CARRY OVER EFFECTS OF SUMMER CROPS ON VIRIPPU RICE

BY

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REGINA LILY EDWIN.

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LIST OF ABBREVIATIONS

AICRIP	All India Co-ordinated Rice Improvement Project.
@	At the rate of
cm	Centimetre
Cm^2	Square centimetre
var	variety
DAT	Days after transplanting
g	gram
HI	Harvest Index
ha	hectare
kg	kilogram
KAU	Kerala Agricultural University
m	metre
m^2	square metre
mm	milli metre
Rs	Rupees
t	tonnes

INTRODUCTION

1. I N T R O D U C T I O N.

Maintenance of soil fertility and efficient use of fertilizer in a multiple cropping system are much relevant in India where crop intensification is the major alternative to meet the rising needs of the increasing population. In Kerala rice is the most important food crop grown. The acreage of rice in Kerala is 5,37,313 hectares with a production of 11.34 lakhs tonnes (Anon, 1989). Till recently a single crop of rice was grown in most of the rice growing tracts on account of the long duration of the varieties and lack of irrigation facilities. But with the introduction of short duration, photo-insensitive fertilizer responsive dwarf varieties of rice coupled with the recent concept of minimum tillage in crop production and with the increase in irrigation facilities, multiple cropping is being recommended. Now it has become a common practice in many parts of Kerala to subject the paddy fields, during the third crop season to the cultivation of various short duration crops like vegetables, pulses, sesamum, maize etc.

The wetland conditions of the paddy fields definitely differ from the upland situations in which the above mentioned crops are usually grown. In aerobic soils, the product of mineralization of organic nitrogen is nitrate whereas in submerged soils it is ammonium which gets accumulated. Concentration of total ammoniacal nitrogen up to 300 ppm.have been reported in submerged soils within 20 days of flooding. (Ponnamperuma, 1965). Further in upland conditions a part of the ammoniacal fertilizer gets nitrified by the nitrifying bacteria and gets lost through diffusion to the anaerobic zone where it gets denitrified. This does not happen in wet land conditions. Ponnamperuma (1972) studied the kinetics of water soluble phosphorus in submerged soils and found that under submergence the concentration of water soluble phosphorus increased with time. For fast growing crops, the intensity of potassium supply is of primary importance. The release of exchangeable potassium to the soluble form is enhanced under the flooded conditions. Clark and Renicky (1956) observed an almost doubled potassium concentration in the soil solution.

The growing of annual crops other than rice in wet lands which are kept dry for the cultivation of these crops will undoubtedly affect the fertility status of the soil. This necessitates fertilizer management for rice based cropping sequences in wet lands. Soil exhaustion due to multiple cropping should also be taken into account under this situation. Hence suitable cropping patterns accompanied by ideal manurial practices which replenish the soil must be devised.

Use of chemical fertilizers is an important part of the package of practices for raising crops and there is a direct relationship between average crop yields and fertilizer consumption in the country. Fertilizer recommendations for individual crops for optimum yields are available for different regions. However, a majority of farmers are not able to conform to the requisite fertilizer recommendations owing to the higher cost and the shortages in supply.

In the past fertilizer recommendations were done based on the nutrient requirement of individual crops. But a crop does not absorb all the nutrients contained in the fertilizers supplied to it. Very often in such type of recommendations, the residual effect of preceding crops on the succeeding crop is ignored. At least a part of the nutrients left over in the soil will be utilized by the succeeding crop in the same field. While making fertilizer recommendations on a particular cropping system, discount will have to be made on the manures and fertilizers applied to the succeeding crop. Additionally the types of crops included in the system, as well as their order in the system also affect the productivity of individual crops. While developing the suitable fertilizer management practices, it is necessary to take into account the residual effect of fertilizer and also that of the preceding crop on the succeeding crop (Mahapatra etal,1981). Hence it is clear that for the succeeding crop in a rotation, fertilizer application is to be made taking into account the residue of available nutrients left in the soil after the harvest of the first crop as well as yield targeted for the second crop in the rotation (Ramamoorthy et al,1971).

In this situation the cultivators need guidance on phasing a fixed quantity of fertilizer for different crops in a rotation for reasonably high returns. In view of the energy crisis and price hike of fertilizer, its use in cropping system rather than in an individual crop is assuming greater importance to effect its use efficiency. This is more so in rice based cropping sequences where the soil situations change from wetland to upland conditions when summer annuals are grown in the third crop season, thereby influencing the availability of native nutrients, residual fertility etc.

Therefore, the present study "Carry over effects of summer crops on virippu rice" was undertaken with the following objectives.

(a) To study the carry over effects of selected summer crops and fallow on the subsequent rice crop.

(b) To compare the economics of different summer crops and fallow preceding first crop rice.

(c) To assess the total biomass production of the summer crop - rice sequence.

(d) To work out the nutrient balance sheet in different summer crop- first crop rice sequences under varying fertilizer levels.

(e) To identify the most profitable annual crop for the summer season.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE.

Two field experiments were conducted at the Instructional farm, College of Agriculture, Vellayani to study the carry over effect of selected summer annual crops and fallow on the succeeding virippu rice and to assess the effect of different NPK fertilizer levels on the growth and yield of the latter. Similar studies in rice based and other cropping systems are briefly reviewed in this chapter.

2.1. Effect of previous crops or fallow on the succeeding crop.

2.1.1. Growth attributes.

Sasidhar (1978) on studying different rice based cropping systems in wet lands found that a preceding summer cowpea crop resulted in tallest plants and maximum number of effective tillers in the following virippu rice, compared to other preceding crops like groundnut, sesamum, sweetpotato and punja rice. Purushothaman (1979) observed that plant height of kharif rice following an intercropping system of ragi plus greengram was highest among all the systems he tried. Leaf area index was found to be higher when rice was preceded by ragi plus greengram and cotton plus blackgram than other systems. When a greenmanure crop preceded rice, application of only 75 per cent N as urea to rice increased its plant height, number of tillers and leaf area index (Muneendra Naidu, 1981). Ramaswamy (1982) observed increased plant height when it was preceded by summer rice with straw incorporation. Rekhi and Meelu (1983) reported higher plant height of rice in a wheat, greengram, rice rotation where the straw of the preceding greengram was incorporated into the soil. Increased plant height and tiller number of rice up to four weeks after transplanting due to the effect of a preceding greenmanure crop Sesbania cannabina grown as a catch crop in a rice - wheat sequence had been reported by Pei (1984). Rajendra Prasad (1985) found that plant height, leaf area index and number of tillers per m^2 of rice were increased by incorporation of preceding pulse crop residues.

2.1.2. Nutrient uptake.

Lu et al. (1965) observed that in a wheat - rice rotation, under equal rates of P application, the P uptake by the crops were double when all the P was applied to the wheat crop. Wheat crop after moong, guar and sanai contained more of N and P_2O_5 than the crop following fallow land (Singh, 1969). Jones (1974) observed that groundnut with comparative yields increased the N uptake of the succeeding sorghum crop. Ramachandran (1971) found that greenmanuring increased the uptake of P in rice. At Raipur rice crop with comparative yields removed more K when preceded by maize as compared to greengram. At Rudrur the uptake of nutrients by rice was relatively low when it was preceded by greengram, than by either bajra or blackgram eventhough high yields were obtained in the former case (Anon.,1974). Mahapatra et al (1974) were of the view that rice crop with comparative yields removed more potassium when preceded by maize. The virippu rice crop removed maximum quantity of N and K when preceded by summer cowpea, next came groundnut. P uptake of rice crop did not vary much with the summer crops (Sasidhar, 1978). Tiwari et al (1980) reported that the mean concentration of N,P and K of rice at tillering stage was significantly higher with greenmanuring with daincha than when preceded by fallow. The content of nutrients in grain and straw also considerably increased after a summer crop of daincha. Ramaswamy (1982) opined that incorporation of rice crop stubbles of the summer rice crop had favorable influence on the following monsoon rice in terms of increased nutrient uptake.

2.1.3. Yield components.

Purushothaman (1979) reported that number of productive tillers and thousand grain weight of kharif rice were higher when it was preceded by an intercropping system of ragi and greengram compared to other systems. He found that different preceding crops had no significant influence on the number of filled grains per panicle of the kharif rice. Rekhi and Meelu (1983) found that dry matter accumulation and panicle number of rice improved in a wheat - summer greengram - rice rotation. Significantly lower grain sterility percentage in rice after cowpea straw incorporation had been reported by Sanchez and Lopez (1983). Joseph (1986) reported that the number of panicles /m^2, total number of grains per panicle, weight of panicle and percentage of filled grains of rice var Triveni were higher when it was preceded by a summer daincha crop along with the application of half the recommended dose of fertilizers to rice.

The effect of preceding legumes coupled with the residual effect of applied phosphorus resulted in more lodging of wheat which led to a decrease in the thousand grain weight and harvest index of a subsequent wheat crop (Tripathi,1979). Bhat (1980) reported that a cowpea crop fertilized with 40 kg $P2O_5$/ha increased the number of earheads per unit row length, number of grains per panicle, thousand grain weight and grain yield of the subsequent wheat crop.

2.1.4. Yield.

Maintenance of cereal grain yields at much higher levels in a legume cereal sequence had been reported by many workers. (Raheja and Mishra 1952.,Sandor1975., Misra and Misra., 1975., and Rao and Bhradwaj., 1980). Sanyasiraju (1952) observed an increase in the grain and straw yield of paddy by 207 and 417% when grown after daincha. Arunachalam (1966) opined that both daincha and sunhemp increased the yield of grain and straw of paddy. The benefit of growing cowpea in summer in increasing the yield of succeeding rice had been reported by Bains and Sadapal (1971) and Sasidhar (1978). Sharma and Singh (1972) found significantly higher yield of rice when it was sown after pea and gram than after fallow. According to Chandrasekharan et al (1974) sesamum did not depress the yield of succeeding crop, let it a cereal on legume but increased the yield. Chakraborthy (1978) observed that a pre-kharif sesamum crop benefited the subsequent rice. Meelu and Rekhi (1981) opined that maize was a better preceding crop for wheat than rice in terms of the grain yield of wheat. Purushothaman (1979) found that maize as a summer crop preceding kharif rice has adverse effect on rice yield. Rajat De (1980) reported that compared to maize, cowpea was a better preceding crop of rice in terms of grain yield. The increase in the yield of rice after the incorporation of daincha than compared to its yield when preceded by fallow had been reported by Tiwari et al 1980 and Joseph 1986. Biswaset al (1977) observed that rice after mustard and fallow gave identical yields.

2.2. Effect of levels of nutrients on rice.

2.2.1. Nitrogen.

2.2.1.1. Growth attributes.

Increase in plant height with increase in the levels of applied nitrogen has been reported by many workers (Sadayappan and Kolandaiswamy.,1974; Sushamakumari., 1981., Surendran., 1985). The effect of this nutrient on tiller production has been observed to be positive (De Datta and Surjith 1981; Ajithkumar., 1984). Drymatter production had been reported to increase with increase in nitrogen application (Ramanujam and Rao., 1971., Sushamakumari., 1981).

2.2.1.2.Yield components and yield.

Increase in the number of productive tillers with increase in the levels of nitrogen up to 120kg N/ha had been reported by Venkata Rao (1979). Sushamakumari (1981) found positive effect of nitrogen on the number of panicles per hill upto 90 kg N/ha. She reported that the levels of nitrogen significantly influenced the number of spikelets per panicle.

The percentage of filled grains was not altered beyond 60kg N/ha (Ramanujam and Rao,1971). De Datta and Surjith(1981) have reported that number of filled grains per panicle increases with increase in the levels of nitrogen.

Kalyanikutty and Morachan (1974) obtained the highest thousand grain weight at 120 kg N/ha, in Co-30 a dwarf indica rice variety. Nair (1976) observed significant increase in the test weight when the level of nitrogen was enhanced from 50 to70 kg/ha.

Singh and Modgal (1978) observed that the optimum rates for the dwarf cv. Jaya was 116 kg N/ha. Singh _et al_ (1978) reported that with cv Jaya, application of 100 kg N/ha in split doses gave the highest yield of 7.5 tonnes of rough paddy per hectare. Singh _et al_ (1979) opined that the most profitable nitrogen rate calculated for Jaya was 140 kg/ha.

Ramanujam(1971) reported that increasing nitrogen levels from zero to 180 kg/ha increased straw yield. Venkateswaralu (1978) stated that straw yields increased with increase in nitrogen levels upto 200 kg/ha.

Prasad (1981) reported a decrease in the harvest index with an increase in the level of nitrogen from zero 100 kg/ha.Sreekumaran (1981) observed significant reduction in grain to straw ratio with increase in the levels of nitrogen.

2.2.1.3.Uptake of nutrients.

Hanway (1962) stated that application of higher levels of N increased the P uptake. Favorable influence of N on the uptake of K was reported by Mukherji and Sircar (1969). Gopalaswamy and Raj (1977) reported that increase in the rate of applied nitrogen from zero to 200 kg/ha produced linear increase in the uptake of nitrogen. Significant increase in the nitrogen uptake with N levels upto 80 kg/ha was reported by Rai and Murthy (1979). Iruthayaraj and Morachan (1980) reported that in all the seasons, the uptake of phosphorus was more at 240 kg N/ha than at lower levels. Rana et al (1984) reported that the uptake of nitrogen and phosphorus decreased with the curtailment in the NPK fertilizer dose.

2.2.2. Phosphorus.

2.2.2.1. Growth attributes.

Levels of phosphorus did not influence the plant height (Jayaraman., 1980., and Suseelan., 1969). Chowdhary and Mian (1978) found that number of tillers per plant increased with increasing levels of phosphorus and application of P aided in early tillering capacity..pa

2.2.2.2.Yield components and yield.

Increased number of productive tillers, panicle length, panicle weight, 1000 grain weight and more number of filled grains at 60 kg P_2O5/ha as compared to zero P level had been reported by Jayaraman (1980).

Patnaik and Gaikwaad (1969) observed that the P uptake increase the grain weight and yield of rice. Nagarajah et al (1978) stated that the application of 60 kg $P_{2O}5$ per hectare increased the grain yield by three t/ha over control.

2.2.2.3. Uptake of nutrients.

Oomen *et al* (1972) recorded an increase in the total phosphorus content of the plant with an increase in the dose of phosphorus applied from 22.75 to 51.5 kg P_2O_5/ha. Loganathan and Raj (1976) reported higher uptake of N in the presence of P. Rana *et al* (1984) observed that phosphorus uptake of crops decreased with curtailment in NPK fertilizer dose.

2.2.3. Potassium.

2.2.3.1. Growth attributes.

Vijayan and Sreedharan (1972) observed significant increase in the plant height with increase in the level of potassium from 20 to 80 kg/ha in rice variety IR-8. Kulkarni *et al* (1975) reported that the effect of potassium was significant and positive on tiller production in rice. Singh and Singh (1979) obtained increased tillering with the application of potassium upto 60 kg K_2O/ha.

2.2.3.2. Yield components and yield.

Kulkarni *et al* (1975) observed that potassium application increased the number of productive tillers in rice.

Singh and Singh (1979) reported that application of 60 kg K_2O/ha in splits increased panicle length in rice.

Vijayan and Sreedharan (1972) reported increase in the number of spikelets per panicle with increase in the levels of potassium from 20 to 80 kg K_2O/ha. Filled grain percentage was more in plants supplied with potassium @ 50 kg K_2O/ha compared to control (Venkatasubbiah et al 1982).

Singh and Singh (1979) after detailed study on rice, concluded that application of 60 kg K_2O/ha increased the thousand grain weight compared to control.

The grain yield of rice increased with increase in the level of potassium (Robinson and Rajagopal, 1977) and the effect was linear upto 60 kg K_2O/ha. Agarwal (1980) observed significant increase in rice yield by the application of K_2O upto 80 kg/ha.

Singh and Singh (1979) reported an increase in straw yield with increase in level of potassium from zero to 60 kg K_2O/ha. Highly significant increase in yields of grain and straw in rice var Jaya due to increase in the applied potassium was observed by Venkatasubbiah et al (1982).

2.2.3.3. Uptake of nutrients.

Agarwal (1978) reported that higher levels of potassium application increased the uptake of N,P and K by rice. Esakkimuthu et al (1975) observed that nitrogen uptake was more due to potassium application. Loganathan and Raj (1976) reported higher uptake of N by rice in the presence of potassium. Singh and Singh (1987) reported that the total uptake of and percentage translocation of N,P and K by rice increased significantly with increasing levels of potassium.

2.3. Combination effect of preceding crops and levels of fertilizers on rice.

Purushothaman (1979) while conducting experiments on different rice based on cropping sequences with three fertilizer levels concluded that the interaction between the sequences and the fertility levels exerted significant influence on the grain and straw yield of kharif rice crop during two consequtive years. Rajat De (1980) found that the grain yield of kharif rice crop at zero,30,60 &90 kg N/ha when the rice crop was preceded by cowpea grain were 4.28; 5.08;5.06 and 5.16 t/ha respectively as compared to 2.49;3.41;3.81 and 4.4 t/ha when the preceding crop was fodder maize. Rekhi and Meelu (1980) reported the grain yield of rice at zero and 60 kg N/ha to be 52.8 and 63.5 q/ha respectively when a daincha crop was incorporated insitu. But the corresponding values were 26.5 and 45.5 q/ha respectively when rice was preceded by summer fallows. In a study with four levels of N to rice (zero,40,80 and 120 kg N/ha) with and without the incorporation of daincha insitu, it was found that the responses of the following rice crop to N at 80 and 120 kg N/ha were higher after fallow, as compared to those treatments including daincha incorporation. The grain yield of rice at 40 kg N/ha plus greenmanuring was comparable with 120 kg N/ha after fallow. (Tiwari et al, 1980), Joseph (1986) found that number of panicles/m^2, total number of grains per panicle, percentage of filled grains, panicle weight and grain yield of rice were higher with the incorporation of daincha along with half the recommended dose of $N:P_2O5:K_2O$ (35:17.5:17.5 kg/ha) when compared with daincha +100% NPK, daincha +75% NPK, 100% NPK + no daincha and daincha + no NPK.

2.4. Total nutrient requirement of rice based cropping systems.

The amount of nutrients which a given crop species can extract from the soil to complete a productive life cycle is valuable information in designing fertilization practices for any cropping system (Oelsligle *et al*, 1976). Mahapatra *et al* (1974) while studying some rice based cropping systems at Mangalore, found that a rice-rice-cowpea sequence removed maximum quantity of NPK (560;38 and 407 kg/ha respectively) followed by rice-rice-ragi (N-361,P-36 and K-334 kg/ha) and rice -rice-rice (N-363, P-36 and K- 330kg/ha) In a study with different annual crops raised during summer in a rice based cropping system,Sasidhar (1978) found that rice-rice groundnut sequence removed the maximum quantity of nitrogen and the least quantity was by rice-rice-sesamum. The uptake of P was highest for rice-rice-sweetpotato, rice-rice-cowpea removed the minimum quantity. The rice-rice-cowpea system required the highest amount of potash and the lowest quantity was removed by rice-rice-sesamum sequence. In a rice based multiple cropping experiment conducted at Coimbatore (Purushothaman, 1979) the yield data showed that reducing the fertilizer application to each crop to 50 present of the recommended level caused a considerable reduction in the yield of all crops, cereals being the most affected. However application of N to each crop and P and K only to summer upland crops gave similar yields as application of recommended level of NPK to each crop. Thus P and K can be restricted to only the summer crops thus saving about 100 kg each of P and K. Fertilizer use in rice-rice cropping system was reviewed by Mahapatra et al (1981). From the results of field studies conducted at different centres in India under the All India coordinated Agronomic Research Project, they observed that application of 75 per cent to kharif and full recommended dose to rabi crop was adequate for getting the highest productivity in many centres.Until now, crop production research has been focusing attention on individual crops disregarding the fact that a crop is only a component of cropping system. Fertilizer does for the individual crops are decided based on their responses without considering the cropping system as a result of which rather high and uneconomic recommendations for fertilizer use are made. Hence fertilization must be considered not for the individual crop, but for the cropping system as a whole (Mahapatra et al 1974).

2.5. Saving of fertilizers and fertilizer management in multiple cropping systems.

Residues of fertilizers left in the soil often raise yields in ways that are difficult to initiate with fresh fertilizer dressings, sometimes response to fresh applications are unaffected by residues of previous dressings but usually residues lessen the quantity of fresh applications needed (Cooke, 1967). Fertilizer recommendations for multiple cropping system have so far generally been based on the schedules recommended for individual crops. It is a well known fact that fertilizer needs of a crop will vary depending on the characteristics of the preceding crop in the rotation. The fertilizer applied to one crop, benefits to some extent the succeeding crops because of their direct residual and cumulative effects on different crops grown in a sequence.

2.5.1. Nitrogen .

Inclusion of legumes in cropping system improved the soil nitrogen status thus reducing the N application to the succeeding crop (Palaniappan et al, 1976). Morachan et al (1977) observed that the inclusion of legumes in the cropping system had helped to save upto 25 per cent of the recommended level of N application to the associated cereal. Residual nitrogen effect to the tune of 60 kg N/ha for cowpea had been reported by Giri and De (1979) under Indian conditions. Rajat De (1980) observed that a saving of 47 to 78 kg N/ha was apparent when rice was grown following grain legumes. Application of 40 kg N/ha to rice after greenmanuring with daincha gave as much yield as that obtained with 120 kg N/ha (Rajat De 1980 and Tiwari et al 1980). In rainfed rice-pulse system fertilizer should be applied to rice alone. Inclusion of legumes in a rice culture contributes 20-40 kg N/ha (Anon., 1982) Meelu and Rekhi (1981) reported that in a berseem-rice rotation rice responded up to 90 kg N/ha indicating a saving of about 30 kg N/ha. Muneendra Naidu (1981) found that application of 75 per cent N as urea along with green manure produced results on par with 100 per cent N as Urea. Khind et al (1982) estimated the efficiency of greenmanures substituted for applied N in rice. They found that the combination of 60 kg N/ha as urea and daincha incorporation gave grain yield as did 120 kg N/ha as urea without greenmanure crop. This suggests a saving of about 50 per cent of N needed by rice. Meelu and Rekhi (1981) found that the residual effect of lucerne as a previous crop varied from 140-175 kg N/ha whereas that of maize ranged from 90 to 110 kg/ha.

2.5.2. Phosphorus.

Bhide (1952) found that phosphate applied to the previous leguminous crop significantly increased the yield of succeeding crop on soil with low fertility status. When leguminous green manure crop is planted before rice, P fertilizer applied completely or mostly to the greenmanure crop can give good residual effects. (Zhao and Tanginin 1964). Garg et al(1971) reported that P application to cowpea had a marked effect on increasing the yield of wheat crop which followed it in the succeeding season. Goswami and Singh (1976) reviewed the results of All India coordinated Agronomic Research Project and reported that application of P at 60 kg $P_{20}5$/ha to one crop of rice was adequate in a rice-rice rotation. Reviewing the knowledge on fertilizer use in intensive cropping system, the F.A.O consultant group recommended that in a rainfed rice-pulse system, P should be applied to rice only and if moisture conditions are favourable, 20 kg P_2O_5/ha may be applied to pulses only (Anon., 1981). Beri and Meelu (1981) stated that application of 60 kg P_{205}/ha to daincha produced good residual effects on the following rice crop in terms of increased dry matter and grain yield. In a rice-rice-mungbean/soyabean sequential system, it is recommended that P is to be applied only to the second crop of rice along with K application (Anon.,1981). Gill and Meelu (1983) observed that in a wheat-rice rotation application of P to wheat alone was sufficient to meet the requirement of both the crops. ~~De~~ Datta and Gupta (1984) obtained a significant residual effect of P on wheat in a rice - wheat sequence. Dhingra et al (1984) found that in a maize -wheat rotation there was no residual effect of P fertilizer applied to maize on wheat . Rekhi and Meelu (1984) reported that rice did not respond significantly to direct P application in a wheat - maize-rice cropping system.

2.5.3. Potassium.

Khare and Gautam (1969) found no residual effect of K on wheat and fodder cowpea in an intensive rotation of maize-wheat-cowpea (fodder). Experiments conducted under the auspices of the All India Coordinated Agronomic Research Project at Karaiyeruppu and Thanjavur (Tamilnadu) on rice-rice sequence showed that there was no response for the application of K in every season and in alternate seasons (Anon.,1978).

2.6. Soil nutrient content as affected by crop components in a multiple cropping system.

2.6.1. Organic carbon.

Continuous rice cultivation in rice-rice, cropping pattern decreased the soil organic carbon content. Maize during summer tended to increase the organic carbon content before Kharif rice (Sadanandan and Mahapatra, 1975) Nair et al (1973) found that inclusion of legumes in rice based cropping sequences increased the organic carbon content. Sasidhar (1978) stated that among the different summer crops, sweetpotato and sesamum increased the organic carbon content of the soil, whereas cowpea and groundnut reduced it before a virippu rice crop. Triple cropping of rice caused maximum decrease of organic carbon. Sharma et al (1980) while studying eight different rice based cropping systems found that the organic carbon content of the soil showed an increase over the corresponding initial values in all the sequences. The increase was more in sequences involving legumes. Sahu et al (1987) were of the view that continuous cropping with cereals decreased the organic carbon content of soil. However, organic carbon content of the soil increased with cropping sequences like rice-cowpea; rice-greengram and rice-peanut.

