

**STUDIES ON POTASSIUM MANAGEMENT IN
RICE BASED CROPPING SYSTEMS**

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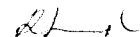

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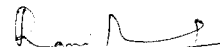
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ABSTRACT

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STUDIES ON POTASSIUM MANAGEMENT IN RICE BASED CROPPING SYSTEMS

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Investigations were carried out at Tamil Nadu Agricultural University, Coimbatore during 1984-85 and at the Agricultural Research Station, Pattukottai during 1986-87 with a view to develop a potassium management strategy for rice based cropping systems.

Field experiments were laid out in both the centres in split plot design with three replications. At Coimbatore, the main plot treatments comprised of four rice based cropping systems with rice crops during south west monsoon and north east monsoon seasons. The third component crops in summer were rice, soybean, finger millet and cotton. At Pattukottai, the main plot treatments were four rice based cropping systems with rice during north east monsoon season and groundnut, soybean, maize and sesame during summer season. The sub-plot treatments consisted of 50 per cent and 100

per cent potassium application at both the centres. In addition, skipping of potassium application to any two crops in the systems and application to all the three crops of the systems at Coimbatore and skipping of potassium application to any one crop in the systems and application to both the crops of the systems at Pattukottai were included.

Application of 25 kg of K_2O ha^{-1} at Coimbatore and 50 kg K_2O ha^{-1} at Pattukottai improved the growth and yield components, besides uptake of major nutrients, leading to enhanced grain yield of rice. In soybean, application of 20 kg K_2O ha^{-1} at Coimbatore and 40 kg K_2O ha^{-1} at Pattukottai promoted the growth and yield contributing characters with the consequence of increased seed yield. The oil content of soybean was enhanced by potassium fertilisation at Coimbatore. The growth characters productive tillers and uptake of NPK by finger millet were positively influenced by the application of 30 kg K_2O ha^{-1} resulting in higher grain yield.

In cotton, application of 15 kg K_2O ha^{-1} improved the LAI, DMP, yield components and seed cotton yield. At Coimbatore, the residual effects exhibited comparable influence on soybean grain yield and seed cotton yield with the direct and cumulative effects. In rice and finger millet, the residual effects did not produce equal yield resulting from cumulative effects.

At Pattukottai, application of 54 kg K_2O ha^{-1} to groundnut promoted the growth attributes, NPK uptake and pod yield. The oil content of groundnut was positively influenced by K fertilisation.

In maize, application of 50 kg K_2O ha⁻¹ improved the growth and yield components, uptake of major nutrients and grain yield. Application of 15 kg K_2O ha⁻¹ promoted the growth as well as yield attributes of sesame leading to increased seed yield. The residual effect was equal with the direct and cumulative effects in respect of soybean and maize. However, in groundnut and sesame, the residual effect was not sufficient to produce equal yield resulted from the cumulative effect.

At Coimbatore, rice-rice-rice system produced the highest biomass with higher gross return. However, rice-rice-soybean system registered lesser energy expenditure, reduced cost of cultivation, higher rice grain equivalent yield with higher net return and benefit cost ratio. The rice-rice-soybean system also improved the soil fertility by improving the soil organic carbon content and with the least depletion of soil reserve potassium.

At Pattukottai, rice-groundnut system produced higher biomass as well as higher rice grain equivalent yield. This system markedly enhanced gross and net returns. The rice-sesame system registered higher benefit cost ratio. The post-harvest soil analysis revealed that the rice-groundnut system improved the soil fertility equal with that of rice-soybean system.

Summing up, potassium fertilisation at 50 per cent recommended dose to each one of the crops in rice-rice-soybean system for soils high in K content in Coimbatore region was highly profitable. Potassium application at 100 per cent recommended dose of K to each one of the crops of rice-groundnut and rice-sesame systems for soils of low-K content at

Cauvery Mettur Project area of Thanjavur district was more remunerative one. Under water constraint situations in Cauvery Mettur Project area, rice-sesame was the best system.

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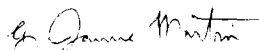
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INTRODUCTION

CHAPTER I

INTRODUCTION

Among the various agricultural inputs, next to water, fertilisers contribute the maximum to crop production. It has been estimated that 50 per cent increase in crop productivity in recent years could be attributed to fertiliser use (FAO, 1981).

Before the introduction of modern high yielding varieties with intensive use of nitrogen, soils were not stressed for potassium supply. Earlier responses to potassium were limited to light textured soils. Since initial responses were very few and not spectacular, research on potash was not given its due importance. As a result of more intensive cropping with high yielding varieties and use of high doses of nitrogen, heavy depletion of soil reserves of potassium are being reported. The inadequate availability of potassium now becomes a limiting factor on soils which were previously considered unresponsive to potassium.

The research information amply reveals that high yields and intensive cropping can be sustained only through optimum use of nutrients in balanced ratios. On a gross basis, crop uptake of potassium exceeds nitrogen uptake by 60 per cent in Indian Agriculture (NCA, 1976). Potassium removals by several crops are much larger than even nitrogen (Goswami and Khera, 1983). Potassium plays a key role in increasing the yield of crops and improving the quality of crop produce.

