sequences will not be economical. With a long range veiw of enhancing crop output from cropping sequences and maintaining soil fertility, it becomes necessary to enhance and maintain higher fertility levels.