2.6.2. Nitrogen.

Inclusion of legumes in cropping sequences improving the soil N status have been reported by many workers. (Bains and Sadapal, 1971; Palaniappan, 1976; Nair et al ,1973; ~~Sharma~~ Singh and Sandhu ,1980; Sharma et al 1980 and Azam et al ,1986). Sadanandan and Mahapatra (1973) while studying different rice based cropping sequences, concluded that the total N content of the soil increased in a groundnut-jute-rice. The loss in N was maximum in maize-rice-rice and rice-jute-rice. Singh and Ramamoorthy (1974) showed that the available nitrogen was better maintained in mung-rice-wheat than in fallow-rice-wheat. Shanmughasundaram et al (1975) reported that among the stubbles from the fields of rice, sorghum, maize, sesame, cowpea, lucerne and ragi stubbles added more N than the stubbles of other crops. Rao and Sharma (1978) stated that a maize-wheat sequence decreased the total N content of the soil whereas sequences involving legumes increased the total N content. Sasidhar (1978) reported that summer crops cowpea and groundnut increased the total N content of the soil. Sequences involving these leguminous crops also caused considerable increase in the total N status. Tiwari et al (1980) observed an increase in the available N content of the soil by 51 and 61.3 per cent than control with the incorporation of a summer daincha crop insitu before a kharif rice crop.

2.6.3. Phosphorus.

Beneficial effects of growing legumes in building up soil phosphorus was reported by many authors. Nair et al (1973) reported no noticeable loss or gain of total P in all the cropping systems tried by them. However, the available P showed a loss in all the treatments, the maximum being in maize rice-rice and jute -rice-rice sequences. An increase in the available phosphorus in all the rotations involving cereals and pulses had been reported by Raghavulu and Sreeramamoorthy (1974). Singh and Ramamoorthy (1974) found that the available phosphorus status of the soil was maintained better under mung-rice-wheat sequence than underfallow-rice-wheat sequence. An increased availability of soil exchangeable P after a maize-wheat sequence have been reported by Rao and Sharma (1978). Sasidhar (1978) observed an increase in the available P status of the soil when cowpea and seasmum were grown before a kharif rice crop. Increase in the available P content of soil to an extent of 107 and 65% during two successive years by the incorporation of daincha insitu before a kharif rice crop had been reported by Tiwari et al (1980). Sahu et al (1987) found a decrease in the available P after a rice -blackgram sequence when there was maximum grain production.

2.6.4. Potassium.

Sadanandan and Mahapatra (1972) stated that the total K content of the soil decreased after every rice based cropping sequence they studied. The maximum decrease was observed in a rice-rice-rice sequence. The summer maize tended to increase the soil K content. Nair et al (1973) found that the available

K slightly improved when leguminous crops were included in a rice based sequence. Singh and Ramamoorthy (1974) reported a better maintenance of available potassium in a mung-rice-wheat than in fallow-rice-wheat. Raghavulu and Sreeramamoorthy (1974) found a decrease in the available K content of soil in all the rotations including cereals and pulses. The summer crops sesamum and cowpea in rice based rotations tended to increase the potassium content of the soil as reported by Sasidhar (1978). Tiwari *et al* (1980) found an increase of about 75 and 51 per cent in the available K content of the soil after the incorporation of daincha insitu before a kharif rice crop. Sahu *et al* (1987) found a decrease in the available K content in a rice-blackgram sequence where the grain production was maximum.

2.7. Soil nutrient content as affected by levels of fertilizer application in multiple cropping system.

Sahu and Nayak (1967) observed that there was an exhaustion of the organic carbon content of the soil after continuous cultivation with rice using only ammonium sulphate. But the loss was minimum in plots where higher doses of ammonium sulphate was applied.

Clark and Mack (1974) conducted continuous cropping experiment without the addition of fertilizers and after four years they found an increase in the total N content of the soil over the initial status. Tiwari et al (1980) observed 14,31 and 43 per cent increase in the available N content of the soil over the initial status at 40,80 and 120 kg N/ha respectively. Increasing the dose of N significantly promoted the available P and K contents of soil at all stages of growth of the rice crop.

The available P content of the soil was unaffected and the available K content decreased with continuous cropping without the addition of fertilizers (Clark and Mack, 1974) Biswas et al (1977) after studying two cycles of crops in a multiple cropping system found that the initial status of available P and K improved in proportion to the rates of application of fertilizers. But the available P and K status declined where no fertilizer was applied. Mandal et al (1984) and Nad and Goswami (1984) were of the view that even in continuous cropping, if fertilizers were applied to the soil, there will be an appreciable build up of available P and K. Yaduvanshi et al(1984) reported that in a long term fertilizer experiment with continuous cropping and manuring the net gain in the soil P and K progressively improved with increasing dose of fertilizer application. Verma et al (1987) found that in continuous cropping coupled with fertilizer application build up of soil P was noted. But the K content of the soil decreased and the extent of the decrease was minimum in plots which received higher doses of potassic fertilizers than which did not receive it.

2.8. Soil nutrient balance in multiple cropping systems.

2.8.1. Nitrogen.

Sharma and Saxena (1970) observed negative N balance under four cropping sequences without N and 35 kg N/ha. When wheat was fertilized at the rate of 70 kg N/ha, the balance of N became positive in the rotation sorghum - wheat and greenmanure - wheat. Nair et al (1973) concluded from rice based multiple cropping studies that the removal of N was about 105 per cent of addition through fertilizer. Sadanandan and Mahapatra (1973a) from a multiple cropping experiment conducted for two years found that loss in N occurred in all the cropping patterns during the first year, whereas in the second year groundnut-jute-rice showed a gain in N. The loss during both the years was highest from maize-rice-rice and rice-jute-rice sequences. Rao and Sharma (1978) found a negative N balance after two years in a maize-wheat sequence. But a build up of total N of soil was observed in sequences where legumes were included. Sasidhar (1978) reported that in rice based cropping system of wetlands a positive balance of N was obtained when cowpea and groundnut were included in the sequence as summer crops. Maximum loss of N was noticed in a rice-rice-rice sequence. Purushothaman (1979) observed that in rice based cropping sequence with different fertilizer levels, there was positive N balance when full N was applied. The balance was negative when only half the N was applied.

2.8.2. Phosphorus

Nair et al (1973) found that in a rice based rotation the removal of P was 96 to 111 per cent of the quantity added. Sadanandan and Mahapatra (1973b) reported that there was no noticeable gain or loss of total P from all the rice based cropping sequences. However, the balance sheet of available P in the soil showed a loss in all the treatments. The loss being more in maize-rice-rice, rice-rice-rice and rice-jute-rice sequences. After two cycles of crop rotation in a multiple cropping system, the initial low status of available P improved to medium or high levels commensurate with the rates of fertilizer application. Available P content declined where P was not added (Biswas et al, 1977). Rao and Sharma (1978) reported that balance of available P was increased after a maize-wheat rotation. Venugopal (1978) observed a positive balance of P in soil at full dose of recommended fertilizer NPK applied to each crop in a cotton based rotation. The balance sheet of P showed a loss in all the sequences, the maximum being in rice rice-sweetpotato (Sasidhar,1978). The balance of P was positive for both full and half the quantity of application in all the rice based sequences tried by Purushothaman (1979). But removal exceeded addition when P application was restricted to summer crops.

2.8.3. Potassium.

Sadanandan and Mahapatra (1972a) reported that the total potassium content of the soil decreased after every crop rotation they studied, the maximum being for rice-rice-rice followed by maize-rice-rice sequence. Nair et al (1973) found that the removal of K exceeded addition by two to three times in a rice based rotation. cropping there was a decrease in the amount of non-exchangeable K but the exchangeable K remained almost constant. In a multiple cropping system, after two years of crop rotation the available K status of the soil improved over the initial status in proportion to the rate of application. But the K content of the soil declined in treatments where there was no K application (Biswas *et al*, 1977). Exchangeable K content of the soil showed good gains in all the rice based cropping sequences tried by Sasidhar (1978). In all the rice based cropping sequences studied by Purushothaman (1979) balance of K was negative with all the fertility levels but the depletion was greater when the K application was given only to the summer crops.

2.9. Economics of different crops or fallow in sequence with rice.

Bains and Sadapal (1971) reported an increase in returns by 13 to 15% when paddy was taken as a kharif crop after the inclusion of unfertilized cowpea in the rotation . A fodder cowpea crop increased the returns by 28%. Sadanandan and Mahapatra (1972) recorded maximum net return from potato-rice-rice system as compared to rice-jute-rice and maize-rice-rice systems. Under wet land conditions of Aliyarnagar, Tamilnadu, rice-rice-sunhemp system recorded maximum net returns (Narayanan and Sivaprakasam, 1975). The cropping sequence rice-groundnut-bajra gave the maximum net profit followed by rice-ragi-groundnut at Bhavani Sagar, Tamilnadu (Ramakrishnan and Sundaramoorthy, 1975). Thirunavakkarsu and Gouthaman (1971) found that rice-rice-greenmanure system was the most renumerative in Pondicherry with the highest net return. Palaniappan *et al* (1978) reported that maximum net return and highest income per rupee invested was in a rice-rice-rice rotation, in Coimbatore. Sasidhar (1978) found that under wet land conditions rice-rice-groundnut sequence gave maximum net income, followed by rice-rice-cowpea. According to Purushothaman (1979) rice-rice ragi + greengram was the most remunerative cropping sequence in Coimbatore followed by rice-rice-rice system. Vedaprakash *et al* (1982) obtained the highest average annual net return and benefit -cost ratio using rice-chickpea rotation followed by rice-lentil, rice-field pea and rice-wheat sequences. The mustard crop (*Brassica juncea*) gave significantly higher net returns than gram when grown after rice. (Singh et al 1984). Deka *et al* (1984) in trials with six rice based crop rotations found that highest net return were obtained in a rice-wheat-maize-fodder cowpea sequence followed by rice - *Trifolium alexandrinum* rotation. Joseph (1986) reported that the lowest cost of production of one kilogram of paddygrain was when the paddy crop was fertilized with 50 per cent of the recommended NPK and a summer daincha crop was incorporated insitu. 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 1:1:5. The sequence could increase the rice production of the region by 174%.

MATERIALS AND METHODS

3. MATERIALS AND METHODS.

Two field experiments were conducted during the summer and kharif seasons of 1987 to study the carry over effects of five summer annual crops and fallow on the subsequent rice crop. The effects of three different levels of NPK fertilizers on the growth, yield attributes and yield of virippu rice were also the subjects of study. The materials used and the methods followed for the experiment are presented below.

3.1. Experimental site and cropping history.

The experiment was conducted at Palapoor area of the Instructional Farm, College of Agriculture, Vellayani. The site is located at 8.5^{o}N latitude and 76.9^{o}E longitude, at an altitude of 29 m above MSL. The experimental area was under a bulk crop of rice during the previous season.

3.2. Soil.

The soil of the experimental area is sandy clay loam in texture. The physical and chemical composition of the soil are given below.

Physical composition (International Pipette method)

Coarse sand : 42.00%

Fine sand : 15.28%

Silt : 7.8%

Clay : 31.2%

Chemical composition.

Total Nitrogen - 0.526% - 1052.6 kg/ha

(Microkjeldahl method)

Available Nitrogen - 126.8 Kg/ha - low

(Alkaline permanganate method)

Available P_2O_5 - 31.47 kg/ha - medium

(Dickman and Bray's molybdenum blue method)

Available K_2O -72.36 Kg/ha - low

(Ammonium acetate method)

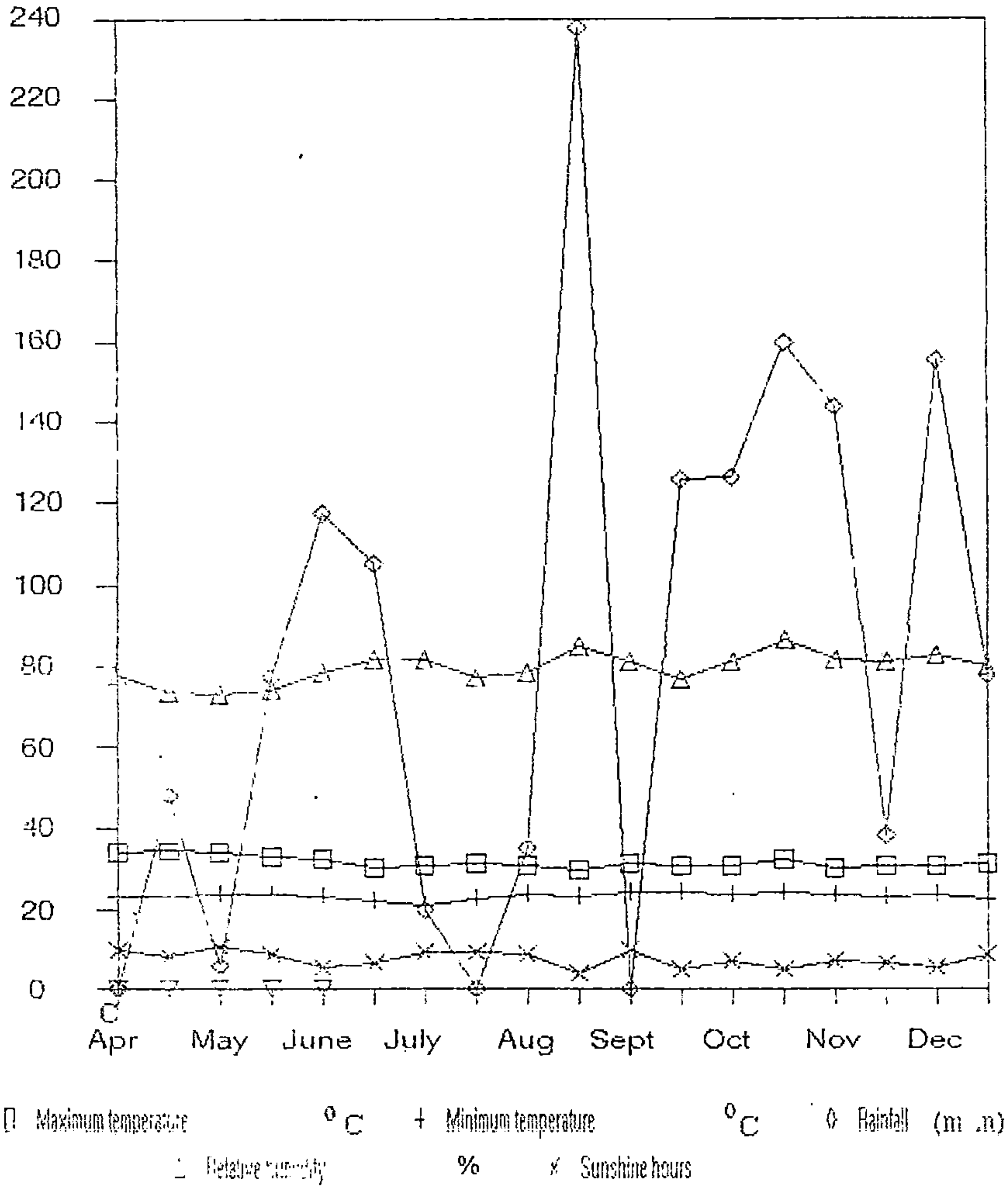
pH - 5.2 (1:2.5 soil solution using pH meter)

Organic carbon - 1.2%

3.3. Climate.

The experimental site enjoys a humid tropical climate. The data on various weather parameters (rainfall, mean maximum and minimum temperatures and relative humidity) during the cropping period are given in Appendix I and graphically represented in Fig.1. The mean maximum and minimum temperature during the crop-

Fig. 1 WEATHER CONDITIONS DURING THE CROPPING PERIOD



ping periods ranged from 29.77°C to33.81°C and 20.6°C to 24.44°C respectively. The mean relative humidity ranged from 72.5 to 86.45 per cent. The monthly rainfall of the cropping period ranged from 0.4 mm to 160 mm during the first season with a total receipt of137.2 mm during the first season and 927.8 mm during the second season. Weather data during the cropping period revealed that the weather did not vary much from the normal weather conditions enjoyed by the place.

3.4. Season.

The annual crops were grown during the summer season of 1986-87 from February to May and their residual effect on rice crop was studied in the following virippu season of 1987-88 from May to September.

3.5. Materials.

3.5.1. Variety.

3.5.1.1.Summer Annuals.

3.5.1.1.a.Cowpea.

The cowpea variety selected for the study was Krishamony (PTB-2) evolved at Rice Research station Pattambi. It is a cross between P-118 and Kolinjipayar. Krishnamony is a short duration, erect, drought tolerant variety which is specifically suited for summer rice fallows. The seeds were obtained from

College of Agriculture, Vellayani.

3.5.1.1.b. Daincha.

Locally available seeds were used. The plants of this variety are bushy and drought resistant producing an average yield 15-20 t/ha of greenmatter generally.

3.5.1.1.c. Sesamum.

Soma (ACV-1) evolved at College of Agriculture, Vellayani, was used for the study. Soma, the white seeded sesamum variety is of 80 days duration and it takes 37.2 days for maturity. The average yield of the crop is 683.77 kg/ha. The seeds were obtained from College of Agriculture, Vellayani.

3.5.1.1.d. Fodder Maize.

Ganga Safed 2 was selected for the study. This white seeded variety of maize is specially suited for fodder purpose. It puts forth luxuriant vegetative growth within a short span of time. The yield from one hectare ranges from 25 to 30 tonnes. The seeds were obtained from the Regional Office of the National Seeds Corporation Ltd., Karamana, Trivandrum.

3.5.1.1.e. Rice.

The rice variety selected for the experiment was Triveni, the progeny of a cross between Annapoorna and Ptb-15 released by Rice Research Station, Pattambi, Kerala. Triveni is a short duration (95-105 days) high yielding variety with moderate tillering. It is widely used in Kerala during all the three crop seasons. Paddy seeds with 96 percent germination obtained from the Regional Office of National Seeds Corporation Ltd., Karamana, Trivandrum, was used for the experiment.

3.5.1.1.f. Fallow.

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

3.5.1.2 . Virippu season.

3.5.1.2.a. Rice.

Jaya a cross between TN-1 from Taiwan and an Indian variety T-141 from Orissa was chosen for the experiment. It is a dwarf, photosensitive, medium duration (130-140 days) variety, evolved at the All India Co-ordinated Rice Improvement Project, Hyderabad. It has special features like long bold white grains with high stability in yield. The rice seeds with 96 per cent germination obtained from the Regional Office of National Seeds Corporation Ltd., Karamana, Trivandrum was used for the experiment.

3.5.2. Manuers and fertilizers.

Cowdung analysing to 0.4% Nitrogen, 0.3% P_2O_5 and 0.2% K_2O, lime with a neutralizing value of 135 were used for the experiment.

Urea analysing to 46 percent nitrogen, superphosphate to 16 per cent P_2O_5 and muriate of potash to 60 percent K_2O were used.

3.6. Methods.

3.6.1. Experimental details.

Two factors viz., residual effect of summer annuals on the following virippu rice and the effect of three different levels of NPK fertilizers on the growth and yield of rice were the subjects of study.

3.6.1.1. Summer Crop.

The experiment was laid out in randomized block design with three replications. There were six treatments.

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Treatments.

C_1 Grain type cowpea

C_1 Daincha

C_3 Sesamum

C_4 Fodder Maize

*C_5 Short duration rice

C_6 Fallow

* C_5 was abandoned because of crop failure.

The gross plot size was 21.1 x 4.95 m. For maintaining the net plot size equal for all the treatments, a uniform space of 1.8 x 0.8 m was left on either side of each plot. In the area provided two rows were left as border rows and one row was left for destructive sampling.Thus the net plot size was 17.5 x 3.35 m. In total there were 18 plots.

3.6.1.2. Virippu rice.

The experiment was laid out in randomised block design with three replications.

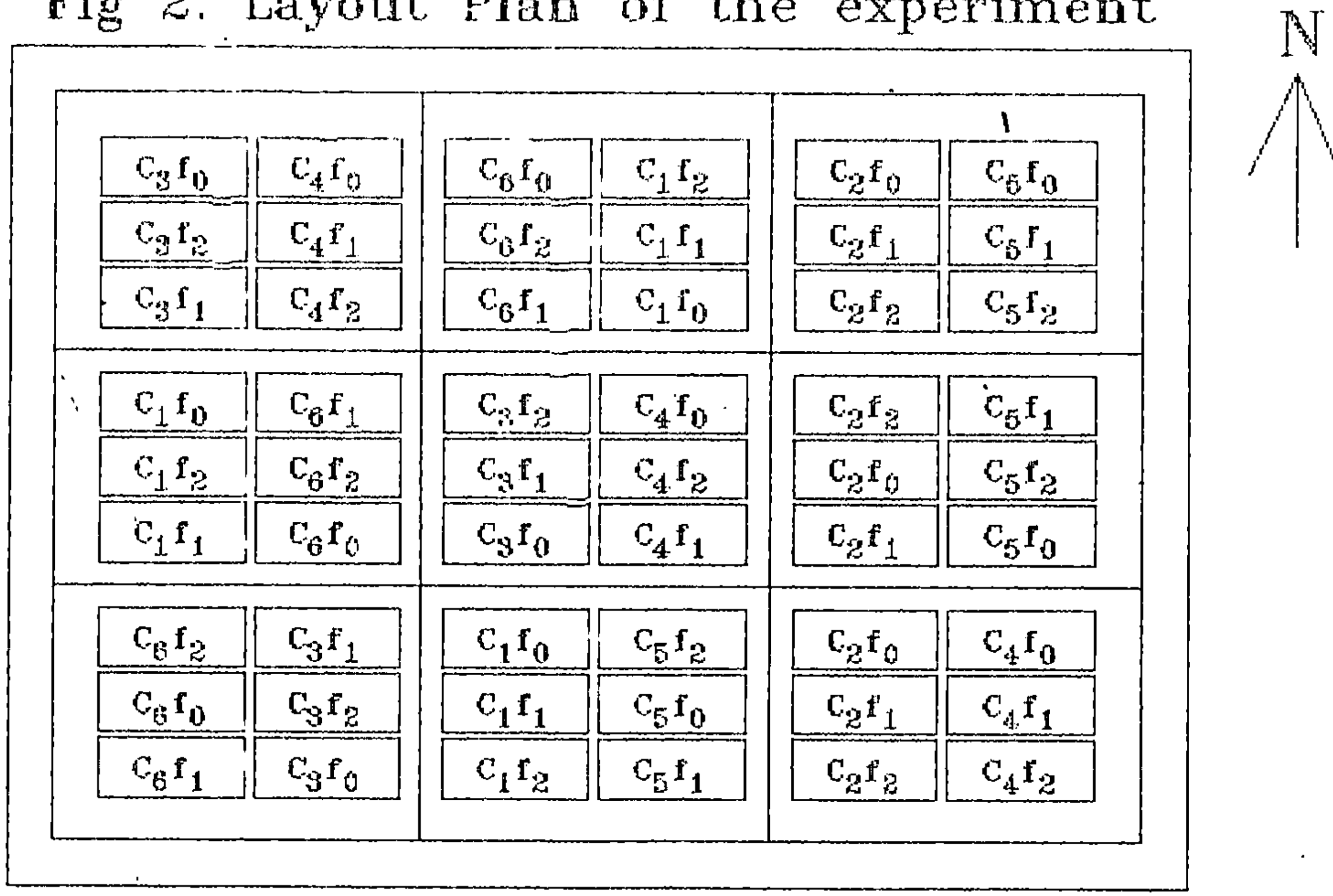
Three Fertilizer levels for Virippu rice:

f_0 - No NPK fertilizer

f_1 - 50% of the recommended dose of NPK fertilizers ($N:P_2O_5:K_2O$- 45:22.5:22.5kg/ha.)

f_2- 100% of the recommended dose of NPK fertilizers

Fig 2. Layout Plan of the experiment



C_1 – Cowpea–rice
C_2 – Daincha–rice
C_3 – Sesamum–rice
C_4 – Maize–rice
C_5 – Rice–rice
C_6 – Fallow–rice
f_0 – No fertilizer
f_1 – $N:P_2O_5:K_2O$ – 45:45:22.5 kg/ha
f_2 – $N:P_2O_5:K_2O$ – 90:90:45 kg/ha

($N:P_2O5:K_2O$- 90:45:45 kg/ha.)

Treatment combinations were as follows:

1-$C_1 f_0$	10-$C_4 f_0$
2-$C_1 f_1$	11-$C_4 f_1$
3-$C_1 f_2$	12-$C_4 f_2$
4-$C_2 f_0$	13-$C_5 f_0$
5-$C_2 f_1$	14-$C_5 f_1$
6-$C_2 f_2$	15-$C_5 f_2$
7-$C_3 f_0$	16-$C_6 f_0$
8-$C_3 f_1$	17-$C_6 f_1$
9-$C_3 f_2$	18-$C_6 f_2$

Each plot of the preceding summer crop grown with a different treatment (summer annual) was divided into three by providing a bund of 20 cm width in between. The gross plot size of each single plot during the virippu rice crop was 6.9 x 4.95 m. Three rows of plants were left breadthwise on either side (two for border,two for destructive sampling). Thus the net plot size was 4.5 x 3.75m. There were fifty four plots.

3.6.2. Details of cultivation.

3.6.2.1 Summer annuals

3.6.2.1.1. Land Preparation.

The main field was ploughed and levelled and plots were laid out with bunds of 30 cm width around. Main and sub-irrigation channels were provided wherever necessary. Individual plots were again ploughed brought into a fine tilth and perfectly levelled. All the summer annuals were raised using the standard procedures and techniques as per the package of practices recommendations of KAU.

3.6.2.1.2. Application of manures and fertilizers.

(a) Grain type cowpea

Superphosphate and muriate of potash were applied at the time of final ploughing to supply phosphorus @ 30 kg P_2O_5/ha and Potassium @ 10 kg K_2O/ha. Urea was applied in two equal splits first at the time of sowing and the second on 25th February to provide nitrogen @ 20 Kg/ha.

(b) Daincha.

No fertilizer was applied for daincha.

(c) Sesamum.

Cattle manure @ 5 t/ha was applied at the time of last ploughing. The entire quantity of superphosphate and muriate of

potash were applied at the time of last ploughing to provide P_2O_5 @ 15 kg/ha and K_2O @ 30 kg/ha as basal dose. Seventy five per cent of the total recommended quantity of urea was applied at the time of sowing and remaining on 2nd March for supplying nitrogen @ 30 kg/ha.

(d) Fodder Maize.

Cowdung @ 10 t/ha was applied in each plot. Urea, superphosphate and muriate of potash were applied as a single dose to supply 120, 60 and 40 kg/ha of N, P_2O_5 K_2O respectively.

(e) Short-duration rice.

Cattle manure was applied at the time of final land preparation @ 5 t/ha. Lime @ 600 kg/ha was also provided. A basal dose of muriate of potash was applied to supply 2/3rd quantity of 70 kg N; 35 Kg P_2O_5 and 35 Kg K_2O. Later the crop failed due to severe drought. The plots were left as such and the treatment was abandoned.

(f) Fallow.

The land was kept fallow without any cultiva tion. No fertilizer was applied.

3.6.2.1.3. Sowing and maintenance.

(a) Grain type cowpea.

The rhizobium treated seeds were sown @ 20 kg/ha in furrows at a spacing 25 x 15 cm, with two seeds per hole. A light irrigation was done four days after sowing. Gap filling was done 10 days after sowing subsequent irrigation was given at the time of flowering. Weeding and hoeing operations were conducted three and six weeks after sowing . Two prophylatic sprayings with Malathion 0.05% were given against pea aphids.

(b) Daincha

Daincha seeds were broadcast after mixing it with three times its volume of sand to ensure uniform coverage and harrowed to cover the seeds with soil. No irrigation and intercultural operations were carried out. Neither manuers nor plant protection chemicals were applied..

(c) Sesamum.

Sesamum seeds @ 5 kg/ha were broadcast, mixed with three times its volume of sand. A harrow was worked to cover the seeds with soil. Thinning was done two weeks after sowing such that a spacing of 15 -25 cm in maintained between plants. Weeding and hoeing were done two and four weeks after sowing. Two irrigations were given one during two weeks after planting and the other at the time of flowering. No plant protection measure was taken.

(d) Fodder Maize.

Seeds @ 80 kg/ha was sown in furrows at a spacing of 30 cm between rows and 15 cm between plants. Thinning of the crop was done 2 weeks after sowing. A single weeding was done when the crop was 30 days old. No irrigation or plant protection measure was given.

(e) Short duration rice

Direct sowing of rice seeds was done @ 90 kg/ha at a spacing of 15 x 10 cm. Sprouting of the seeds was unsatisfactory due to scarcity of water. Though gap filling was done, the crop stand was very poor. In about three weeks time, the crop showed symptoms of wilting and hence it was abandoned.

(f) Fallow.

No crop was raised in these plots. The field was ploughed two times, levelled and left without any crop.

3.6.2.1.4. Harvesting and post harvest operations.

In the case of all the treatments, the crop in the border rows was harvested separately and thereafter the crop in the net area of the individual plots was harvested.

(a) Cowpea.

Picking of pods were done 55 days after sowing. Three pickings were done. The bhusa left after the picking of the pods was weighed and incorporated into the soil. The harvested seeds were dried under sun, cleaned and weight recorded.

(b) Daincha.

Daincha plants were harvested at the starting of flowering about 90 days after sowing. The plants were cut at the base, weighed, chopped and ploughed into the soil.

(c) Sesamum.

The plants were pulled out when the leaves turned yellow. The root portion was cut and plants were stacked in bundles for 3-4 days until the leaves fell off. Then they were dried in the sun and beat with sticks to open the capsules. The bhusha yield left after the collection of seeds and the yield of seeds were recorded.

(d) Fodder Maize.

Fodder Maize plants were cut at the base 60 days after sowing just before tasselling stage.

(e) Short duration rice

Due to the crop failure, the treatment was abandoned. The -plots were left without any cultivation during the succeeding virippu rice season.

(f) Fallow.

The land was kept fallow without any cultivation.

3.6.2.2. Virippu rice.

3.6.2.2.1. Nursery preparation.

The nursery area was ploughed well and raised beds of 1m width and 15 cm height were prepared, with drainage channels in between. Cowdung at the rate of two kg/m2 of nursery bed was applied and incorporated with the soil. Sprouted seeds were broadcast uniformly on 4th June 1987. A seed rate of 75 kg/ha was adopted/. Irrigation was commenced on the 5th day after sowing and the depth of water level was maintained at 5 cm depending upon the growth of seedlings.

3.6.2.2.2. Land preparation.

The main field was ploughed and levelled and plots of 4.5 x 3.75 m were laid out with bunds around. Main and sub irrigation channels were provided wherever necessary. Individual plots were again puddled and perfectly levelled.

3.6.2.2.3. Application of manuers.

Cowdung was applied @ 5 t/ha in all the plots. Ten days prior to transplanting lime was applied at the rate of 600 kg/ha and incorporated with the soil. Three different levels of NPK fertilizers on rice crop was the subject of study. In the case of f_0, no NPK fertilizers was applied.

In plots with f_1 fertilizer treatment, urea, super phosphate and muriate of potash were applied to provide nutrients at the rate of 45 kg N, 22.5 kg P_2O_5 and 22.5 kg K_2O respectively. Half N, full P_2O_5 and half K_2O were applied as basal, and the remaining quantity of N and K_2O at panicle initiation.

Urea, superphosphate and muriate of potash were applied in plots receiving f_2 treatment to supply N, P_2O_5 and K_2O @ 90,45 and 45 kg/ha respectively. Half N, full $P_2O_5$and half K_2O were applied as basal and half the quantity of N and K_2O before panicle initiation.

3.6.2.2.4. Transplanting and maintenance.

Twenty days old seedlings were transplanted on 24th June 1987. Gap filling was done on the tenth day after transplanting wherever necessary. The crop was hand weeded on the twentieth day after transplanting.

A water level of 1.5 cm was maintained initially and later increased to 5 cm depth. The irrigation was given continuously and the water was cut off ten days prior to harvest.

Moderate incidence of sheath blight, rice stem borer and leaf roller were observed. Two sprayings with Metacid and a single spraying with Hinosan were given to the crop. The stand of the crop was moderately good.

3.6.2.2.5. Harvest.

Ten days before harvest, the field was drained. The plots in the border rows were harvested separately and thereafter the crop in the net area of the individual plots were harvested, threshed, cleaned, dried, winnowed and yield at 14 per cent moisture was recorded. The weight of the sun dried straw was also recorded.

3.6.3. Observations.

3.6.3.1. Observations on summer annuals.(Appendix -II)

(a) Grain type cowpea.

(i)Grain yield

The plots were harvested individually after removing the border rows all around. The grain from the net plot area was weighed, the dry weight recorded and expressed in kg per hectare.

(ii) Bhusa yield.

The bhusa left behind after the harvest of the grains from the net area of each plot was weighed and the yield was converted into kg/ha.

(b) Daincha.

Green matter yield at harvest.

Daincha plants were harvested from the net area of all the plots leaving the border rows. The weight was recorded and expressed in kg/ha.

(c) Fodder Maize.

(i) Green matter yield.

The green fodder cut from all the plots after leaving the border rows was weighed and expressed in kg/ha

(ii) Dry matter yield.

Four sampling plants were cut, the green weight noted, oven dried and the weight of the dry matter produced was recorded. The percentage loss in weight due to drying was noted and using this, the dry matter produced per hectare was calculated from the green fodder yield obtained from each plot.

(c) Sesamum.

(i) Seed yield.

The seed yield obtained from the net area of all plots after leaving the border rows was recorded and expressed in kg/ha.

(ii) Bhusa yield.

The bhusa left behind after harvesting the seeds from the net area of all plots was weighed and expressed in kg/ha.

cut along with the mature pods, they were weighed, oven dried and again the weight was recorded. The percentage loss in weight due to drying was noted and using this the dry matter produced per hectare was calculated.

(e)Short duration rice

No observation was recorded since the crop failed.

(f)Fallow

The land was kept fallow without any cultivation. So no observation was taken.

3.6.3.2. Virippu rice

Biometric observations were taken from the net plot area and destructive sampling was done from the observation area.

3.6.3.2.1. Crop growth characters.

(a) Height of the plant.

The plant height in cm was recorded at tillering, panicle initiation, flowering and at harvest. Four hills were randomly selected and the average height of these plants is taken as a measure of the growth of the plants. Height was measured from the base of the plant to the top of the longest leaf or to the top of the longest earhead, whichever was taller (Gomez, 1972).

(b) No of tillers per m^2

Tiller count was recorded at tillering, panicle initiation and flowering. Tiller number was taken from twelve randomly selected hills and expressed as number of tillers per m^2.

(c)Leaf area index.

Leaf area index was computed at flowering by the method suggested by Gomez (1972). Six sample hills were selected to work out LAI. The maximum width `W' and length `L' of all the leaves of the middle most tillers were noted and leaf area index was calculated as follows.

Leaf area of a single leaf = LxWxK

where K in the adjustment factor which is 0.67 at seedling stage and harvest and 0.75 at other stages.

Leaf area per hill = Total leaf area of middle tiller x total number of tillers.

$$LAI = \frac{\text{sum of leaf area/ hill of 6 sample hills}}{\text{Area of land covered by 6 hills (cm}^2\text{)}}$$

3.6.3.2.2. Yield attributes.

(a) Number of productive tillers.

At harvest, the number of productive tillers were counted from 12 randomly selected hills in the net plot area and was expressed as the number of productive tillers per m^2

(b) Weight of panicle.

All the panicles in the 12 sample hills were weighed and weight per panicle was worked out..pa

(c) Number of spikelets per panicle.

The main culm panicles from the 12 sample hills were threshed and both the number of filled grains and unfilled grains were counted and mean computed.

(d) Number of filled grains per panicle.

The main culm panicles from the 12 hills were threshed and the number of filled grain (f) and the weight of filled grain (w) were determined. The rest of the panicles from all the 12 hills were also threshed and the weight of unfilled grains (W) was assessed. From these data the number of filled grains per panicle was calculated using the following formula suggested by Gomez (1972).

(e) Percentage of filled grains.

The total filled and unfilled grains from the panicles were separately counted and the percentage of filled grains was recorded.

(g) Grain yield.

Grain yield was recorded from the net area, weight adjusted to 14 per cent moisture and expressed in kg/ha.

(h) Straw yield.

Straw obtained from the net plot was uniformly sun dried, weighed and expressed in kg/ha.

(i) Biomass production of rice.

The wet weight of the grain and straw from each net plot were added and expressed in kg/ha.

(j) Harvest index.

This is the percentage of grain weight to the total plant weight. This is calculated from the grain and straw weight of the respective plots. Harvest index was calculated by deducting the weight of grains with the total weight of grain and straw.

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

3.6.4. Chemical analysis.

3.6.4.1. Soil analysis.

Composite soil samples collected before the start of the experiment, i.e., after the summer annuals and after the virippu rice crop were analysed to determine the total nitrogen, available P_2O_5, available K_2O and organic carbon. The physical composition and pH were determined only for the initial soil sample..pa

(a) Physical composition.

Percentage of coarse sand , fine sand, silt and clay were determined by International Pipette method based on Stoke's law (Piper, 1950).

(b) Total nitrogen

Total nitrogen was determined by Microkjeldahl digestion method (Jackson, 1967).

(c) Available nitrogen

Available nitroen was estimated by alkaline - permanganate method (Subbiah and Asija, 1956).

(d) Available P_2O_5

Available P_2O_5 was determined by Dickman and Bray's molybdenum blue method (1940) in a Klett semmerson photo electric colorimeter. The soil was extracted with Bray's reagent No. 1 (0.03N ammonium fluoride in 0.025 N hydrochloric acid) (Jackson, 1967).

(e) Available K_2O

Available K_2O was determined in the neutral normal ammonium acetate extract by the flame emission method using EEL flame photometer (Jackson, 1967)..pa

(f) Organic carbon.

Organic carbon content of the soil samples were estimated by the method suggested by Walkley & Black (1934).

(g) Soil reaction.

pH of the soil sample was determined in 1: 2.5 soil: water suspension using the glass electrode of the Perkin Elmer pH meter.

3.6.4.2. Plant analysis.

The plant samples were collected from both the summer and virippu crops were taken at harvest. The grain and the vegetative parts were analysed separately for nitrogen, phosphorus and potassium.

3.6.4.2.a. Total Nitrogen.

Total nitrogen was estimated by Microkjeldahl digestion method (Jackson, 1967).

3.6.4.2.b. Total phosphorus.

Total phosphorus content was estimated by using Vanado molybdo-phosphoric yellow colour method after extraction with triple acid. The yellow colour was read in a Klett Semmerson photoelectric colorimeter at 660 nm (Jackson, 1967).

3.6.4.2.c. Total Potassium.

The same extract for phosphorus estimation was used for the estimation of total potassium using the flame photometer method (Jackson, 1967).

3.7. Uptake studies.

The values of total uptake of N, P and K by crop was obtained as the product of the content of these nutrients and the dry weight of crop expressed in kg per hectare.

3.6.4. Economics.

The economics was worked out based on the following assumptions.

1.Cost of cultivation

	Rs/ha.
(a) Cowpea -	2000
(b) Daincha -	1000
(c) Sesamum -	2000
(d) Fodder Maize -	2900
(e) Fallow -	Nil

2. Cost of NPK fertilizers.

	Rs/kg
(a) Urea -	2.40
(b) Superphosphate -	1.05
(c) Muriate of potash -	1.40

3. Price of produce

(a)	Cowpea grain -	5.00
(b)	Daincha -	Nil
(c)	Sesamum grain -	16.00
(d)	Fodder maize -	0.20
(e)	Rice grain -	2.00
(f)	Paddy straw -	0.50

The net income and benefit cost ratio were calculated as follows.

Net income (Rs./ha) = Gross income - total cost

~~expenditure~~

$$\text{Benefit cost ratio} = \frac{\text{Net income}}{\text{Total expenditure}}$$

3.7.Statistical analysis.

The data generated from the experiments were subjected to Analysis of Variance (ANOVA) technique (Snedecor and Cochran, 1967). Important correlations were estimated and tested for their significance.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION.

Two field experiments were conducted at the Instructional farm, College of Agriculture, Vellayani to study the effect of selected summer annual crops and fallow on the succeeding virippu rice grown with three different levels of NPK fertilizers. The experimental data were subjected to statistical scrutiny to bring out the effects of preceding crops and levels of NPK fertilizers on the growth and yield of the following rice crop. The results obtained are discussed in this chapter.

4.1. Growth characters of rice.

4.1.1. Height of the plant (Table 1)

The height of the kharif rice plants was not markedly influenced by the preceding summer crops or fallow at any stage of its growth viz. tillering, panicle initiation, flowering or at harvest. But the levels of fertility did influence the height of the plants within all the sequences at every stage of growth.

At tillering, a similar trend was observed in four out of the five systems tried .Within the cowpea-rice (C_1), sesamum-rice, (C_3) Maize-rice (C_4) and

Table 1. Growth characters of rice as influenced by preceding crops and levels of fertilizers.

Treatent		Plant height(cm) 40 DAT	Trt. total	80DAT	Trt. total	Flowering	Trt. total	Harvest	Trt. total	No of tillers/m2 40 DAT	Trt. total	80 DAT	Trt. total	Flowering	Trt. total	LAI AT Flowering	Trt. total
	f0	40.4		62.2		74.5		76.5		406.7		322.3		300.0		2.7	
C1	f1	44.7	47.5	78.0	75.9	84.3	83.1	85.1	84.1	475.3	505.6	410.3	397.8	344.0	360.0	3.1	4.2
	f2	57.5		87.7		90.5		90.8		634.7		460.7		436.0		6.8	
	f0	40.6		65.4		76.9		76.9		410.0		315.3		299.0		2.4	
C2	f1	50.6	49.9	73.1	74.2	90.0	83.1	90.0	83.1	503.7	506.8	457.3	432.4	392.7	377.7	4.0	4.3
	f2	58.7		84.1		82.5		82.5		606.7		524.7		441.3		6.6	
	f0	39.6		60.1		71.2		71.2		333.3		292.3		295.3		2.2	
C3	f1	44.7	46.9	73.9	71.9	81.1	80.4	81.1	80.4	386.3	401.7	354.0	358.3	350.3	338.0	2.9	3.4
	f2	56.4		81.6		88.8		88.8		485.3		428.7		368.3		5.0	
	f0	40.6		62.0		75.8		75.8		433.7		304.7		294.0		2.2	
C4	f1	44.5	47.0	64.3	68.0	80.8	81.3	80.8	81.3	476.0	477.6	356.0	381.1	337.3	346.2	2.5	3.0
	f2	55.9		77.8		87.3		87.3		523.0		482.7		407.3		4.4	
	f0	40.8		60.8		75.7		75.6		424.7		322.0		306.7		3.6	
C6	f1	44.4	46.2	64.3	69.3	79.4	81.3	79.4	81.3	522.7	496.8	363.3	394.0	345.0	346.8	4.3	4.2
	f2	53.3		82.8		88.9		88.9		543.0		496.7		388.7		4.8	
CD(Seq)		6.85		7.54		. 5		5.89		48.55		37.81		81.82		1.26	
CD(Treat. within seq)		5.41		8.98		5.86		9.49		36.22		66.37		57.55		0.71	
SE/plot		1.84		3.04		1.99		3.22		25.61		22.5		22.5		0.24	

fallow-rice (C_6) systems application of full dose of recommended dose of fertilizers (F_2) had significant superiority over that of no fertilizers (F_0) and half the dose of fertilizers (F_1). But the height of the plants resulted with f_0 and f_1 levels were comparable in these systems. Within the daincha-rice system the height of the plants recorded was in proportion to the quantity of fertilizers. The tallest plant of 58.66cm was produced by f_2 followed by f_1 and the shortest plants by f_0 in the daincha-rice system.

During panicle initiation the maximum plant height was recorded with the application of the full dose of NPK fertilizers(f2) in all the five sequences. It had significant superiority over that of no fertilizer application (f_0) within all the systems. In the systems except sesamum-rice, f_2 had marked superiority over that of f_1 also. Application of half the dose of NPK (f_1) produced plants having similar heights that of no fertilizer application (f_0) in daincha-rice, maize-rice and fallow-rice sequences . Fertility level f_1 had pronounced superiority over f_0 only when cowpea and sesamum preceded rice.Here also the tallest plants (84.1cm high) resulted with f2 treatment in the daincha-rice sequence.

At flowering, within the maize-rice, sesamum-rice and fallow-rice systems, the plants resulted with f_0 and f_1 levels had comparable heights. But the height of plants recorded with the application of full dose of NPK fertilizers(f_2) had significant superiority over that of f_1 and f_0. In the case of cowpea-rice, all the three fertility levels had significant difference. Within this system tallest plants were produced by f_2 and the shortest by f_0. When daincha preceded rice similar heights were recorded with both half the dose (f_1) and full dose of NPK (f_2). But significant superiority of f_2 and f_1 over f_0 was observed. The highest plant height of 90.7cm during flowering was recorded by the f_2 treatment in this sequence.

At the time of harvest, within the cowpea-rice and maize-rice systems tallest plants resulted with the application of full dose of NPK fertilizers (f_2) and it had significant superiority over that of no fertilizer application. Here when half the dose (f_1) was applied, the plants resulted had similar height as that produced by the application of full dose of NPK(f_2). In the system where fallow preceded rice, f_0 and f_1 levels produced plants having similar heights. But f_2 showed marked superiority over both f_0 and f_1. In the sesamum - rice sequence no fertilizer application (f_0) resulted in the lowest plant height of 71.6cm during harvest.

The other two fertility levels f_1 and f_2 recorded plant heights which were comparable and both these had pronounced superiority over that of f_0. In the sequence where daincha preceded rice, the plant height recorded by both f_2 and f_1 were similar. These two treatments resulted in taller plants.

From the foregoing analysis of the plant height of rice the following facts emerged. The height of rice plants was not significantly influenced by the preceding crops at any stage of the growth. Though not significant at some instances, in general it could be said that the height of rice plant improved progressively with the increase in the levels of NPK fertilizers at all stages of growth within all the cropping systems tried. This is well supported by different authors. Increase in plant height with increase in the levels of applied nitrogen had been reported by many workers (Sadayappan and Kolaindaiswamy 1974; Sushamakumari, 1981; Surendran, 1985). Vijayan and Sreedharan (1972) observed significant increase in the plant height with the increase in the levels of potassium from 20 to 80 kg/ha.

4.1.2. No of tillers (Table 1)

The preceding crops and fallow influenced the no of tillers at 40 DAT. The highest number of 507 tillers at 40 DAT was registered in the daincha - rice system, on par with cowpea-rice, fallow-rice and maize-rice. The daincha rice system had significant superiority over sesamum-rice sequence which recorded the lowest number of tillers of 402.

Comparing the three fertility levels, within all the systems presence of full recommended quantity of NPK fertilizers (f_2) had pronounced superiority over no fertilization(f_0). Within cowpea-rice and sesamum-rice sequences f_2 had pronounced superiority over f_1 (50 per cent of the recommended dose of NPK) also. But f_0 and f_1 were on par in these two sequences. Within daincha all the three fertility levels resulted in number of tillers which differed significantly.Here an increase in the number of tillers with the quantity of NPK fertilizers was observed. In the maize-rice system, f_1 & f_2 and f_1 & f_0 were on par. But f_2 was significantly superior to f_0. When fallow preceded rice, reducing the quantity of fertilizers to 50 per cent (f_1) was sufficient to produce more or less the same number of tillers as that with cent per cent of recommended NPK fertilizers.F_1 was superior to f_0 in this system.

During panicle initiation also the number of tiller production followed the same trend as that during 40 DAT. The maximum number of tillers 432.44 were produced in the daincha-rice system on par with cowpea-rice sequence and the least in the sesamum - rice sequence (358.33). In the cowpea-rice system reducing the quantity of major nutrients to half (f_1) was sufficient for producing the same number of tillers as that with the full compliment of NPK fertilizers (f_2). But f_2 & f_1 were significantly superior to no fertilizer application (f_0).Within daincha the number of tillers resulted with the three fertility levels differed significantly. F_2 produced the maximum no of tillers followed by f_1 and the least number was recorded with f_0. In the sesamum - rice, maize-rice and fallow-rice systems f_0 and f_1 produced the same number of tillers. But here the full dose of NPK application had marked superiority over both the lower levels of fertility.

During flowering the summer crop treatments did not influence the number of tillers produced in the succeeding virippu rice. However, as during tillering and PI here also, the highest number of tillers were produced in the daincha - rice sequence (377.67) followed by cowpea-rice and the least in the sesamum-rice sequence (338). In the cowpea-rice and maize- rice systems f_2 was significantly superior to both f_0 and f_1. But in these two, f_1 was on par with f_0. Within sesamum-rice, fallow- rice and daincha-rice full dose of NPK (f_2) and half the dose of NPK (f_1) produced more or less same number of tillers. When sesamum and fallow preceded rice, f_1 was on par with f_0. But in daincha-rice, the lower two fertility levels differed significantly.

From the above results on the number of tillers at three different stages of the growth of the rice the following conclusions can be arrived at. The number of tillers was always highest when daincha and cowpea preceded rice. This may be due to the addition of nutrients particularly N to the soil through the fixation of N in the root nodules and decomposition of stubbles of these leguminous crops. This might have promoted the cell division resulting in more number of tillers. The favourable influence of NPK on the tiller production is well documented. It is also clear that the presence of full compliment of major nutrients influenced the tiller production significantly, at all stages of the crop growth within all the sequences. This may also be due to the greater supply of nutrients in f_2. Progressive increase in the number of tillers with the increase in the NPK nutrients is in agreement with the following findings. Positive effect of nitrogen on the tiller production had been observed by De Datta and Surjith (1981). Chowdhary and Mian (1978) found that increasing levels of phosphorus increased the number of tillers. Kulkarni et al (1975) reported that the effect of potassium was significant and positive on tiller production in rice.

4.1.3. LAI of rice plant at flowering (Table 1).

Leaf area index determines the total photosynthesizing area available to the plant and the quantum of source that would ultimately be available for translocation to the sink. In rice marked difference in LAI was observed with the different crops preceded it. Highest LAI of 4.31 was observed in the daincha - rice system which was found to be on par with that of fallow-rice, cowpea-rice and Sesamum -rice. Lowest LAI value of 3.00 was recorded in the maize-rice sequence. Greater LAI value in the daincha - rice sequence might be due to the favourable effect of daincha incorporation on the following rice which prevailed during the vegetative phase of the crop. It should be noted that though not significant the tallest plants were produced in the daincha-rice sequence. Maize being a voracious feeder might have depleted the soil of nutrients. This in turn might have caused a reduced vegetative growth and thus a lower LAI was recorded. Higher LAI value of rice after daincha and cowpea is in agreement with the findings of Purushothaman (1979),who reported a higher LAI of rice after intercropping system involving legumes.

The fertility levels (F_0, F_1 & F_2) influenced the LAI within all the cropping systems. A same trend of influence of levels of fertilizers on the LAI of rice was observed in cowpea-rice, maize-rice and fallow-rice sequences. Within these three systems the presence of entire quantity of recommended NPK fertilizers resulted in the maximum value of LAI which had significant superiority over both the other levels. But reducing the quantity of major nutrients to half (f_1) recorded LAI values on par with that of no fertilizers (f_0). Within daincha-rice and sesamum-rice system all the three fertilizer levels resulted in LAI values which differed significantly. The general trend observed within all the systems i.e., increase in LAI with the increase in the levels of nutrients is well supported by different authors. Increase in the LAI with increasing levels of N was observed by Fagada and De Datta., (1971), Tanaka (1972) and Ramaswamy (1975).

4.2. Nutrient uptake.

The uptake of NPK nutrients, by the Virippu rice crop as well as the total uptake of nutrients by the summer crop-virippu rice sequence are discussed here.

4.2.1. Uptake of NPK nutrients by virippu rice. (Table 2 and Fig.3,4 and 5).

Table 2 shows the N,P and K uptake pattern of the virippu rice crop as affected by the preceding summer crops and the fertility levels. The uptake of all the three nutrients (N,P and K) by rice was similarly influenced both by the preceding crops and fertility levels and showed a more or less similar trend. So here they are discussed together.

Daincha incorporation during summer resulted in the maximum uptake of all the three nutrients by rice in the virippu season.The N:P:K uptake of rice in this sequence was 85.09:27.64:60.41 kg/ha. This was on par with the values recorded when cowpea was the preceding crop. Daincha- rice sequence had marked superiority over the other systems such as maize-rice, sesamum-rice and fallow-rice in the uptake of nutrients. The lowest N and P uptake of rice 62.01 and 21.07 kg/ha respectively was when sesamum preceded it. Potassium

Table 2. Nutrient uptake of rice and summer crop-rice sequences as influenc
by preceding crops and levels of fertilizers

Treatment		Nutrient uptake of rice at harvest (Kg/ha)						Nutrient uptake of seq at harvest (Kg/ha)				
		N	Trt total	P	Trt total	K	Trt total	N	Trt total	P	Trt total	K
	f0	46.2		14.5		32.8		140.3		21.1		71.
C1	f1	80.7	79.9	26.8	24.5	56.5	55.0	172.6	173.9	33.3	31.1	95.
	f2	112.7		32.2		75.8		208.9		38.8		109.
	f0	46.3		15.8		35.6		103.2		31.9		62.
C2	f1	87.3	85.1	32.1	27.7	64.2	60.4	142.2	141.7	47.8	43.8	91.
	f2	121.7		35.2		81.4		179.8		51.7		109.
	f0	41.1		13.5		29.2		81.8		23.6		41.
C3	f1	56.8	62.0	23.3	21.0	49.3	47.2	97.0	102.7	33.2	31.1	61.
	f2	88.2		26.3		63.1		129.3		36.5		75.
	f0	39.8		15.1		27.3		105.6		23.2		65.
C4	f1	70.2	63.4	23.7	22.0	48.1	46.5	137.7	130.6	31.9	30.2	87.
	f2	80.3		27.1		64.2		148.4		35.4		103.
	f0	43.9		15.1		30.3		43.9		15.1		30.
C6	f1	70.3	70.5	25.5	23.1	52.6	50.3	70.3	70.5	25.5	23.1	52.
	f2	97.4		28.6		68.1		97.4		28.6		68.
CD(treat)		10.80		2.29		5.37		13.96		2.86		8.2
CD(treat. within seq.)		12.03		2.18		5.28		13.74		2.17		3.5
SE/plot		4.08		0.74		1.79		4.66		0.74		2.

Fig. 3 UPTAKE OF NITROGEN BY VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

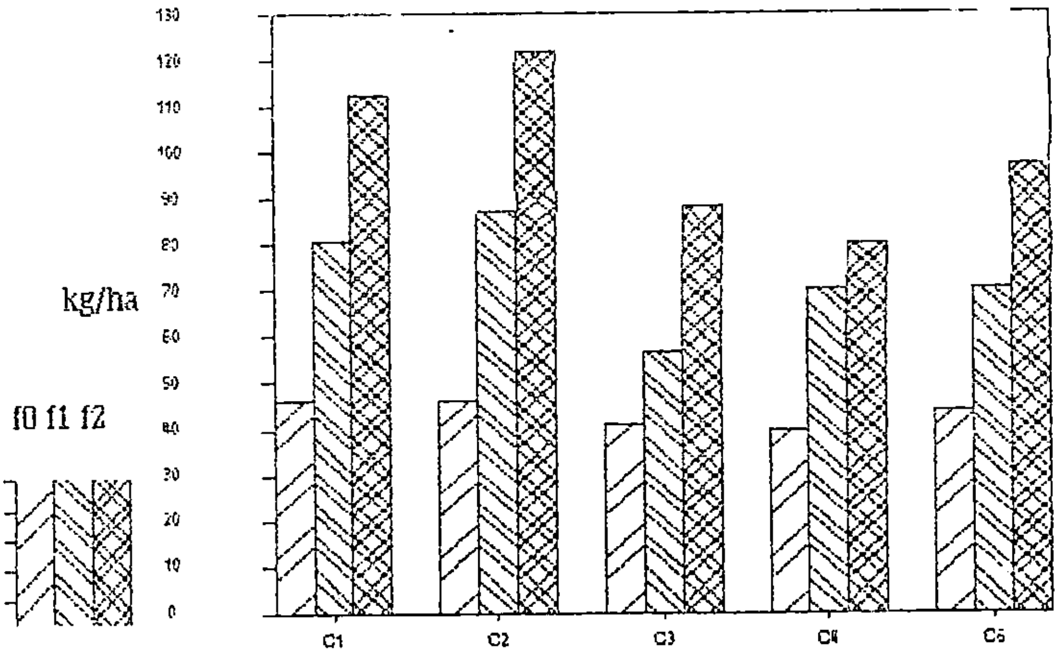
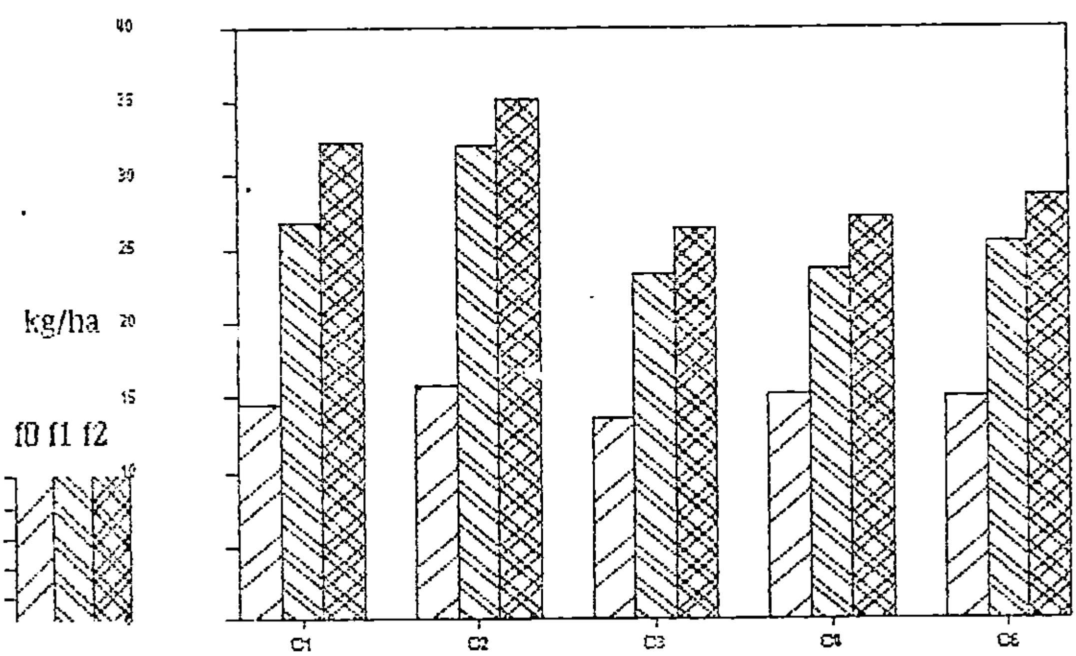


Fig. 4 UPTAKE OF PHOSPHORUS BY VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



uptake was minimum (46.51 kg/ha.) when the land was kept fallow before the rice crop. The higher biomass production of rice recorded when daincha and cowpea preceded it (table 4) may be the cause for the higher uptake of nutrients by rice when these legumes were its previous crops. Biomass production of rice was comparatively low when sesamum, and fallow were the summer treatments and hence the low uptake of nutrients by rice when these preceded it. Increased uptake of N,P and K by rice after the incorporation of daincha as greenmanure had been reported by Tiwari et al (1980). Sasidhar (1978) observed higher N and K uptake of virippu rice after the summer cowpea crop. Potassium uptake of rice when maize preceded it, was similar to that of rice in the daincha-rice and cowpea- rice sequences which recorded maximum values. Increased uptake of potassium by rice when maize was the previous crop had been reported by Mahapatra et al (1974) and Anon., (1974).

Uptake of N,P and K was markedly influenced by fertility levels within all the summer crop-rice sequences. Application of full dose of N,P and K to rice (f_2) had pronounced superiority over that of half the dose of NPK (f_1) and no fertilizer application (f_0). F_1 was also significantly superior to f_0. The higher uptake of nutrients with increase in the fertility levels could be attributed to the higher biomass production and the increased supply of nutrients when full and half compliment of N, P and K were given. The change in the uptake of nutrients with the change in the fertility levels had been studied by different workers. Gopalaswamy and Raj (1977) reported higher uptake of N with increase in the quantity of N applied. Increased P uptake with increase in the level of nitrogen (Hanway, 1962) and favouravle influence of K uptake by higher levels of N (Mukherji and Sircar, 1969) had been observed. Loganathan and Raj (1976) reported higher uptake of N in the presence of P and K. Linear increase in the uptake of P with the increase in the P fertilizer applied had been reported by Oomen _et al_. (1972). Increase in the uptake of N,P and K by rice with increasing levels of potassium had been reported by Agarwal (1978) and Singh and Singh (1987). On the other hand Rana _et al_ (1984) observed that nitrogen and phosphorus uptake of crops decreased with curtailment in the NPK fertilizer dose. The above mentioned findings support the change in the uptake of NPK nutrients by rice with the change in the fertility levels. Thus it could be said that the uptake of nutrients by rice was influenced by the residual effect of the preceding

Fig 5 UPTAKE OF POTASSIUM BY VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

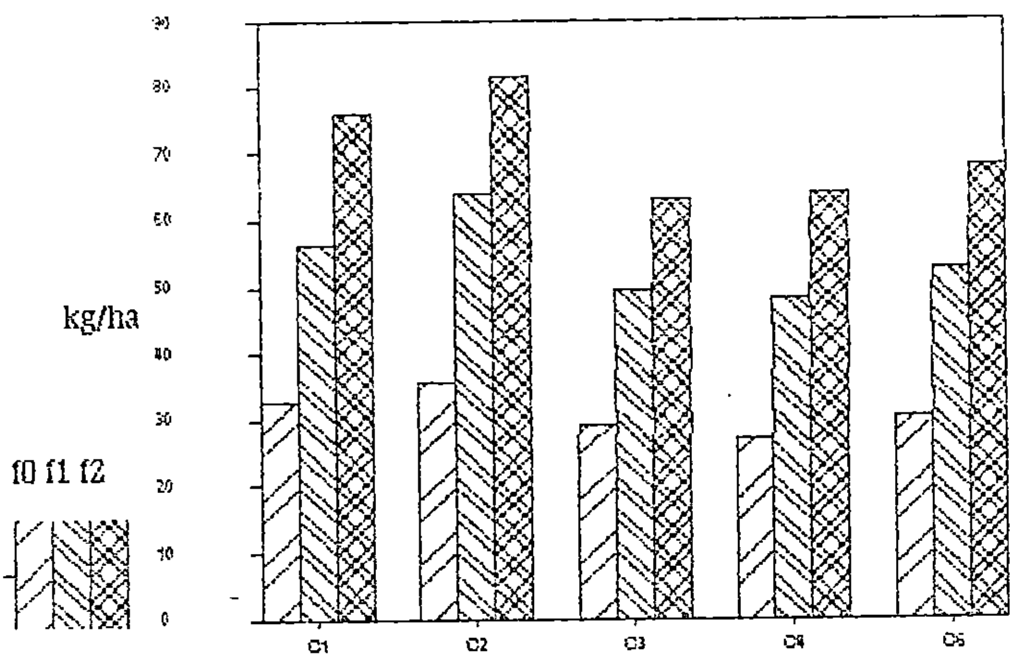
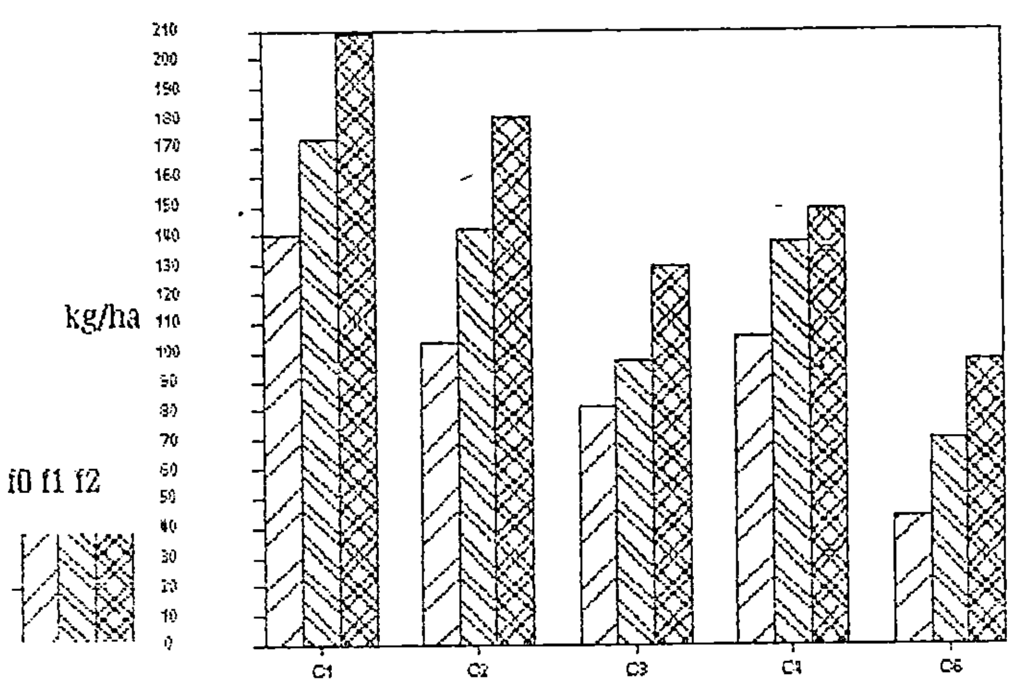


Fig. 6 UPTAKE OF NITROGEN BY SUMMER CROP RICE SEQUENCES AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



summer crops. But it may be noted that the effect of fertility levels was more dominant than the residual effect of the preceding summer crops that they exerted the same influence on rice irrespective of the preceding summer crop.

4.2.2. Uptake of nutrients by the summer crop- rice sequence. (Table 2)

4.2.2.1. N uptake (Table 2 and Fig.6).

Highest N uptake of 173.97 kg/ha was in the cowpea-rice system having significant superiority over all other sequences and lowest in the fallow-rice system (70.56 kg/ha). Daincha-rice system recorded the second highest uptake value of 141.71 kg/ha which was on par with that of maize-rice sequence. The high N uptake in the cowpea-rice sequence was due to the greater biomass production by it. Moreover it may be noted that cowpea, danicha and maize removed comparatively higher amounts of N from the soil. The higher biomass production recorded by the daincha-rice and maize-rice systems also support their high N uptake (Table 4). This increased the total uptake in the systems where they were components. Higher uptake of N by cowpea-rice sequence is in accordance with the finding of Mahapatra _et al_(1974). The lowest removal of N by the fallow-rice system is quite understandable.

4.2.2.2.P uptake (Table 2 and Fig.7).

The uptake of 43.75 P kg/ha registerd in the daincha-rice system was the highest, followed by sesamum-rice which was on par with maize-rice and cowpea-rice sequences. The lowest removal of 23.04 kg/ha P was noticed in the fallow-rice sequence. The highest uptake in the daincha-rice sequence may be due to the increased availability and absorption of P under low land conditions (Ponnamperuma, 1972) coupled with the response of daincha to P application which was highest among the summer crops. Moreover biomass production of the daincha-rice system was the second highest among the different sequences (Table 4). Phosphorus availability from added fertilizer would have been increased by the organic acids produced by the decomposition of the green manure and through reduced P fixation due to production of organic complexes with chelating effects. Hence the greater amount of P removal by the systems including green manure crop is easily understood. The minimum removal of P by the fallow-rice system is self explanatory.

4.2.2.3.K uptake (Table 2)

Among the cropping sequences, cowpea-rice

Fig. 7 UPTAKE OF PHOSPHORUS BY SUMMER CROP RICE SEQUENCES AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

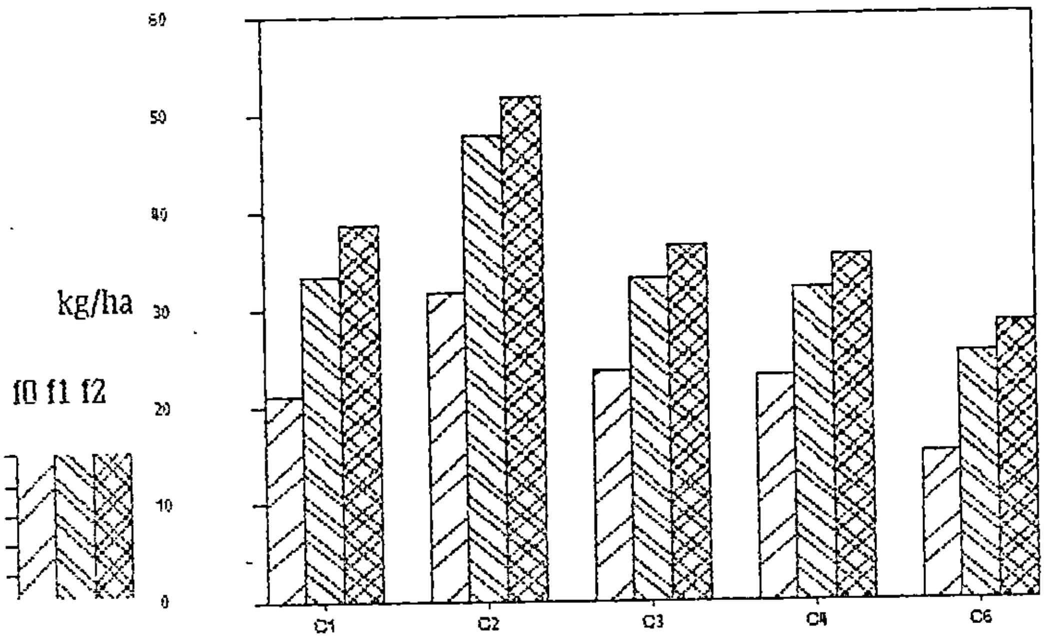
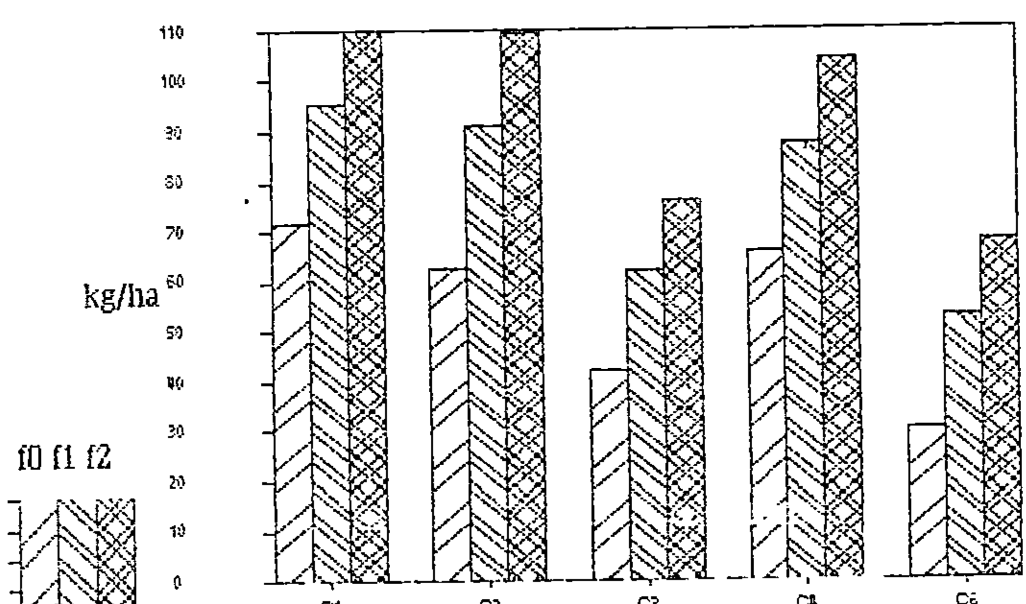


Fig. 8 UPTAKE OF POTASSIUM BY SUMMER CROP RICE SEQUENCES AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



depleted the soil of 92.21kg K/ha which was more than any other sequence. The lowest removal of 50.32 kg/ha K was by the fallow-rice system. Among the summer crops it was cowpea that recorded the maximum uptake of potassium and hence the system involving it registered the highest uptake. The higher uptake of potash by the cowpea-rice system is in agreement with the finding of Sasidhar (1978).

4.2.2.4.NPK uptake by sequences as influenced by fertility levels.

While considering the effect of the fertility levels in the uptake of nutrients by the summer crop-virippu rice sequences marked influence of the fertilizer levels on the latter could be observed. The same trend of influence was noticed in the uptake of N,P and K nutrients by rice and hence they are discussed together. Though the preceding crops did influence the uptake of N,P and K nutrients by rice, a more dominant effect was exerted by the fertility levels. Application of the full dose of recommended NPK fertilizers to rice (f_2) resulted in the maximum uptake of N,P and K by all the sequences tried and it had pronounced superiority over half the dose (f_1) and no fertilization (f_0). Within all the sequences the lowest NPK uptake was when no fertilizer was applied. F_1 was significantly superior to f_0 in all the systems tried. Significant increase in the nitrogen uptake with N levels up to 80 Kg/ha was reported by Rai and Murthy (1979). Increase in the uptake of the quantity of N favourably influencing P uptake was reported by Hanway (1962) and former increasing the uptake of K was observed by Mukherji and Sircar (1969). In the case of phosphorus Oommen*et al* (1972) found proportionate increase in the P removal with the quantity applied. Loganathan and Raj (1976) observed higher uptake of N by rice in the presence of P. Singh and Singh (1987) reported that the total uptake of N,P and K rice increased with the increase in the quantity of N applied. These findings substantiate the uptake trend noted with the different fertility levels.

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4.3. Yield Components

4.3.1. Productive tillers/m^2. (Table 3)

All the tillers produced in the rice plant do not bear panicle and hence only the number of productive tillers have a direct bearing on the ultimate productivity of the crop. The number of productive tillers of virippu rice in the different systems was not affected by the crops preceding it. Though not

Table 3. Yield attributes of rice as influenced by preceding summer crops and levels of fertilizers

Treatment		No of productive tillers/m2	Trt total	No of spikelets/ panicle	Trt total	No of filled grains/ panicle	Trt total	Weight of the panicle (in g)	Trt total	1000 grain weight	Trt total
	f0	284.0		85.0		70.5		1.2		23.5	
C1	f1	341.0	336.4	89.1	90.7	81.5	82.8	1.4	1.5	24.1	24.5
	f2	384.3		98.0		96.4		1.9		26.0	
	f0	293.3		77.6		68.5		1.4		23.6	
C2	f1	374.3	353.1	97.8	98.6	82.3	87.4	1.7	1.7	24.3	24.6
	f2	391.6		120.4		111.4		1.9		26.0	
	f0	272.0		77.6		74.7		1.2		23.3	
C3	f1	315.6	307.9	95.1	90.1	81.8	80.1	1.3	1.4	23.8	24.2
	f2	336.0		97.5		83.8		1.8		25.6	
	f0	283.3		78.2		70.5		1.2		23.0	
C4	f1	309.3	316.5	86.0	86.9	63.7	71.9	1.3	1.4	23.9	24.3
	f2	357.0		96.5		81.5		1.8		25.9	
	f0	271.3		79.3		67.5		1.3		22.9	
C6	f1	301.0	313.2	93.7	94.2	76.2	76.5	1.3	1.4	23.8	24.2
	f2	367.3		109.6		85.8		1.7		26.0	
CD1(treat)		78.39		3.36		5.96		0.19		0.18	
CD2(treat. within seq)		48.3		6.67		6.46		0.14		0.39	
SE/plot		16.37		2.26		2.19		0.02		0.58	

significant the maximum number of 353.11 productive tillers/sq.m was produced in the daincha-rice sequence and the minimum 307.9 was produced when rice was preceded by sesamum.

Application of recommended level of NPK in f_2 had significant influence on the number of productive tillers within all the systems. In the daincha-rice and cowpea-rice systems both f_2 and f_1 levels were superior over f_0. But f_1 and f_2 resulted in more or less the same number of productive tillers/m^2. This reveals that when daincha and cowpea precede rice, reducing the quantity of NPK nutrients to half to rice will not adversely affect the productive tiller production. The residual effect of nutrients particularly N supplied by the stubbles and roots of these leguminous crops might have contributed to the tiller production of rice when only the half the quantity of fertilizers were present. In the sesamum-rice and maize-rice systems the number of productive tillers resulted with no fertilization was on par with that of half the dose of NPK. The effective tiller number resulted with full dose major nutrients was also more or less same as that of half the compliment of NPK (f_1).

In general, it may be observed that within all the cropping systems application of full dose of NPK fertilizers (f_2) resulted in the maximum number of productive tillers. The greater supply of nutrients in f_2 and the greater number of tillers in this treatment may be attributed for the same. Increase in the number of productive tillers with increase in the levels of nitrogen up to 120 kg N/ha had been reported by Venkata Rao (1979). Jayaraman(1980) found increased number of productive tillers with increase in the quantity of P. Favourable influence of K application on the productive tiller number had been reported by Kulkarni et al (1975).

4.3.2. No. of spikelets/panicle. (Table 3)

Among the different systems tried daincha as the preceding crop resulted in the highest number of 98.64 spikelets per panicle in the rice having marked superiority over the other systems. The minimum number of 86.92 spikelets/panicle was observed when maize preceded rice. It was on par with that of sesamum-rice. Incorporation of daincha insitu might have increased the supply of nutrients to the succeeding rice crop. Thus an increase in the vegetative growth might have occurred which led to higher photosynthesis as reflected in the higher LAI after daincha. Thus an improvement in the source (the leaf area) increased the sink activity also i.e., the production of more number of spikelets. Joseph (1986) found highest number of grains per panicle with daincha incorporation before a rice crop.

Within daincha-rice ,maize-rice and fallow-rice sequences all the three levels of NPK fertilizers produced significant results. F_2 produced maximum number of spikelets per panicle and it had significant superiority over the other two.Lowest number of spikelets per panicle was produced when no fertilizer(f_0)was applied . In the cowpea-rice system,f_2 was significantly superior than f_0 and f_1.But both the lower levels were on par.

In general, it could be seen that within all the systems, application of recommended levels of NPK in f_2 had significant influence on the number of spikelets per panicle and reducing the quantity of fertilizers adversely affect the same. This is in agreement with the findings of Sushamakumari (1981) and Alexander (1974) who observed favourable influence of N on the production of spikelets and Vijayan and Sreedharan(1972) who reported increase in the number of spiklets per panicle with the increase in the levels of potassium.

4.3.3. No. of filled grains per panicle. (Table 3)

The daincha-rice system produced the maximum number of 82.81 filled grains per panicle. This was on par with that of cowpea -rice sequence. The lowest number of 71.94 filled grains/panicle was recorded in the maize-rice system. The increased supply of nutrients particularly N due to the incorporation of the stubbles of daincha and cowpea and the fixation of N in their root nodules might have contributed to the source (photosynthesizing area) of rice plant in C_1 and C_2 which consequently led to a higher sink activity (grain filling). Significantly lower grain sterility of rice with cowpea straw incorporation had been reported by Sanchez and Lopez (1983).

In the daincha-rice, cowpea-rice and fallow-rice sequences all the three fertility levels caused significant difference in the number of filled grains per panicle. Within these sequences, there was an increase in the number of filled grains with increase in the quantity of fertilizers. In the sesamum - rice system number of filled grains resulting with the two higher fertility levels (f_2 and f_1) were comparable. Here application of full dose of NPK (f_2) had pronounced superiority over no fertilisation (f_0). In the maize-rice system f_2 had marked superiority over f_0 and f_1. But the lower two levels of fertility produced more or less similar results.

Generally, it could be stated that there was a proportional improvement in the grain filling with the increase in the levels of fertilizers. This in confirmatory with the findings of many workers.De Datta and Surjith (1981) have reported that number of filled grains per panicle increased with increase in the level of nitrogen. More number of filled grains per panicle with increase in the level of phosphorus had been reported by Jayaraman (1980) and Subbiah (1976). Favourable influence of potassium on the percentage of filled grains have been reported by Venkatasubbiah et al (1982).

4.3.4. Weight of the panicle. (Table 3)

The panicle weight of the virippu rice crop was affected by the summer treatments. The maximum weight of panicle 1.72 g was recorded when daincha preceded rice and the minimum 1.48 g was when fallow and maize were the summer treatments before rice. A higher panicle weight recorded in the daincha-rice sequence is in confirmatory with the finding of Joseph (1986).

In the daincha-rice and cowpea-rice sequences, the weight of the panicle increased with the increase in the quantity of NPK fertilizers, the maximum being in the f_2 treatment and the minimum in f_0. In the other three sequences, (sesamum-rice, maize-rice and fallow-rice) the lower two fertility levels f_0 and f_1 recorded comparable weights, where as f_2 resulted in the highest weight of the panicle which had marked superiority over the other two. The favourable influence of increasing levels of N,P and K nutrients increasing the weight of the panicle had been reported by Sushamakumari (1981).

4.3.5. Thousand grain weight. (Table 3)

The test weight of virippu rice crop was influenced by the preceding summer annuals and fallow. Rice in the daincha -rice system recorded the highest thousand grain weight of 24.66g which was on par with that of cowpea-rice sequence. The minimum test weight of 24.25 was observed in the fallow- rice system. Higher test weight of rice grown after legumes is in conformity with the finding of Purushothaman (1979).

The three different levels of NPK fertilizers exerted marked influence on the thousand grain weight of the rice crop. Within all the sequences tried, application of the entire dose of NPK fertilizers (f_2)

resulted in the maximum test weight having significant superiority over that of f_0 and f_1. Half the recommended dose of NPK (f_1) was also found to have pronounced superiority over f_0. Influence of NPK nutrients on the test weight of rice is well documented. Increase in the test weight of rice with increasing levels of nitrogen had been reported by Kalyanikutty and Morachan (1974) and Nair (1976). Jayaraman (1980) found a positive influence of levels of P on the thousand grain weight of rice. Levels of potassium favourably affecting the test weight of rice is in conformity with the findings of Singh and Sing (1979).

4.4. Yield.

4.4.1. Biomass production of rice. (Table 4 and Fig.9)

The grain and straw yield of the rice crop were added and the sum is referred to as the biomass production. The same trend noticed in the grain and straw yield is observed here also. Highest biomass of rice 8987 kg/ha was recorded in the daincha-rice system. This was on par with that of cowpea-rice sequence.Lowest biomass of 7096.31 kg/ha was when fodder maize was the previous crop of rice.

Fertility levels had marked influence on the biomass production of rice within all the sequences.

Table-4 Yield, harvest index and biomass production of rice as influenced by preceding summer annuals and levels of fertilizers.

Treatment		Grain yield Kg/ha	Trt total	straw yield Kg/ha	Trt total	Harvest index	Trt total	Biomass production Kg/ha	Trt total
	f0	1932.30		3676.10		0.34		5608.50	
C1	f1	2863.20	2871.00	5726.30	5231.43	0.33	0.35	8589.50	8102.50
	f2	3817.50		6291.90		0.38		10109.50	
	f0	2240.10		3794.00		0.37		6032.70	
C2	f1	3840.90	3456.63	5938.40	5380.70	0.39	0.39	9779.60	8836.97
	f2	4288.90		6409.70		0.40		10698.60	
	f0	1689.60		3487.60		0.33		5177.30	
C3	f1	2410.10	2471.77	5420.00	4893.70	0.30	0.33	7651.90	7127.80
	f2	3315.60		5773.50		0.36		8554.20	
	f0	1644.80		3369.80		0.33		5014.70	
C4	f1	2145.50	2276.73	5372.80	4819.03	0.28	0.32	7519.70	7096.30
	f2	3039.90		5714.50		0.35		8754.50	
	f0	1779.20		3440.50		0.34		5219.70	
C6	f1	2608.70	2589.83	5349.30	4823.00	0.32	0.34	8101.70	7454.47
	f2	3381.60		5679.20		0.37		9042.00	
CD(Seq)		150.72		145.44		0.02		696.7	
CD(Treat. within seq)		321.97		334.84		0.03		309.58	
SE/plot		109.14		113.51		0.01		218.91	

Fig. 9 BIOMASS PRODUCTION OF VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

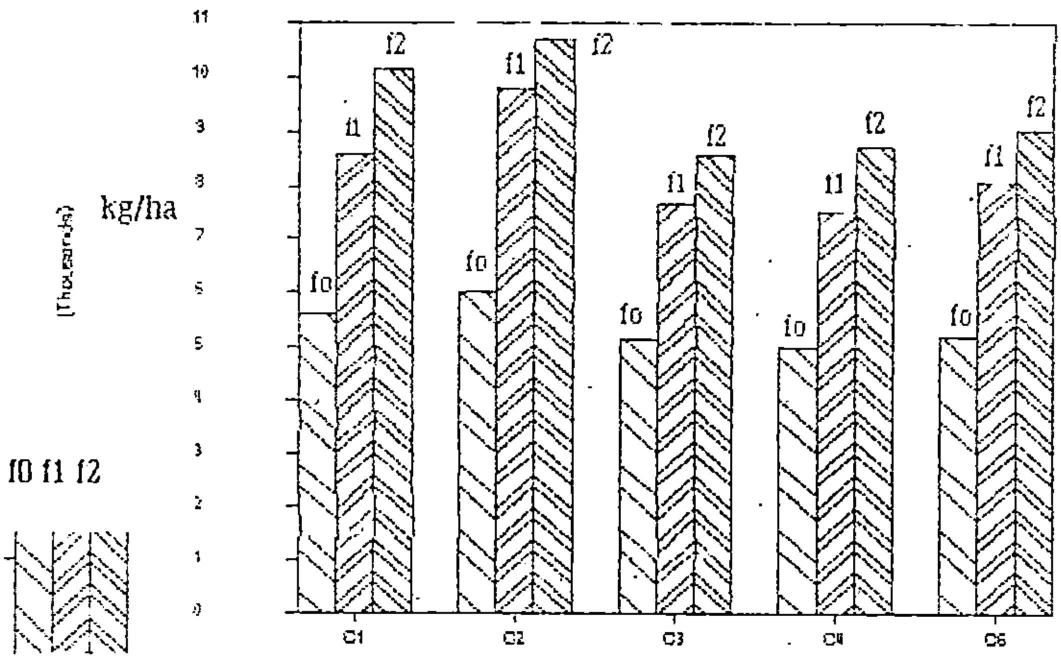
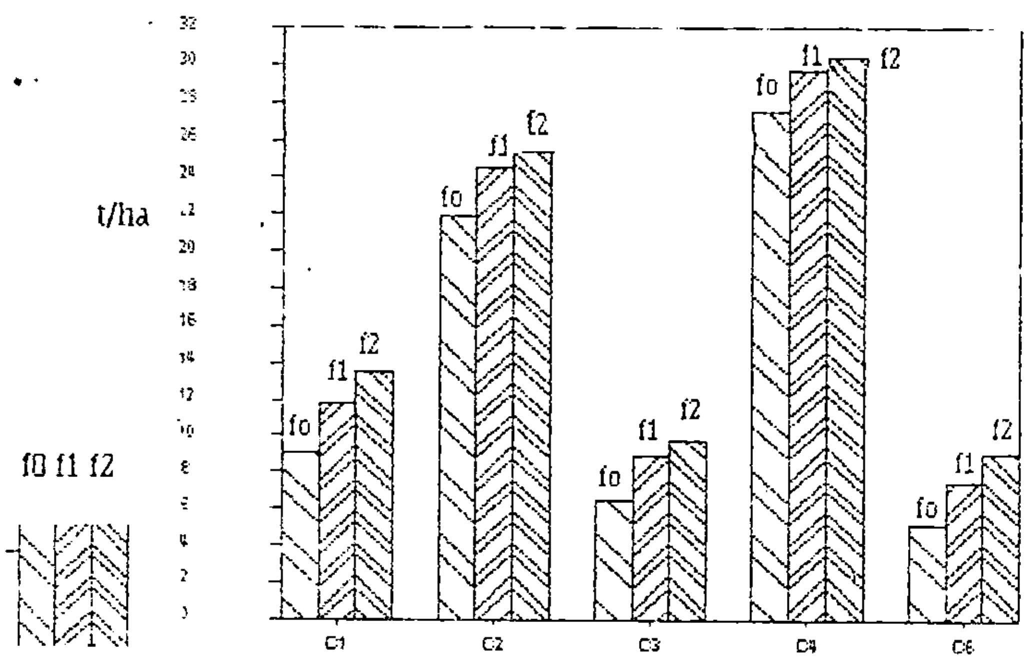


Fig. 10 BIOMASS PRODUCTION OF SUMMER CROP RICE SEQUENCES AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



Application of the full compliment of NPK nutrients (f_2) was found to be the best within all the systems and it had pronounced superiority over both the lower fertility levels (f_1 and f_0). F_1 was also significantly superior to f_0. Lowest biomass of rice was registered with no fertilizer application (f_0). An improvement in the grain and straw yield of rice with the increase in the quantity of NPK fertilizers was observed which is attributed to the higher supply of major nutrients. Since biomass is the sum of grain and straw yield, the reasons for the increase in the grain and straw yields with the increase in the quantity of nutrients is applicable to the biomass production of rice also which is discussed else where .

4.4.2. Biomass production of the summer crop - rice sequence.(Table 8 Fig.10).

The total biological yield harvested from each system (the yield from the summer crop + grain and straw yield of the following rice crop) is referred as the biomass production of the sequence. Among the different sequences the maximum biomass of 29.19 t /ha was produced by the maize-rice system. It was markedly superior to all the other. sequences. Daincha-rice system was the second best. The lowest biomass of 7.23t/ha was recorded in the fallow rice system. Maize during summer recorded the highest biomass yield as compared to other crops. Daincha came next (Appendix-II). This contributed to the higher biomass production by those sequences where these crops were components. Since the land was kept fallow before rice, the lowest biomass recorded by this sequence is quite understandable. Comparing the three different fertility levels, in general, it could be said that within each system application of the full compliment of NPK to the rice crop (f_2) resulted in the highest biomass production and it was significantly superior to no fertilization (f_0). This was true for all the sequences tried. But the biomass produced when half the dose of NPK fertilizers (f_1) was applied to rice was comparable with full dose application (f_2) in the sequences except cowpea-rice. In the cowpea-rice system f_1 produced markedly higher biomass as compared to no fertilizer application. In the other sequences viz., daincha-rice, sesamum-rice, maize-rice and fallow-rice half the recommended dose of major nutrients (f_1) to rice resulted in biological yield same as that obtained with the application of full dose of NPK (f_2). The dominance of f_2 over f_0 observed within all the sequences may be attributed to the higher uptake of NPK nutrients by all the sequences when the full dose of recommended fertilizers (f_2) were present(Table 2) and consequent higher biomass production of rice in that treatment. In those systems where half the dose of fertilizers (f_1) produced comparable results as that of f_2 it could be said that reducing the recommended dose of NPK fertilizers applied to rice up to 50 per cent will be sufficient and it will result in more or less the same quantity of biomass as that produced with the full compliment of NPK fertilizers.

4.4.3. Grain Yield (Table 4 and Fig.11).

The summer treatments exerted considerable influence on the grain yield of the subsequent rice crop in all the sequences tried. Daincha as the preceding summer annual recorded maximum rice grain yield of 3456.69 kg/ha on par with that of cowpea-rice system. Lowest yield of 2276.77 kg/ha was in the maize-rice sequence. Comparatively low grain yield was noted in the fallow-rice sequence also. The yield contributing characters like number of panicles/m^2, filled grains per panicle, weight of the panicle and thousand grain weight (table 3) were higher when daincha and cowpea were the preceding crops of rice. Moreover the plant growth (table 1) as well as the nutrient uptake (table 2) of rice were higher in those systems where these crops were the preceding components. The cumulative effect of all these might have resulted in a higher grain yield in these systems. Daincha and Cowpea as the preceding crops would have contributed some amount of N to the soil through the stubbles and fixation of N in their root nodules. Atleast a part of this N would have become available the following rice, thus favourably influencing the growth and productivity of the crop. Maintenance of cereal grain yields at much higher levels in legume-cereal sequences had been reported by many workers (Raheja and Misra 1952; Sen and Dhillon ,1963; and Rao and Bhradwaj ,1980). The favourable effect of daincha as a summer crop on the grain yield of following rice had been observed by Tiwari et al (1981), Beri and Meelu (1981) and Joseph (1986). Purushothaman (1979) opined that maize as a summer crop preceding kharif rice decreased rice yields. This is in conformity with the lowest yield of rice registered after the maize crop. Decrease in the grain yield of rice when it was preceded by fodder maize than compared to a preceding crop of cowpea had been reported by Rajat De (1980). The grain yield of rice when it was preceded by fallow was significantly inferior to that of after daincha incorporation. This is in agreement with the findings of Beri and Meelu(1981).

Yield variation due to different NPK fertilizers was significant in virippu rice within all the systems. In the systems except daincha-rice, all the three fertility levels resulted in grain yields which had marked difference, ie, f_2 was superior to both f_1 and f_0 and f_1 had pronounced superiority over f_0. In the daincha-rice system highest level of NPK fertilizer (f_2) recorded the maximum grain yield of rice. This was more or less similar to the yield obtained with the application of half the dose of NPK fertilizers (f_1). Combined effect of half the recommended dose of NPK and daincha incorporation was found to be on par with the application of the entire dose of NPK (f_2). This shows that when daincha is the preceding crop of rice, application of half the dose of major nutrients will be sufficient to produce grain yield same as that resulting with the application of full dose of NPK fertilizers. This facilitates a saving of 50% of NPK fertilizers in a daincha-rice system. Similar results had been reported by Tiwari <u>et al</u> (1981) and Joseph (1986).

The influence of N on grain yield of rice is universally accepted. Rao <u>et al</u> (1971) reported that higher yield of rice was obtained with 90 kg. N/ha than with 60 kg N/ha. According to Patnaik and Gaikward

Fig. 11 GRAIN YIELD OF VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

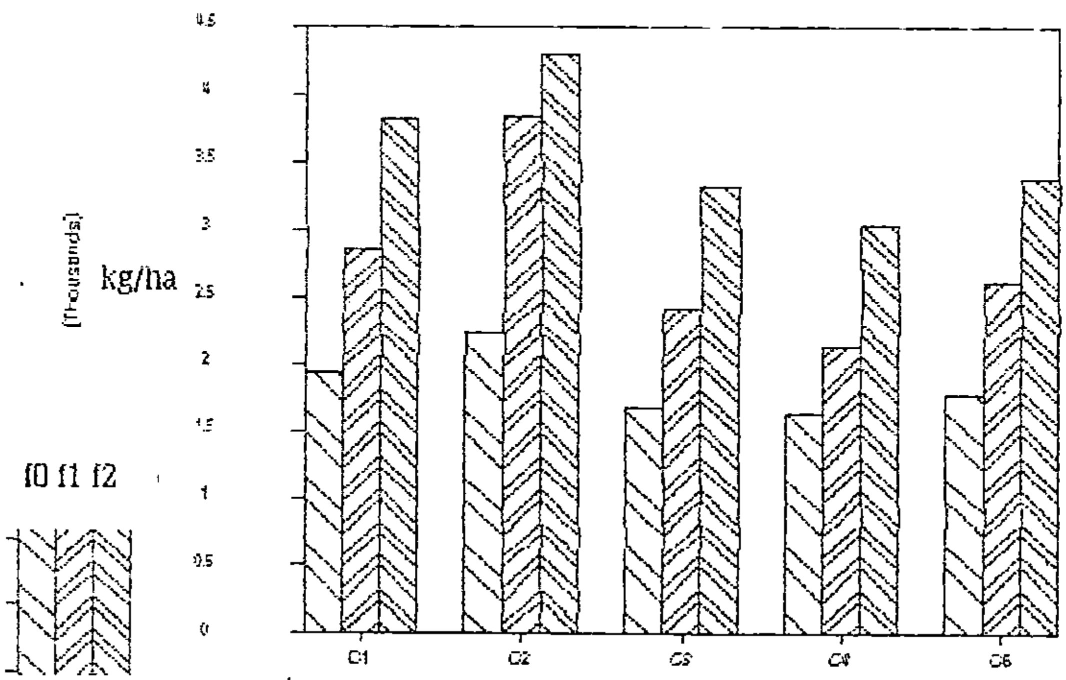
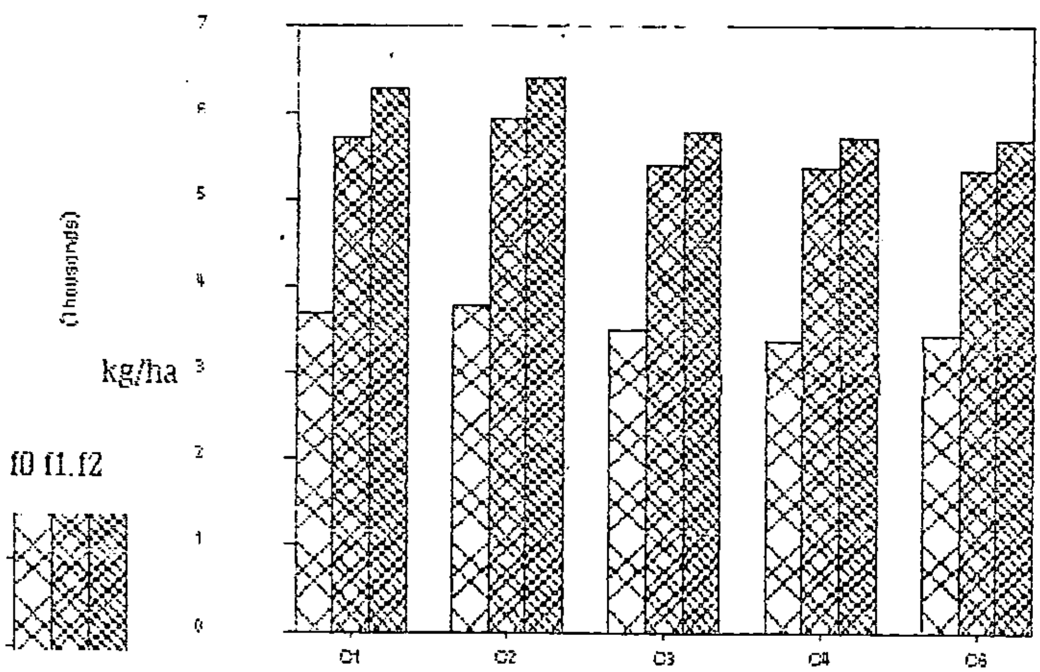


Fig. 12 STRAW YIELD OF VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



(1969) and Nagarajah et al (1978) increase in the quantity of P increased the grain field of rice. Robinson and Rajagopal (1977) observed favourable effect of K in increasing the grain yield of paddy. These explain the increase in the yield of rice observed due to the increase in the levels of NPK fertilizers.

4.4.4. Straw yield. (Table 4 Fig 12).

As in the case of grain yield the straw yield was also highest in the daincha-rice system.(5380.75 kg/ha) This was comparable with the straw yield in the cowpea-rice sequence. Virippu rice recorded the lowest straw yield of yield with maize as the preceding crop. Rice with sesamum and fallow as previous crops registered comparatively low straw yields which were on par with that of maize. In the crop sequences, where legumes were the preceding crops of rice, more amount of nutrients particularly N would have been added to the soil. The over riding influence of N on the vegetative growth of rice crop is well known. A higher vegetative growth of rice in these sequence(table 1) might have contributed to an increased straw yield. Increased straw yield of rice after green manuring with daincha had been reported by Sanyasiraju (1952) and Arunachalam (1966).

Comparing the fertility levels, within all the systems, f_2 had pronounced superiority over both the lower fertility levels. Application of half the dose of NPK (f_1) was also superior to no fertilizer application (f_0). Increased nutrient supply in f_2 and f_1 might have been the reason for the progressive improvement in the straw yield recorded by them. The favourable influence of N on the straw yield of rice is well documented by Rao and Ramanujam, 1971 and Venkateswaralu, 1978. Increase in the straw yield of paddy with the increase in the levels of potassium had been reported by Singh and Singh (1979).

4.5. Harvest index. (Table 4)

Harvest index is the percentage of grain weight to the total plant weight ie the ratio between the grain yield to the sum of grain and straw yields. Hence the same trend observed in the grain and straw yields was noted here also. Highest harvest index value of 0.39 was recorded in rice after green manuring with daincha in the daincha-rice system. This was on par with that of cowpea-rice sequence. Lowest HI of value of 0.32 was registered in the maize - rice system. This was comparable with harvest index of rice recorded when sesamum and fallow were the previous crops.

Within the systems cowpea-rice, sesamum-rice and fallow-rice the levels of fertilizers influenced the harvest index values similarly. Application of recommended level of NPK in f_2 had marked superiority f_0 and f_1). But the lower fertility levels f_1 and f_0 were on par. The higher grain yields resulted from increased nutrient supply could be the reason for the greater Hl values with higher levels of fertilizer doses. In the daincha-rice system all the three fertility levels recorded similar HI values which were on par. This may be because the positive effect of increased fertilizer application was more or less balanced with increased transport from source (vegetative parts) to sink (grain) when daincha was incorporated, even in the f_0 treatment.In the maize-rice system f_2 had pronounced superiority over f_1. The HI value recorded with f_0 came after f_2. But both f_2 and f_1 were on par with f_0.The higher HI value with f_0 may be attributed to the decrease of both the numerator (grain yield) and denominator(grain yield +straw yield).

4.6. Soil nutrient content.

The chemical analysis of the soil for the determination of NPK and organic carbon content was

Table 5 Soil nutrient content after summer

Treatment	Org.C %	Trt total	Total N (Kg/ha)	Trt total	Av.P2O5 (Kg/ha)	Trt total	Av.K2O (Kg/ha)	Trt total
	1.4		993.55		36.30		84.80	
C1	1.4	1.37	1093.10	1036.18	35.10	35.77	83.70	84.17
	1.3		1021.90		35.90		84.00	
	1.5		1028.30		36.60		81.10	
C2	1.5	1.50	1146.40	1099.43	36.00	36.23	80.30	81.50
	1.5		1123.60		36.10		83.10	
	1.3		968.03		34.22		79.51	
C3	1.2	1.30	886.10	911.34	34.50	34.26	77.20	78.40
	1.4		879.90		34.05		78.50	
	1.2		775.30		31.90		81.30	
C4	1.2	1.23	838.50	805.90	30.60	30.73	80.30	81.54
	1.3		803.90		29.70		83.03	
	1.09		858.90		33.07		78.90	
C6	0.96	2.15	857.17	869.22	33.70	33.42	81.60	80.00
	4.4		891.60		33.50		79.50	
CD	0.010		71.660		1.380		1.970	
SE/plot	0.006		36.560		0.700		0.990	

done before the start of the experiment , after raising the summer crops i.e., before the planting of the virippu rice and after the harvest of the rice.

4.6.1. Soil nutrient content after raising the summer crops. (Table 5 and Fig.13).

4.6.1.1.Organic carbon content.(table 5)

The organic carbon content of the soil after the summer did vary significantly with the summer treatments. The percentage of organic carbon content of the soil recorded after daincha 1.42 per cent was highest followed by cowpea. The lowest value of 1.05 per cent was noted after fallow.

4.6.1.2.Total N content (Table 5)

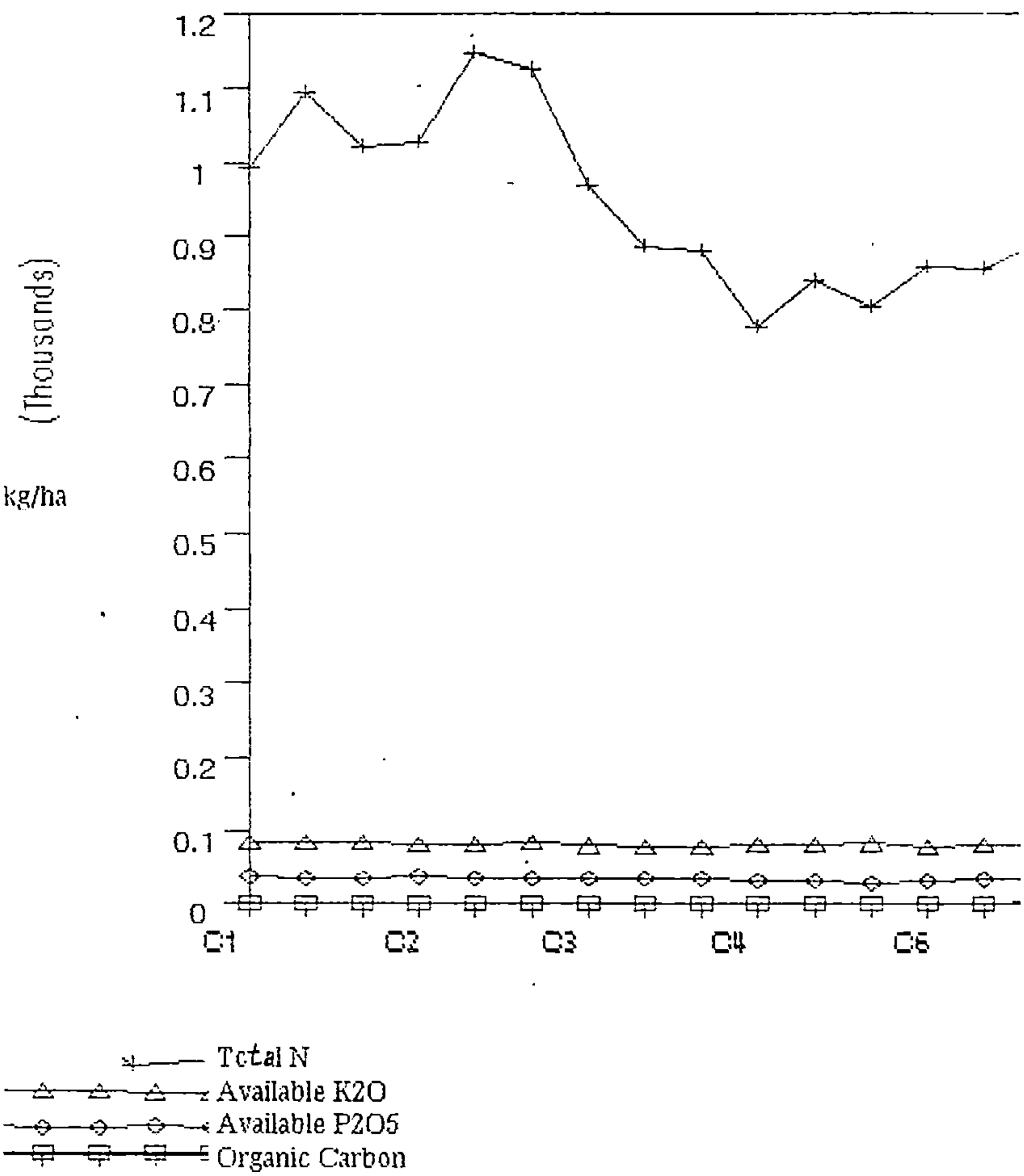
The total N content of the soil increased over the initial status after the leguminous crops daincha and cowpea whereas it decreased after sesamum,maize and fallow. Highest total N content of 1099.5 kg/ha of the soil was obtained after raising daincha followed by that of cowpea. Both these had significant superiority over all the other treatments. Lowest N content was when maize was the summer crop-805.9 kg/ha. Increased total N status after the leguminous crops may be attributed to the fixation of N in their root nodules.

Moreover the daincha crop was incorporated into the soil at the time of flowering and cowpea stubbles were turned into the soil at harvest. These easily decomposable residues might have contributed to the total N content of the soil. This is an agreement with the finding of Prasad and Palaniappan (1987). Inclusion of legumes in the cropping sequences improving the soil N status have been reported by many workers. (Bains and Sadapal, 1971; Nair et al,1973; Palaniappan,1976., Singh and Sandhu,1980 and Azam et al., 1986.) Incorporation of daincha insitu considerably increasing the soil N was observed by Tiwari et al (1980). Increased total N of soil after cowpea had been reported by Sasidhar(1978). These findings are in confirmatory to the higher total N of soil after daincha and cowpea. The total N content after the sesamum crop was better than the other two treatments(C_4 and C_6) . The decrease in the total soil N after the maize crop may be attributed to the greater pressure it exerts on the soil fertility due to its voracious feeding.

4.6.1.3. Available P_2O_5 content.(Table 5)

All the summer treatments except maize caused a slight increase in the available P_2O_5 content of the soil. There was only a negligible decrease of the

Fig. 13 SOIL NUTRIENT CONTENT AFTER THE SUMMER TREATMENTS



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available P_2O_5 content after maize. The increase in the status of soil available P_2O_5 after summer was maximum (36.29 kg/ha) with daincha incorporation, followed by that of cowpea. Lowest available P_2O_5 content of 30.77 kg/ha was after maize. The leguminous crops with their extensive root systems absorb phosphorus from deeper layers of soil where P reserves are found. When the crops or their stubbles are turned into the soil, they decompose and the otherwise unavailable P is brought to the top lawyers of soil as available P. This may be the reason for the higher content of available P_2O_5 after the leguminous crops. Beneficial effect of growing legumes in building up soil phosphorus had been-reported by many authors. (Nair et al, 1973; Sharma et al, 1980). Tiwari et al (1980) had reported an increase in the available P_2O_5 status of soil after daincha. The comparatively high available P_2O_5 content after cowpea is in agreement with the finding of Sasidhar(1978). The maximum reduction of available P_2O_5 over the initial status after maize could be explained by the higher demand and removal of P by maize (Table 2).

4.6.1.4.Available K_2O content (Table 5)

The results revealed that the available K_2O content of the soil after all the summer treatments

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tended to increase over the initial status in all the treatments . The maximum increase was after cowpea, the soil content after it being 84.05 kg/ha. Daincha came next. The lowest available K_2O content of 78.03 kg/ha was observed after sesamum. The potassic fertilizer applied plus the crop residues of leguminous crops might have contributed considerable amount of K to the soil since their uptake was low (Table 2). The improvement of available K status of soil after legumes had been reported by Nair et al (1973) and Sasidhar (1978). Tiwari et al (1980) found remarkable improvement of available K status of soil after insitu incorporation of daincha crop. The higher available K content of soil after the summer maize crop is in confirmatory of the finding of Sadanandan and Mahapatra (1972 a)

4.6.2. Soil nutrient content after the virippu rice crop.

4.6.2.1. Organic carbon content (Table 6)

The organic carbon content of the soil after virippu rice was not significantly influenced by the preceding crops or fallow in any of the cropping systems tried. The three different fertility levels could also exert no significant influence on the percentage of organic carbon of the soil within any of the cropping sequence studied.However, those systems involving legumes (cowpea and daincha) recorded higher organic carbon content 1.5 per cent . The lowest value of 1.33 per cent was noted after fallow.

4.6.2.2.Total N content (Table 6 Fig.14).

The total N content of the soil after virippu season was best maintained by the daincha-rice system (991.5 kg/ha) which was on par with cowpea-rice sequence. The lowest total N content of 883.15 kg/ha was observed after the maize-rice sequence which was more or less similar to the quantity of total N of the soil after the sesamum-rice and fallow-rice sequences. The total N content of the soil after daincha and cowpea during summer were significantly higher than that of other crops (Table 6). This higher initial value is the reason for the better total N content of the soil after sequences involving these crops. Better maintenance of soil N by crop sequences involving legumes had been reported by many workers (Singh and Ramamoorthy, 1974; Rao and Sharma,1978). Higher N content of the soil after a cowpea-rice-rice sequence had been observed by Sasidhar (1978). The loss in the total N after a maize-rice sequence is in agreement with the finding of Sadanandan and Mahapatra (1973 a)

Table 6. Soil nutrient content and balance of nutrients after virippu rice as influenced by preceding summer treatments and fertility levels

		After virippu rice								Nutrient balance					
		Org.C (%)	Trt total	Total N (kg/ha)	Trt total	Av.P205 (kg/ha)	Trt total	Av.K20 (kg/ha)	Trt total	N (kg/ha)	Trt total	P (kg/ha	Trt total	K (kg/ha	Trt total
	f0	1.50		955.02		32.59		81.46		298.36		28.86		44.63	
C1	f1	1.30	1.33	1018.48	984.20	32.06	32.90	86.06	84.57	375.70	322.05	31.08	31.35	49.80	48.48
	f2	1.20		979.10		34.04		86.20		292.09		34.10		51.01	
	f0	1.50		980.60		33.10		80.40		290.70		52.90		42.60	
C2	f1	1.50	1.47	1024.42	991.54	33.30	33.83	83.80	85.22	332.60	313.63	56.10	54.35	41.20	43.67
	f2	1.40		969.60		35.09		91.45		317.60		54.05		47.20	
	f0	1.30		879.20		30.30		76.50		156.70		37.04		11.08	
C3	f1	1.20	1.23	874.40	883.30	30.90	30.87	76.80	78.73	122.60	141.67	37.00	34.85	12.09	11.19
	f2	1.20		896.30		31.40		82.90		145.70		30.50		10.40	
	f0	1.10		866.90		25.35		76.30		75.50		14.50		20.40	
C4	f1	1.20	1.17	891.63	883.14	27.10	27.22	80.20	79.03	57.90	65.67	14.30	12.53	25.40	23.40
	f2	1.20		890.90		29.20		80.60		63.60		8.80		24.40	
	f0	1.20		886.10		28.90		76.10		152.90		34.40		20.50	
C6	f1	1.32	1.31	905.10	884.76	30.80	30.59	79.90	79.23	155.10	142.70	35.70	35.30	25.30	22.43
	f2	1.42		863.07		32.06		81.70		120.10		35.80		21.50	
CD1(treat)		0.22		29.52		1.70		4.81		30.15		3.30		10.75	
CD 2 treat within seq		0.08		74.23		3.79		5.08		66.74		5.00		8.64	
SE/plot		0.01		25.16		1.28		1.72		22.62		1.69		2.93	

Fig. 14 TOTAL NITROGEN CONTENT OF SOIL AFTER VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

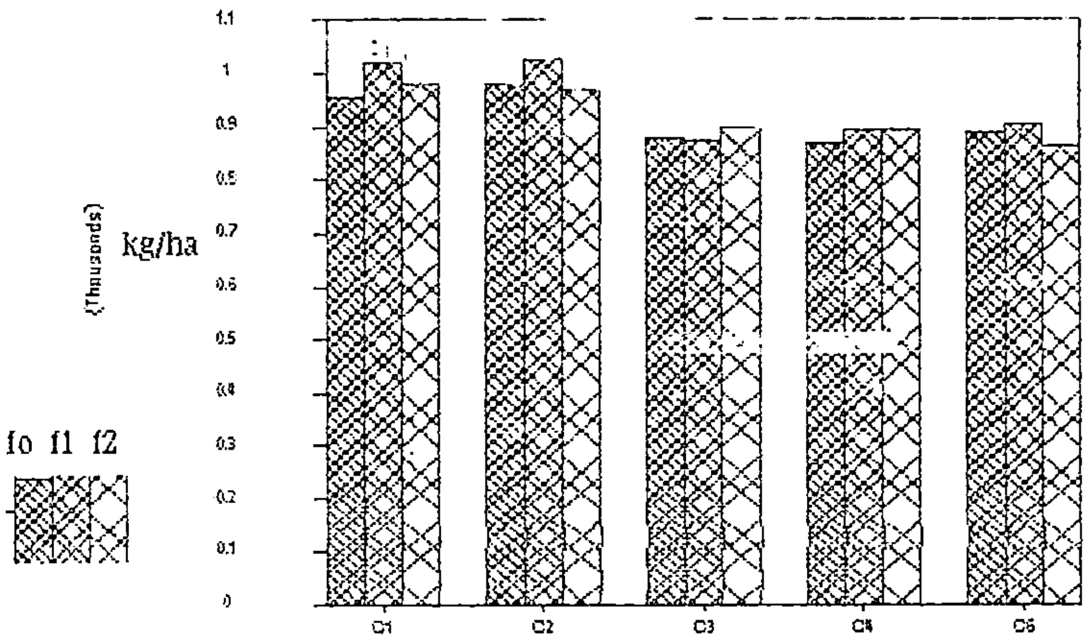
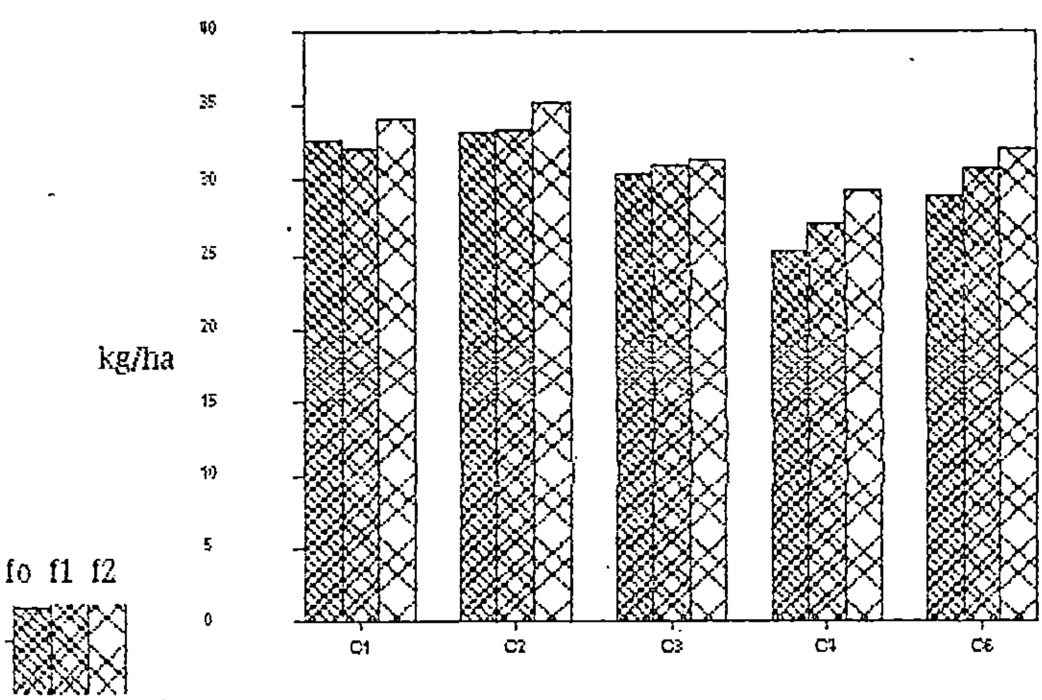


Fig. 15 AVAILABLE P2O5 CONTENT OF SOIL AFTER VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



The three fertility levels could exert no significant influence on the total N content of the soil after virippu rice within any of the five systems tried. The various losses of N such as leaching when rice is grown could have reduced the gap between the total N content of plots where f_2, f_1 and $f_2$were applied.

4.6.2.3. Available P_2O_5 content (Table 6 and Fig.16).

The available P_2O_5 content of 33.85 kg/ha of the soil after virippu rice registered in the daincha-rice sequence was the highest which was on par with that of cowpea-rice system. The maximum loss of available P_2O_5 was found in the maize-rice sequence the soil content after it being 27.24 kg/ha. The high content of available P_2O_5 of soil before the legume(daincha,cowpea) virippu rice sequences (Table 5) may have contributed to a higher available P content after the rice crop also. The greater available P_2O_5 content of soil after crop sequences involving legumes had been reported by Sasidhar (1978) and Raghavulu and Sreeramamoorthy (1974). The greater loss of available P in the maize-rice sequence is in agreement with the finding of Sadanandan and Mahapatra (1973 b).

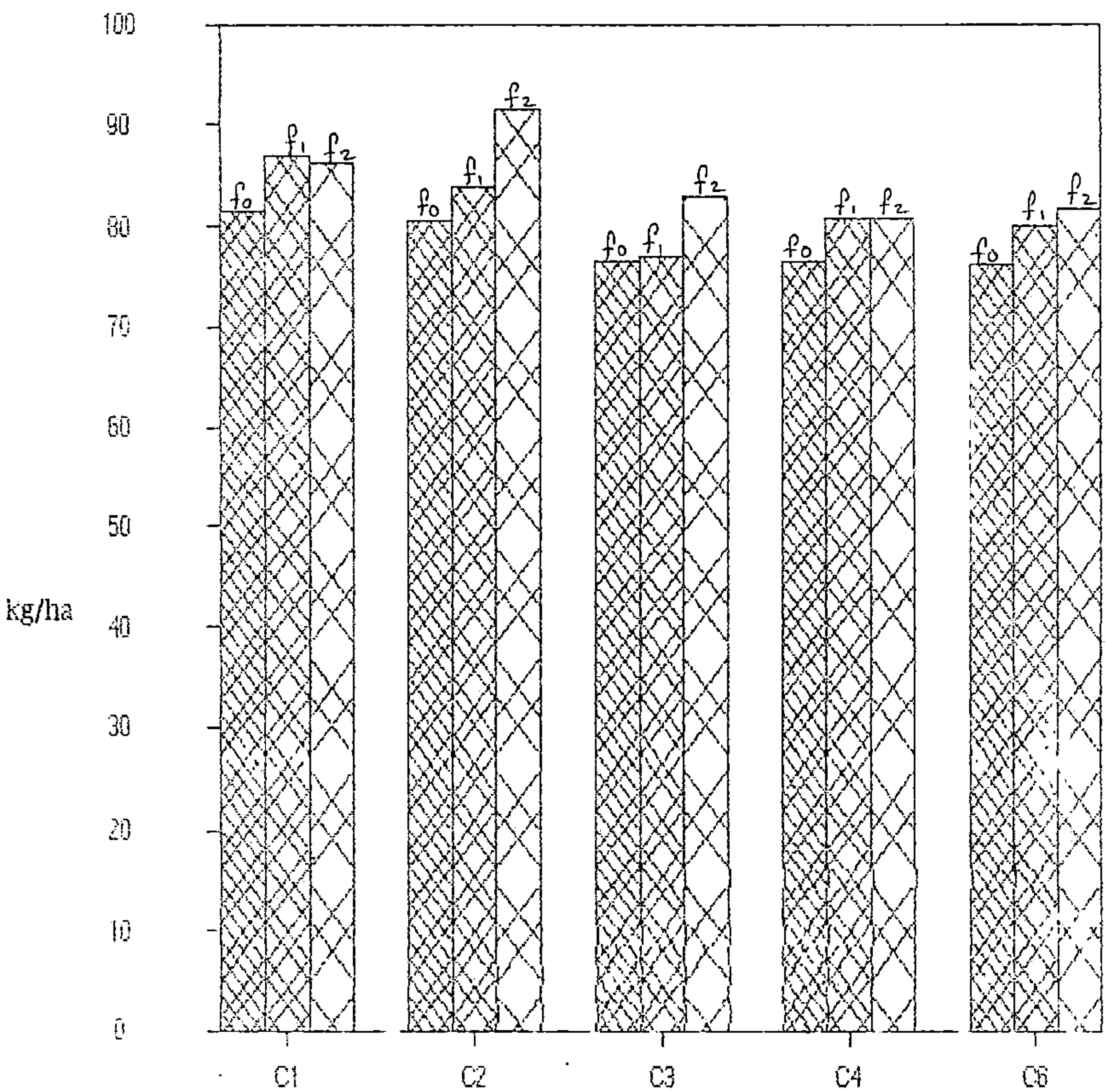
The three fertility levels could exert no significant influence on the available P_2O_5 content of soil within all sequences except maize-rice. The increase in uptake of P ouccurred with the increase in the quantity of P applied (table 2) may have reduced the available P content in the soil and thus reduced the gap between the soil nutrient content resulted with f_2, f_1 and f_0 .

Within the five systems tried except maize-rice all the three fertility levels resulted in more or less the same quantity of available P_2O_5 after rice. In the maize-rice system, when full compliment of NPK was given to rice (f_2) the available P_2O_5 content was found to be significantly superior to that of no fertilizer application (f_0). But f_2&f_1 and f_1 and f_0 were on par.

4.6.2.4.Available K_2O Content (Table 6 and Fig.16).

The results revealed that the maximum available K_2O content of 85.26 kg/ha after kharif rice was in the daincha-rice sequence. It was on par with that of after cowpea-rice. Both these systems had significant superiority over the other sequences tried. The sesamum-rice system recorded the minimum quantity of 78.78 kg/ha available K_2O after it. Daincha and cowpea

Fig. 16 AVAILABLE K2O CONTENT IN SOIL AFTER VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



contributed comparatively greater quantities of potassium to the soil through the decomposition of their stubbles (Table 5). So the systems involving them as components resulted in a higher potassium content after rice. The increase in the K content of the soil after daincha incorporation had been observed by Tiwari et al (1980). The improvement in the K content of the soil when legumes were included in a rice based system had been reported by Nair et al (1973). The available K_2O after the kharif rice was influenced by the levels of fertility within the sequences except maize-rice and cowpea-rice. In these systems all the fertility levels produced similar results. In the daincha-rice and sesamum-rice systems f_2 was significantly superior to both f_1 and f_0.The lower two fertility levels were on par. The available K_2O content recorded by f_2 in the fallow-rice system was significantly higher than that of f_0, but was on par with f_1. In general it could be stated that though not significant at some instances, the available K_2O content of the soil resulted after all the sequences was in proportionate to the quantity of fertilizers applied. This is in confirmatory with the finding of Yaduvanshi et al (1984).

4.6.3. Balance sheet of nutrients.

Balance sheet of different nutrients was arrived at by subtracting the total quantity of nutrients removed by the crops included in each cropping system for the entire period from the total quantity of nutrients applied through fertilizer to each crop in the cropping period.

4.6.3.1.Balance sheet of nitrogen. (Table 7 a)

A positive N balance was observed in cowpea-rice and daincha-rice sequences. They were on par. This indicates that the quantity of N applied was more than the quantity removed. In sesamum-rice, maize-rice and fallow-rice the all the three fertility levels resulted in negative balance of N. The uptake of N exceeded the quantity applied in all the cases. The maximum loss of N occurred in the maize-rice sequence. The contribution of N by the crop residues and N fixation by the leguminous crops enriched the soil with N where legumes were components. This helped in the maintenance of a positive balance of nitrogen, which shows that there is a possibility of reducing N application.Maize on the other hand with its devouring nature, depleted the soil of the nutrients and hence the maximum loss. A positive balance of N in sequences where legumes were components had been reported by Sasidhar (1978). Sadanandan and Mahapatra (1973) ob-

Table 7 a Balance sheet of Nitrogen

Treatment		Initial status of N in soil (Kg/ha)	Qty of N applied (Kg/ha)	Trt total	Total qty of N in soil (Kg/ha)	Trt total	Total qty of N removed (Kg/ha)	Trt total	expected balance (Kg/ha)	Trt total	Actual balance (Kg/ha)	Trt total	Net loss or gain (Kg/ha)	Trt total
	f0	977.00	20.00		140.34		140.30		856.66		954.90		98.60	
C1	f1	977.00	65.00	65.00	172.62	173.96	172.60	173.93	869.38	871.05	1018.50	991.96	175.77	122.16
	f2	977.00	110.00		208.91		208.90		887.10		1002.47		92.10	
	f0	977.00	0.00		106.15		106.20		877.70		968.37		90.70	
C2	f1	977.00	45.00	45.00	142.14	142.75	142.20	142.77	879.80	886.43	1012.53	1000.14	142.67	117.02
	f2	977.00	90.00		179.95		179.90		901.80		1019.52		117.68	
	f0	977.00	30.00		81.81		81.80		925.20		881.96		-43.22	
C3	f1	977.00	75.00	75.00	97.00	102.73	97.00	102.73	955.00	949.27	877.64	892.06	-84.19	-60.56
	f2	977.00	120.00		129.37		129.40		967.60		916.57		-54.26	
	f0	977.00	120.00		105.64		105.60		991.30		866.90		-124.49	
C4	f1	977.00	165.00	165.00	137.70	130.57	137.70	130.57	1004.30	1011.40	862.50	877.24	-142.34	-134.39
	f2	977.00	210.00		148.37		148.40		1038.60		902.33		-136.33	
	f0	977.00	0.00		43.93		43.90		933.20		886.18		-47.07	
C6	f1	977.00	45.00	45.00	70.33	70.56	70.30	70.53	951.70	951.50	905.16	884.80	-44.84	-57.25
	f2	977.00	90.00		97.43		97.40		969.60		863.07		-79.83	

The contributions of N from the FYM applied and the crop residues incorparated are also taken into account served, that among the different cropping sequences, the sequence of rice including maize recorded the maximum loss of N.

The fertility levels could not affect the N balance of the soil within any of the sequence may be because the various losses of N through leaching etc., when rice was grown could have narrowed down the differences.

4.6.3.2. Balance sheet of phosphorus. (Table 7 b)

The P balance of soil was maintained positive in all the sequences except fallow-rice. This shows that the was less than the quantity applied.Since the soil of the experimental site was rated in available P status the would have taken up most of their requirement from native source. Daincha-rice system resulted in the highest quantity of P remaining after the uptake. The maximum loss was in the maize-rice system. This is in agreement with the finding of Sadanandan and Mahapatra (1973)

Here also the fertility levels could not exert any significant influence on the balance of soil within any of the cropping systems tried. Perhaps the increased uptake and P fixation with increase in added fertilizers could have narrowed the gap between the

Table - 7 b Balance sheet of Phosphorus

Treatment		Initial status of P in soil (Kg/ha)	Qty of P applied (Kg/ha)	Trt total	Total qty of P in soil (Kg/ha)	Trt total	Total qty of P removed. (Kg/ha)	Trt total	expected balance (Kg/ha)	Trt total	Actual balance (Kg/ha)	Trt total	Net loss or gain (Kg/ha)	Trt total
	f0	13.34	13.10		26.44		21.14		5.37		14.20		8.86	
C1	f1	13.34	22.90	22.92	36.24	36.26	33.32	31.05	2.92	3.01	14.00	14.35	11.10	11.55
	f2	13.34	32.75		46.09		38.69		0.75		14.86		14.70	
	f0	13.34	0.00		13.34		31.85		-18.51		15.06		32.98	
C2	f1	13.34	9.80	9.82	23.17	23.17	44.77	42.78	-21.60	-17.90	14.56	14.98	36.16	34.41
	f2	13.34	19.65		32.99		51.72		-13.58		15.33		34.10	
	f0	13.34	6.55		19.89		23.66		-3.77		13.27		17.04	
C3	f1	13.34	16.38	16.38	29.72	29.72	33.21	31.07	-3.50	-1.36	13.51	13.50	17.00	14.85
	f2	13.34	26.20		39.54		36.35		3.20		13.71		10.52	
	f0	13.34	26.20		39.54		23.18		16.50		11.65		-5.42	
C4	f1	13.34	35.81	35.95	49.15	49.29	31.94	30.17	17.48	19.26	11.84	12.09	-5.64	-7.46
	f2	13.34	45.85		59.19		35.40		23.79		12.77		-11.32	
	f0	13.34	0.00		13.34		15.17		-1.74		12.72		14.46	
C6	f1	13.84	9.83	9.83	23.17	23.17	25.47	23.07	-2.31	0.12	13.47	13.40	15.77	15.35
	f2	13.84	19.65		32.99		26.57		4.42		14.00		15.82	

The contributions of P from the FYM applied and the crop residues incorparated are also taken into account

Fig. 17 NITROGEN BALANCE IN SOIL AFTER VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

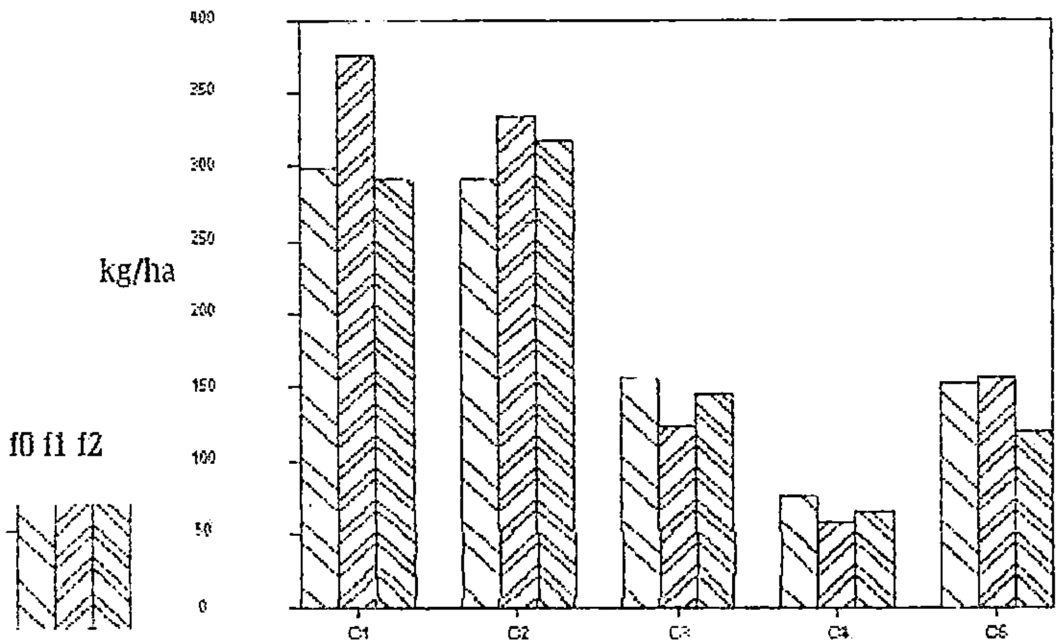


Fig. 18 PHOSPHORUS BALANCE IN SOIL AFTER VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

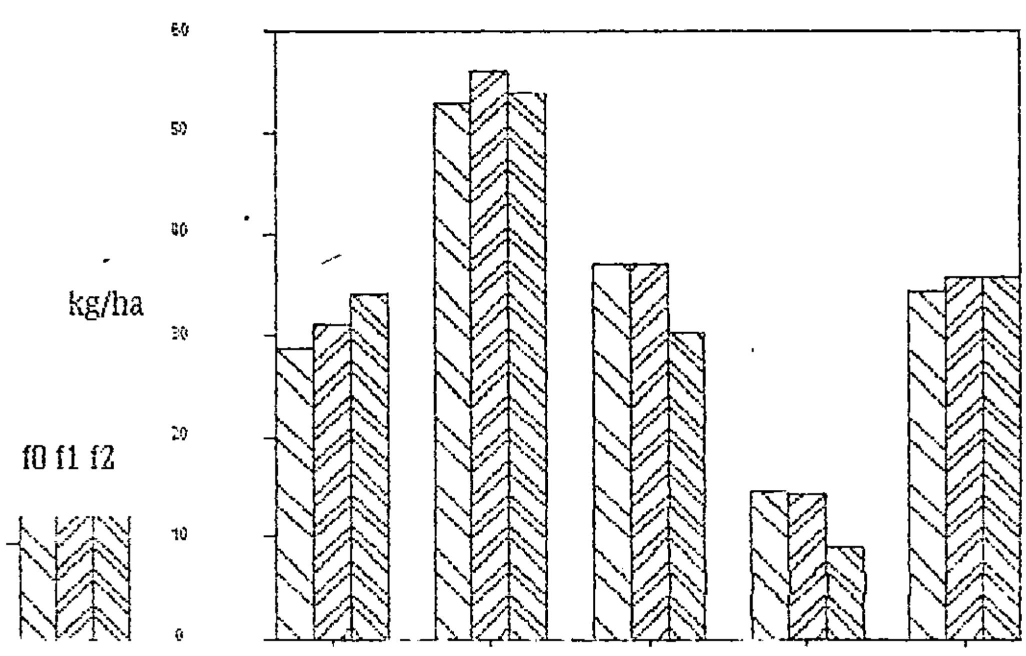
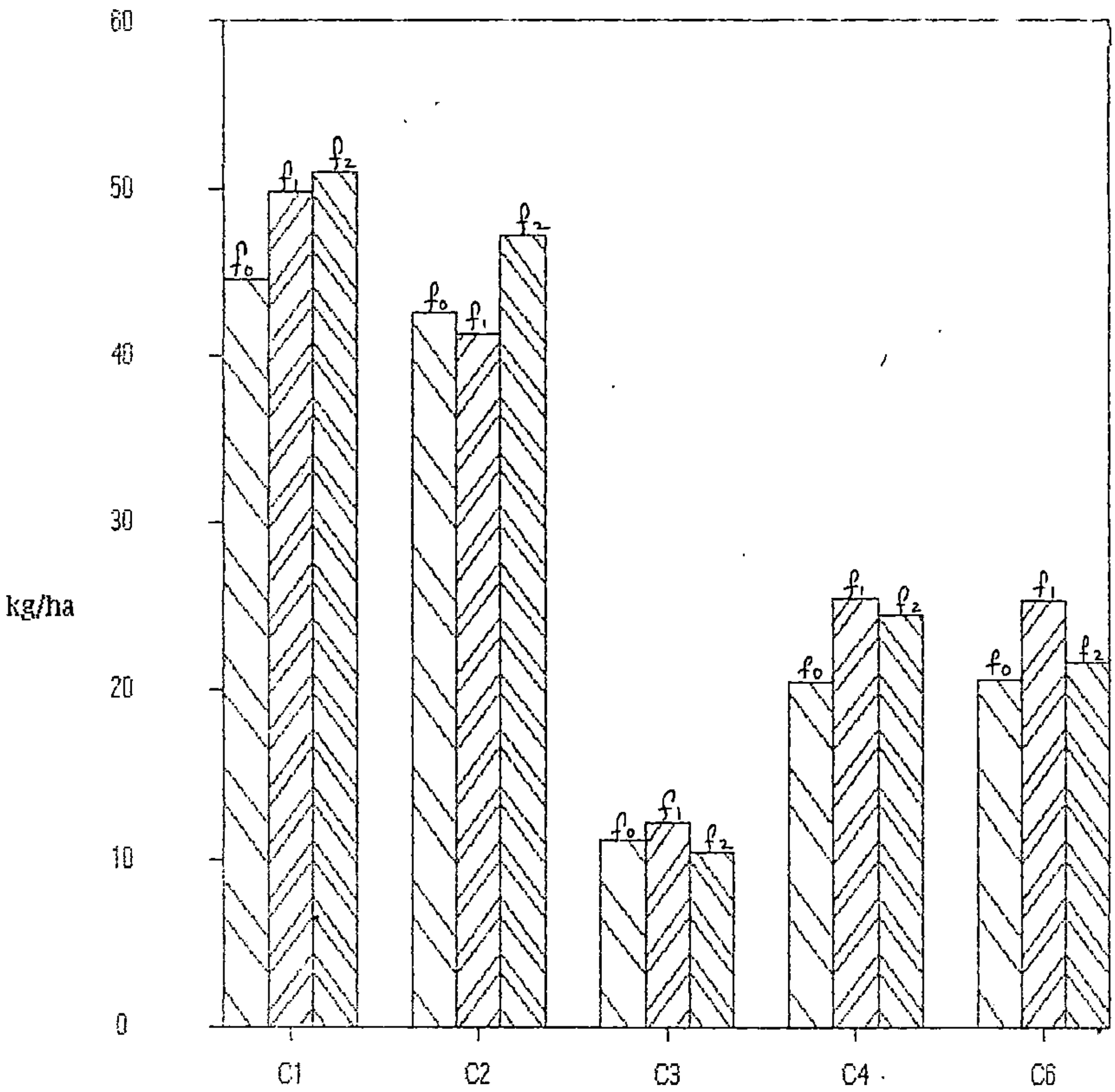


Table - 7 c Balance sheet of Potassium

Treatment		Initial status of K in soil (Kg/ha)	Qty of K applied (Kg/ha)	Trt total	Total qty of K in soil (Kg/ha)	Trt total	Total qty of K removed (Kg/ha)	Trt total	expected balance (Kg/ha)	Trt total	Actual balance (Kg/ha)	Trt total	Net loss or gain (Kg/ha)	Trt total
	f0	65.46	8.33		69.30		71.68		2.11		67.72		65.61	
C1	f1	65.46	27.08	27.08	94.60	92.38	93.74	93.35	-1.20	-0.81	72.46	70.69	73.67	71.51
	f2	65.46	45.83		113.23		114.63		-3.34		71.90		75.24	
	f0	65.46	0.00		61.90		62.96		2.50		67.03		65.55	
C2	f1	65.46	18.75	18.75	90.91	87.04	90.95	87.08	2.16	1.67	69.89	71.04	67.83	69.73
	f2	65.46	37.50		108.32		107.33		0.35		76.21		75.80	
	f0	65.46	25.00		40.14		42.00		48.48		72.87		45.84	
C3	f1	65.46	43.75	43.75	62.56	60.83	63.45	60.47	46.03	48.84	64.05	68.51	18.29	27.02
	f2	65.46	62.50		79.80		75.96		52.00		68.60		16.92	
	f0	65.46	33.33		64.15		65.60		33.20		63.65		30.43	
C4	f1	65.46	52.08	52.08	84.84	83.13	87.60	85.71	29.98	32.14	67.26	66.05	37.28	34.20
	f2	65.46	70.83		100.39		103.93		33.24		67.25		34.89	
	f0	65.46	0.00		27.98		31.83		93.31		63.47		29.84	
C6	f1	65.46	18.75	18.75	50.18	48.40	52.56	50.83	31.74	53.37	66.66	67.64	34.96	34.17
	f2	65.46	37.50		67.05		68.11		35.07		72.80		37.72	

The contributions of K from the FYM applied and the crop residues incorparated are also taken into account

Fig. 19 POTASSIUM BALANCE IN SOIL AFTER VIRIPPU RICE AS INFLUENCED BY PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



available soil P with f_0, f_1 and f_2.

4.6.3.3.Balance sheet of potassium. (Table 7c)

All the cropping sequences tried resulted in the positive balance of K.The crops grown would have absorbed the native source of available potassium and hence a positive balance. Maximum balance of K was found in the danicha-rice system on par with cowpea-rice and both these were significantly superior than all the other treatments. Sesamum caused the maximum loss.

The fertility levels did not influence the K balance within any of the sequence. Perhaps, because of dynamics of soil potassium more of exchangeable K would have come to the soil solution state with lower levels of K application and the vice versa could have occurred with higher level of application thereby reducing the effect of added fertilizers on soil K balance.

4.7. Economics of cropping sequences.

4.7.1. Net income (Table 8 Fig.20).

Net income from each cropping system was calculated by subtracting the cost of cultivation from the

Table 8. Biomass production and economics of summercrop- rice sequences as influenced by preceding summer crops and levels of fertilizers.

Treatment		Biomass t/ha	Trt. total	Net income (Rs.)	Trt. total	Benefit-cost ratio	Trt. total
	f0	9.00		4473.20		1.81	
C1	f1	11.70	11.37	6770.23	6609.74	2.10	2.07
	f2	13.40		8585.80		2.30	
	f0	21.80		1533.40		1.34	
C2	f1	24.40	23.83	5730.07	4568.02	2.10	1.88
	f2	25.30		6440.60		2.20	
	f0	6.40		4902.10		1.89	
C3	f1	8.90	8.37	6714.30	6689.63	2.10	2.10
	f2	9.80		8452.50		2.30	
	f0	27.50		2977.50		1.47	
C4	f1	29.60	29.17	4418.40	4582.80	1.65	1.67
	f2	30.40		6352.50		1.88	
	f0	5.22		1778.60		1.51	
C6	f1	7.44	7.23	3964.30	3667.97	2.01	1.91
	f2	9.04		5261.02		2.20	
CD1(treat)		2.27		586.56		0.12	
CD2(treat. within seq.)		1.60		791.62		0.15	
SE/plot		0.56		268.34		0.05	

gross returns. The data are presented in table 8.

Among the cropping systems, sesamum- rice gave the maximum net income of Rs.6689.65/ha on par with the cowpea-rice system. The lowest net income of Rs.3668.01/ha was recorded in the fallow-rice sequence. Maize-rice and Daincha-rice gave comparatively lower net' income and they were on par. The summer crop of sesamum yielded fairly well and the grain and straw yield of the virippu rice crop following it was also comparatively good. Among the economic produces of the summer crops raised in this experiment, sesamum grain was the most priced. The high cost of the sesamum grains coupled with the comparatively low cost of cultivation of the same contributed to the higher net income from that sequence. The higher cost of cultivation of the maize crop and the comparatively low yield of the following rice crop may be the reason for the decreased net income from the maize-rice sequence. In the case of daincha-rice sequence, though highest economic yield was obtained from the succeeding rice, since daincha was returned as input for rice to the soil, no additional income could be obtained during summer. Hence the lower net returns in that system. Eventhough the net returns obtained from the rice crop in the fallow-rice sequence was comparatively

Fig 20 NET INCOME OF SUMMER CROP RICE SEQUENCES AS INFLUENCED BY
PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS

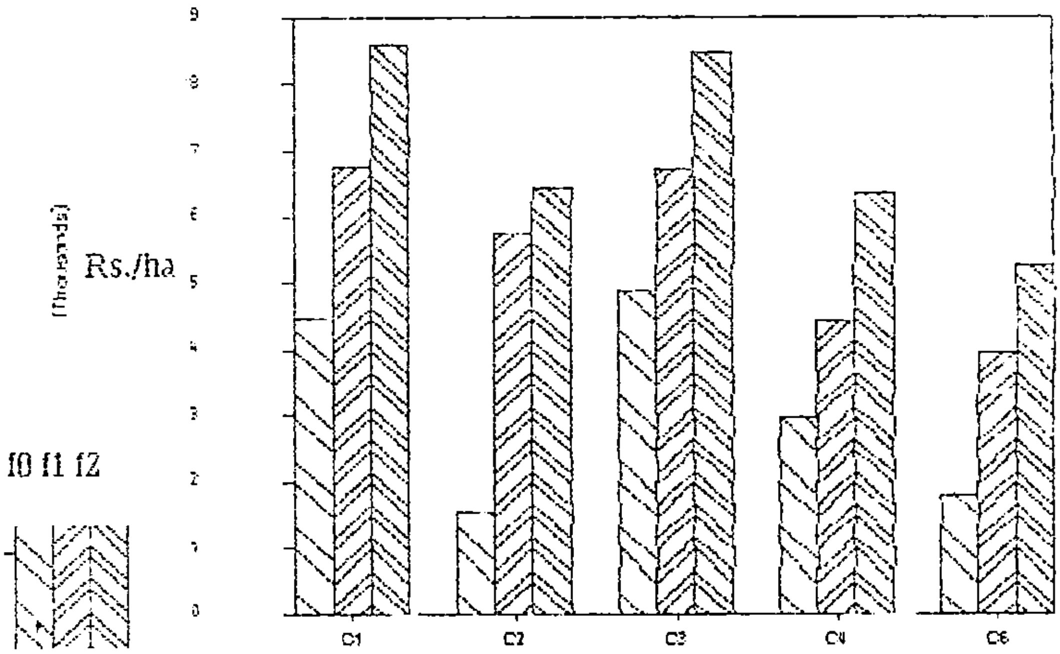
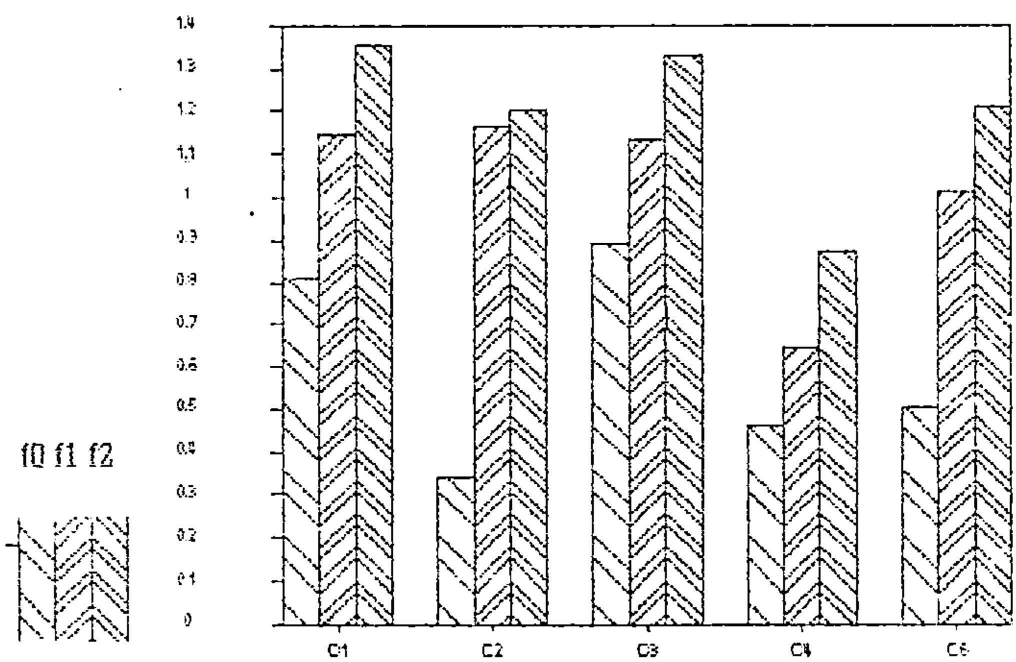


Fig. 21 COST-BENIFIT RATIO OF SUMMER CROP RICE SEQUENCES AS INFLUENCED BY
PRECEDING SUMMER TREATMENTS AND FERTILITY LEVELS



high, it could not over ride the net income of the other sequences where two crops were raised. Hence the lowest net income that sequence.

Comparing the fertility levels within all the systems application of full dose of recommended quantity of NPK (f_2) registered the maximum net income which had pronounced superiority over no fertilizer application (f_0), that gave the lowest net returns. Reducing the quantity of NPK to 50 per cent of the recommended dose (f_1) recorded markedly higher net income than f_0. f_2 level was significantly superior than f_1 in all the sequences except in daincha-rice system. The economic yield obtained from all the systems was positively proportional to the quantity of fertilizers (Table 4). Hence the same trend in the net income also. In the daincha-rice system net income obtained with the application of half the dose of major nutrients (f_1) was comparable to that obtained with the application of 100 per cent of recommended dose (f_2). So when daincha precedes rice it could be suggested that application of half the recommended dose of NPK will be as good as the full compliment of fertilizers in terms of the net returns from the system. Thus a saving of the cost of half the recommended dose of NPK fertilizers can be achieved when daincha precedes rice.

4.7.2. Cost - benefit ratio. (Table 8 and Fig. 21).

The C-B ratio for each system was obtained by dividing the gross income with the total cost involved. The C-B ratio is an indicator which shows whether a particular business is profitable or not.

Among the different sequences tried, sesamum-rice registered the maximum value of 2.10 on par with cowpea-rice system. The C-B ratio values registered with maize-rice daincha-rice and fallow-rice sequences (1.91, 1.88 and 1.66) were below unity which indicates that these systems are less profitable. Maize-rice system recorded the lowest value for C-B ratio. The net returns from the maize-rice sequence was comparatively high, but the total cost of production of the sequence, was higher. This led to a lower value.

Within all the sequences, the f2 level had superiority over that of f0. F2 level was significantly superior to f1 also, within all the sequences except in daincha-rice system. The lowest value for the C-B ratio was registered with no fertilization in all systems tried. The higher yields obtained within all systems with the f2 level led to higher net returns. This contributed to the high values of C-B ratios. In the daincha-rice

Table 9 Simple correlation coefficients between grain yield of virippu rice and some selected observations.

No	observation	correlation coefficients
1	Plant height of virippu rice at harvest.	0.322.*
2	No of tillers of rice during panicle initiation.	0.527.*
3	N uptake of rice at harvest.	0..609*
4	P uptake of rice at harvest.	0.585.*
5	K uptake of rice at harvest.	0.547.*
6	No. of spikelets per panicle of rice.	0.703.*
7	No. of filled grains per panicle of rice.	0.737.*
8	Weight of panicle of rice.	0.527.*
9	Thousand grain weight of rice.	0.723.*
10	Biomass producton of rice	0.864.*
11	Total N content of soil after summer crops.	0.717.*
12	Available P2O5 contenet of soil after summer crops.	0.699.*
13	Available K2O content of soil after summer crops.	0.685.*

* Significant at 0.05 level.

sequence application of half the recommended quantity of NPK resulted in cost benefit ratio that was comparable to that obtained when the full compliment of NPK was present. This was true in the case of net returns also. So it could be concluded that when daincha is the preceding crop of rice in the summer only half the quantity of the NPK nutrients may be applied to rice. This reduction will neither affect the net returns nor the cost benefit ratio of the system.

4.8.2. Correlation studies.(Table 10).

There was significant correlation between the grain yield of virippu rice and the characters selected. They are presented in table-10. The correlation between grain yield and biomass production was the highest.The yield attributing factors were positively correlated with grain yield. It may be noted that comparatively high values of correlation coefficients were registered for the correlation between the N,P and K uptake and grain of rice as well as between the soil nutrient content after summer.

SUMMARY

5. SUMMARY

Two field experiments were conducted at the Instructional farm, College of Agriculture, Vellayani, Trivandrum during 1987 to evaluate the carry over effects of five summer crops and fallow on the following virippu rice crop and to study the effects of three different levels of NPK fertilizers on the growth, yield attributes and yield of rice.

The experiment was laid out in randomised block design with three replications. There were six treatments during summer (grain type cowpea, daincha, sesamum, fodder maize,* short duration rice and fallow). The following virippu rice crop was given three levels of NPK fertilizers (f_0 -No fertilizers;
f_1 - 50% of the recommended dose $N:P_2O5:K_2O$
45: 22.5:22.5 kg/ ha; f_2 - 100% of the recommended dose
$N:P_2O_5$: K2O-90:45:45kg/ ha).
The rice variety used was `Jaya'.
The results of the experiments are summarised below.

1. The height of the rice plant was not significantly influenced by the preceding crops at any stage of the growth. Though not significant at some instances, in general it could be said that the height of the rice

*The treatment was abandoned due to crop failure.

plant improved progressively with the increase in

the levels of NPK fertilizers within all the cropping systems tried at all stages of growth.

2. Daincha and cowpea proved their superiority in increasing the number of tillers of the following rice crop. Progressive increase in the number of tillers with the increase in the NPK nutrients was also observed within all the sequences tried.

3. Highest value for LAI of rice was recorded when daincha preceded rice and the lowest in the fodder maize-rice systems. In the cowpea-rice, fodder maize-rice and fallow-rice systems reducing the quantity of major nutrients to half (f_1) recorded LAI values on par with that of no fertilization (F_0). But in other systems there was linear increase in LAI with the quantity of fertilizers.

4. Daincha incorporation during summer recorded the maximum uptake of all the three nutrients by rice in the virippu season. The lowest N and P uptake of rice was when sesamum preceded it and minimum potassium uptake when fallow was the summer treatment. The uptake of major nutrients increased in proportion to the quantity of fertilizers applied.

5. Nitrogen and potassium uptake was highest in

the cowpea-rice system. Phosphorus uptake was maximum in the daincha - rice sequence.The lowest removal of all the three nutrients was by the fallow-rice sequence. Application of the full recommended NPK fertilizers to the rice crop (f_2) resulted in the maximum uptake of N,P and K by all the sequences tried and it had pronounced superiority over half the dose (f_1) and no fertilization(f0).

6. The number of productive tillers of virippu rice in the different systems was not affected by the crops preceding it. In the daincha - rice and cowpea - rice systems both f_1 and f_2 resulted in more or less the same number of productive tillers per m^2. In the other sequences, the productive tiller production was in proportion to the quantity of NPK fertilizers.

7. Among the different systems tried, daincha - rice sequence resulted in the highest number of spikelets per panicle in rice and the lowest number was observed when maize preceded rice. Reducing the quantity of fertilizers adversely affected the number of spikelets per panicle.

8. Maximum number of filled grains per panicle in rice was produced after the daincha crop and the minimum number in the maize-rice system. In the daincha-

rice, cowpea-rice and fallow-rice sequences all the three fertility levels caused significant difference in the number of filled grains per panicle. In the sesamum-rice system f_2 and f_1 produced comparable results and in the maize-rice system the two lower fertility levels (f_0 and f_1) produced more or less similar results.

9. The panicle weight of rice was maximum when daincha preceded it and minimum when fallow was the previous treatment. In the daincha-rice and cowpea-rice sequences the weight of the panicle increased with the increase in the quantity of fertilizers. In the other three sequences the lower two fertility levels recorded comparable results. But f_2 recorded significantly higher weight of the panicle.

10. The test weight of the rice crop was highest in the daincha-rice system. The minimum thousand grain weight was in the fallow-rice system. Within all the sequences, the in proportion to the quantity of fertilizers.

11. Highest biomass of rice was recorded in the daincha-rice system on par with cowpea-rice sequence. Lowest biomass was obtained when fodder maize was the previous crop of rice. Progressive increase in the biomass production of rice with the increase in the

quantity of NPK fertilizers was observed within all the sequences.

Among the different cropping sequences tried the maximum biomass production was by the maize-rice system. The lowest biomass production was recorded by the fallow-rice system. Within all the sequences, highest biomass production was registered by the treatment f_2 which was significantly superior to f_0. The biomass produced when half the dose of NPK fertilizers (f_1) applied to rice was comparable with full dose application (f_2) in all the sequences except cowpea - rice.

12. Daincha as the preceding summer annual recorded maximum grain yield of rice on par with that of cowpea-rice system. Lower yields were noted in maize-rice and fallow-rice sequences. Within all the sequences except daincha-rice, linear increase in the grain yield was noted with the increase in the quantity of fertilizers. Combined effect of half the recommended dose of NPK (f_1) and daincha incorporation was found to be on par with that of f_2 in the daincha - rice system.

13. The straw yield of rice was also maximum in the daincha-rice system. Lowest straw yield was recorded with maize as the preceding crop. Proportionate in-

crease in the straw yield was observed with theimprovement on the quantity of NPK fertilizers applied.

14. In the daincha-rice system highest value of HI was noted. The minimum HI value was registered in maize-rice system. Within the cowpea-rice, sesamum-rice and fallow-rice sequences, the highest level of fertilizers produced maximum HI. But the two lower levels resulted in more or less similar HI values. In the maize-rice system though f_2 recorded higher HI than both the lower levels, f_0 had registered a better HI than F1. In the daincha-rice sequence all the three fertility levels resulted in more or less similar HI values.

15. The N,P,K and organic carbon content of the soil was analysed after raising the summer crops and after the harvest of the virippu rice crop. The percentage of organic carbon content of the soil recorded after daincha was the highest and the lowest was after fallow.

Highest total N and available P_2O_5 of the soil were recorded after daincha and the lowest after maize. There was maximum increase in the available K_2O after cowpea. The lowest available K_2O content of the soil was observed after sesamum.

16. The organic carbon content of the soil after virippu rice was neither significantly influenced by preceding crops or fallow nor the different levels of fertilizers.

The total N content and available P_2O_5 of the soil was best maintained by the daincha-rice system. The lowest value for these two were noted after maize-rice sequence. The three different fertility levels could exert no significant influence on the total N and available $P_{2O}5$ content of the soil after virippu rice within any of the five systems tried.

The daincha-rice sequence recorded the highest quantity of available K_2O of the soil and the lowest value was after sesamum-rice system.

The available K_2O content was higher after f2 in all the sequences. In the daincha-rice and sesamum-rice sequences f2 had pronounced superiority over both f0 and f1. In the cowpea-rice and maize-rice sequences all the three fertility levels produced comparable results. In the fallow-rice sequence f2 was significantly superior to f0 only. The lower two levels were similar.

17. A positive N balance was observed in the cowpea-rice and daincha-rice sequences. In sesamum-rice,

maize-rice and fallow rice the balance was negative. The P balance of soil was maintained positive in all the sequences except fallow-rice. All the cropping sequences tried resulted in the positive balance of K.

The three fertility levels could not exert any significant influence on the N,P and K balance of soil after the five sequences tried.

18. Among the cropping systems, sesamum -rice gave the maximum net income. The least profitable was the fallow-rice. The highest value for cost-benefit ratio was registered in the sesamum-rice system. Maize-rice; daincha-rice and fallow-rice sequences were found to be unprofitable.

The net income and the cost-benefit ratio recorded by all sequences except daincha- rice were proportional to the quantity of NPK fertilizers applied. In the daincha-rice system application of half the recommended dose of NPK was found to be as good as the full compliment of major nutrients.

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APPENDICES

APPENDIX I

Meterological observations recorded during cropping period, at fortnightly intervals.

Month	max.temp °C	min.temp °C	rainfall (m.m)	RH%	Sunshine hrs.
Feb	32.55	21.6	1.4	78.4	10.46
	32.12	20.77	0	77.6	10.22
Mar	33.81	22.9	0	77	10.52
	32.09	23.68	4.8	72.5	10.5
Apr	33.76	23.5	0	78.16	9.67
	34.19	23.03	48	73.89	8.06
May	33.83	23.6	5.8	73.3	10.68
	32.64	23.67	77.2	74.31	8.74
June	32.15	22.95	117.7	78.36	5.68
	30.21	22.29	105.4	81.56	6.48
July	30.91	21.19	20	81.66	9.58
	31.175	22.6	0.4	77.06	9.28
Aug	30.99	23.89	35.2	78.2	8.82
	29.77	23.1	237.4	84.63	3.73
Sept	31.57	24.44	0	81.33	9.94
	30.99	24.09	125.7	76.9	5.1
Oct	30.84	23.7	126	81.2	7.2
	32.26	24.21	160	86.45	5.02
Nov	30.26	23.63	143.8	81.72	7.36
	30.66	23.5	38.5	81	6.76
Dec	30.69	23.81	155.5	82.5	5.614
	31.03	22.66	77.7	80.29	8.94

APPENDIX II

Observations on summer annuals

Crop		Observations recorded			
Grain type cowpea	Grain yield kg/ha	Bhusa yield t/ha	uptake of nutrients at harvest-kg/ha N	P	K
plot 1	854.06	2.54	94.22	6.65	38.84
plot 2	820.29	2.41	91.96	6.48	37.25
plot 3	829.90	2.55	96.20	6.62	38.79
Daincha		green matter yield at harvest t/ha	uptake of nutrients at harvest-kg/ha N	P	K
plot 1		15.84	56.89	16.10	27.34
plot 2		14.37	54.86	15.76	26.76
plot 3		14.66	58.08	16.57	27.93
Maize	green fodder yield t/ha	Dry matter production t/ha	uptake of nutrients at harvest-kg/ha N	P	K
plot 1	21.44	4.44	40.75	10.10	12.77
plot 2	22.09	4.58	40.19	9.90	12.50
plot 3	22.78	4.60	41.12	10.20	12.88
Sesamum	grain yield kg/ha	Bhusa yield t/ha	uptake of nutrients at harvest-kg/ha N	P	K
plot 1	318.76	937.76	65.75	8.03	38.35
plot 2	340.37	926.12	67.48	8.25	39.50
plot 3	351.77	950.15	68.04	8.30	39.73

APPENDIX III

Abstract of Analysis of variance table on the growth characters of virippu rice

		Mean sum of square							
		Height of rice plant (in Cm.)				No. of tillers/M^2			
Source	d.f	40 DAT	80 DAT	Flowering	Harvest	40 DAT	80 DAT	Flowering	LAI at flowering
Replication	2	19.11	35.93	18.31	25.91	2224.8	4011.8	3153.9	4.1
Crop Sequence	4	18.75	97.79	5.57	22.92	17474.6**	6575.5	2169	3.31**
Error (1)	8	39.75	48.07	21.12	29.38	1994.58	1209.63	5664	1.34**
Within									
C1	2	237.3**	497.1**	194.3**	154.4**	41043.1**	14706.8**	1441.8**	15.42**
C2	2	246.1**	263.5**	283.5**	107.4**	29030.1**	34259.1**	1570.**	13.15**
C3	2	224.1**	357.6**	105.5**	235.2**	17857**	13.982.3**	9811**	6.16**
C4	2	190.4**	219.5**	84.63**	99.75**	5990.8	25181.8**	4339**	4.3**
C6	2	24.4**	418.1**	272.5**	139.4**	12010.7**	24997.3**	1143**	1.49**
Error (2)	20	10.1	27.8	7.83	31.1	1967.9	1518.3	1050.1	0.17

** Significant at 1% level

APPENDIX IV

Abstract of Analysis of variance table on the nutrient uptake of virippu rice and summer crop-rice sequences. rice

Mean sum ofsquare

source	d.f.	virippu-rice N	P	K	summer crop-rice sequences N	P	K
Replication	2	53.60	5.27	16.57	196.24	4.62	15.25
Crop Sequence	4	96.60 **	59.49 **	306.27 **	13865.40 **	504.74 **	3166.51 **
Error (1)	8	98.76 **	4.43 **	24.40 **	164.96 **	6.94 **	57.67 **
within							
C1	2	3327.31 **	247.03 **	1391.58 **	3529.94 **	245.17 **	1121.50 **
C2	2	4281.35 **	325.19 **	1603.78 **	4407.22 **	332.77 **	1666.07 **
C3	2	1724.44 **	134.79 **	870.63 **	1762.48 **	134.76 **	874.36 **
C4	2	1328.83 **	113.72 **	1029.25 **	1483.42 **	119.02 **	1109.72 **
C6	2	2147.35 **	150.63 **	1085.23 **	2147.35 **	150.64 **	1085.23 **
Error (2)	20	49.89	1.64	9.62	65.12	1.62	19.80

* Significant at 5% level ** Significant at 1% level

APPENDIX V

Abstract of Analysis of variance table on yield attributes of rice and summer crops rice sequence Mean sum ofsquare

source	d.f	No of productive tillers/m2	No ofspikelets per panicle	No of filled grains per panicle	Weight of the panicle	1000 grain weight
Replication	2.00	26644.02 *	9.81	69.78	0.03	0.05 **
Crop Sequence	4.00	321.83	180.56 **	314.92 **	0.09 **	0.30 **
Error (1)	8.00	5199.80	9.50	30.01	0.03	0.07
within						
C1	2.00	7596.78 **	132.38 **	501.59 **	0.37 **	5.00 **
C2	2.00	8265.44 **	1374.15 **	1434.80 **	0.25 **	5.05 **
C3	2.00	3208.11 *	353.42 **	68.34 **	0.35 **	4.23 **
C4	2.00	4187.44 *	251.69 **	240.47 **	0.29 **	7.68 **
C6	2.00	7248.11 **	680.86 **	251.81 **	0.14 **	7.56 **
Error (2)	20.00	804.28	15.34	14.37	0.01	0.32

* Significant at 5% level ** Significant at 1% level

APPENDIX VI

Abstract of Analysis of variance table on yield,biomass and harvest index of rice

		Mean sum ofsquare			
source	d.f	Grain yield	Straw yield	HI	Biomass
Replication	2.00	522405.21 **	15354.04	0.0040 **	513730.96
Crop Sequence	4.00	1889200.79 **	606386.99 *	0.0060 **	4959308.38 **
Error (1)	8.00	19223.16	95181.38	0.0003	410734.73
within					
C1	2.00	2665613.74 **	5682633.71 **	0.0020 *	15727774.98 **
C2	2.00	3480159.27 **	5831457.62 **	0.0010	18327388.83 **
C3	2.00	1991463.25 **	4541991.03 **	0.0030 **	9170662.36 **
C4	2.00	1498428.86 **	4813410.38 **	0.0030 **	10893015.14 **
C6	2.00	1926716.22 **	4382074.47 **	0.0020 **	11899894.88 **
Error (2)	20.00	35734.00	38651.07	0.0030	143761.32

* Significant at 5% level ** Significant at 1% level

APPENDIX VII

abstract of Analysis of variance table on the soil nutrient content after summer.

Mean sum ofsquare					
source	d.f	Org.C	N	P2O5	K2O
Replication	2	0.025	3238	1.25	4.09
Treatments	4	1.1924	118062 **	43.16 **	53.15 **
Error	38	0.077	5608.52	2.08	4.25

* Significant at 5% level ** Significant at 1% level

APPENDIX VIII

Abstract of Analysis of variance table on the nutrient content after summer crop-rice sequences and nutrient balance of soil.

		Mean sum ofsquare												
		After summer crop- rice sequences.						Nutrient balance of soil.						
source	d.f.	Org. C	Total N		Av.P2O5		Av.K2O		N		P		K	
Replication	2.00	0.03	72.61		3.14		2.02		623.76		0.38		25.88	
Crop Sequence	4.00	0.06	29332.32	**	58.50	**	96.71	**	118101.43	**	1986.18	**	5243.02	**
Error (1)	8.00	0.04	737.43		2.43		19.60		769.10		9.24		97.84	
within														
C1	2.00	0.01	3079.09		3.15		26.95		6507.26		20.89		80.10	
C2	2.00	0.05	2521.35		3.50		94.82	**	1357.28		7.88		102.18	
C3	2.00	0.03	397.02		0.76		39.73	*	909.87		42.23		6.82	
C4	2.00	0.03	594.68		11.38		18.60		241.90		31.30		36.22	
C6	2.00	0.00	1333.16		7.52		24.21	*	1151.35		1.79		47.99	
Error (2)	20.00	0.01	1889.37		4.95		8.88		1535.64		8.61		25.72	

* Significant at 5% level ** Significant at 1% level

APPENDIX IX

Abstract of Analysis of variance table on biomass production and economics of summer crop-rice sequences of rice

		Mean sum ofsquare		
	d.f.	Biomass	Net income	C-B ratio
Replication	2.00	3.04 **	170429.83 **	0.68 **
Crop Sequence	4.00	880.98 **	16494546.50 **	0.31 **
Error (1)	8.00	4.35	291134.22	0.01
within				
C1	2.00	15.37 **	12743292.32 **	0.22 **
C2	2.00	9.86 **	21099026.36 **	0.71 **
C3	2.00	9.11 **	9455552.64 **	0.15 **
C4	2.00	6.58 **	8603298.95 **	0.13 **
C6	2.00	11.04 **	9292753.27 **	0.39 **
Error (2)	20.00	6.96	216022.93	0.01

* Significant at 5% level ** Significant at 1% level

CARRY OVER EFFECTS OF SUMMER CROPS ON VIRIPPU RICE

BY

REGINA LILY EDWIN

ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
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VELLAYANI, TRIVANDRUM

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ABSTRACT

With a view to evaluate the carry over effects of different summer crops on virippu rice and to test the effects of three different levels of NPK fertilizers on the growth and yield of rice, two filed experiments were conducted at the Instructional farm, College of Agriculture, Vellayani during 1987. The experiment was laid out in randomised block design with three replications. There were five summer treatments (grain type cowpea, daincha, sesamum, maize and fallow) preceding rice and three NPK levels tried on rice.

The fertility levels were

(i) f_0 - No fertilizers.

(ii) f_1 - Half the recommended dose.

(iii) f_2 - Full recommended dose.

The rice variety used was Jaya. The abstract of the results are given below.

Daincha and cowpea resulted in the maximum number of tiller production. Proportionate increase in the number of tillers with the quantity of fertilizers was observed.

Among the systems cowpea-rice depleted the soil of maximum quantity of nitrogen and potassium. P uptake was highest in the daincha-rice system. Application of full recommended dose caused maximum uptake of the major nutrients.

The number of spikelets per panicle, number of filled grains per panicle, weight of the panicle and the test weight of rice crop were higher in the daincha-rice sequence. In general these yield attributes showed linear response to the quantity of NPK fertilizers in all the systems tried. The grain yield, straw yield, biomass production and harvest index of rice were maximum when it was preceded by a summer crop of daincha. With daincha incorporation insitu, half the recommended dose of NPK fertilizers (f_1) was sufficient to get yields same as that of full compliment of NPK fertilizers(f_2) . In the other systems the results obtained were in proportionate to the quantity of fertilizers.

The organic carbon, total nitrogen and available

P_2O_5 content of the soil were highest after daincha and available potassium after cowpea. Among the sequences, daincha-rice system best maintained the total N and available P_2O_5 content available K_2O of the soil. The three different fertility levels could exert no significant influence on the total nitrogen and the available $P2_O5$ content of the soil. A positive N balance was observed in the cowpea-rice and the daincha-rice sequences. In sesamum-rice, maize-rice and fallow-rice the balance was negative. The P balance of soil was maintained positive in all the sequences except fallow-rice. All the cropping sequences tried resulted in the positive balance of K. The three fertility levels could not exert any significant influence on the N and P balance of soil after the five sequences tried. The K balance of the soil was proportionate to the the quantity of fertilizers in the daincha-rice,sesamum-rice and fallow-rice sequences. The sesamum-rice sequence was found to be the most profitable among the five sequences tried. Highest cost-benefit ratio was registered in the cowpea-rice system.