Usage of potassium in India is approaching 1.0 million tonne of K_2O as compared to 0.5 million in 1976-77 and 0.1 million tonne in 1966-67. Total potash requirements of India are met from imports. This is likely to be the situation in the coming years as well. It is thus imperative to make use of the available potash fertilisers to the most productive use so that each unit gives higher yield response.

With the intensification of agriculture, the focus is shifting from individual crops to cropping systems. The results of All India Coordinated Agronomic Research Project revealed that rice-rice-rice system recorded a grain yield of 13.8 t ha^{-1} at Bhavanisagar (Tamil Nadu) (AICARP, 1978). Three crops of rice in kharif, rabi and summer achieved a grain yield of 20.5 t ha^{-1} in Gujarat (Morita, 1986). Rice followed by a pulse is the predominant cropping system of major rice growing areas of Tamil Nadu.

The Food and Agricultural Organization (FAO) has conceptualized the idea of "Systems approach to plant nutrition (SPAN). The concept of SPAN integrates three systems: (i) integrated plant nutrient system (IPNS); (ii) plant nutrition based on cropping system as a whole rather than on a single crop in the system; and (iii) soil fertility conservation and enhancing soil management system (Roy and Braun, 1984).

Fertiliser use in high intensive cropping systems has been exhaustively reviewed by numerous researchers in recent years (Bhardwaj and Tandon, 1981; Grewal and Sharma, 1981; Mandal et al., 1981; Meelu and Rekhi, 1981; Tandon, 1983; Prasad and De, 1984; Pillai et al., 1985 and Biswas et al., 1987). All of them have suggested that the approach of fertiliser prescription for the system as a whole is economical and efficient with considerable scope of mineral fertiliser economy.

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The production potentials of the cropping systems could be exploited with proper nutrient management practices. The nutrient management in a cropping system often involves accounting of residual effects if any, and contributions from in-situ crop residue recycling. Depending upon the level of input use in relation to crop demand, each successive cropping sequence may have a more fertile soil or more depleted soil. While research works on nutrient management in respect of N and P in rice based cropping systems are numerous, very little work has been done on potassium management. Hence the present investigation was carried out with the following objectives:

- (1) To investigate the magnitude of response of component crops of rice based cropping systems to the different levels of potassium.
- (2) To determine the residual, direct and cumulative effects of potassium in rice based cropping systems.
- (3) To study the effect of potassium fertilisation on the uptake of other major nutrients by the rice based cropping systems and on soil nutrient balance.
- (4) To assess the production potentials of rice based cropping systems with potassium fertilisation.
- (5) To develop management strategies of potassium fertilisation in rice based cropping systems.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Nutrient management gains importance in cropping systems in which many crops of varied nutrient requirements are involved. While applying fertilisers to a particular component crop in a system, discount for residual fertility, addition of crop stubbles from the preceding crop and the contribution of irrigation water are to be taken into consideration. In the present study attempts were made to study the effect of K fertilisation to all the crops compared to skipping K fertiliser application to certain crops or applying only 50 per cent of the recommended dose to all crops or to certain crops in rice based cropping systems. The available literature on the above mentioned aspects are briefly reviewed in this chapter.

2.1. Potassium in soil

The potassium status of a soil varies widely depending upon the composition of parent material, climatic conditions and cropping history. Potassium in soil can move with relative ease to various positions. Because of the relative ease with which K can move in the soil-plant system Albrecht (1943) termed it a nomadic element whose behaviour in a particular situation is difficult to interpret.

2.1.1. Forms of potassium

Potassium occurs in the soil as water soluble, exchangeable, non-exchangeable or fixed K and lattice bound K (Arnold, 1960; Mortland, 1960 and Wiklander, 1960). It is generally accepted that the different forms of K are in equilibrium and are related to each other.

2.1.2. Water soluble potassium

The water soluble K is the fraction of available K which is readily absorbed by the plants and invariably subject to leaching losses in relation to soil properties. Though its presence is common, appreciable quantities are likely to occur by applying water soluble potash fertilisers and from irrigation water of high K content or in soils of naturally high in mixed soluble salts.

Ramanathan (1978) observed that the amount of water soluble K fraction varied with the soil types and generally it followed the order alluvial < black < red < laterite.

Ekambaram and Kothandaraman (1983) observed that the water soluble K was high during the initial periods and progressively decreased as the crop growth advanced.

2.1.3. Exchangeable potassium

Exchangeable K constitutes approximately 90 per cent of the available K in soil pool. Ramanathan and Krishnamoorthy (1973) reported that the clay and silt fractions of black soils were found to contain higher amounts of exchangeable K followed by red, alluvial soil and laterite soils. The same was observed by Pareek *et al.* (1972), Jeyaraj and Dhanapalan (1973), Sarkunan *et al.* (1973), Kansal and Sekhon (1976), Nagarajan (1980) and Taraídar and Mukhopadhyay (1981).

Kar *et al.* (1975) and Ekambaram *et al.* (1975) noticed the increase in exchangeable K in soils through added K over control. Ramanathan (1977) reported that the extent of exchangeable K reduction ranged from 1 to 291

ppm with the corresponding percentages ranging from 2.2 to 90.9 per cent which was inversely related to the extent of non-exchangeable K used.

Ekambaram and Kothandaraman (1983) reported that the exchangeable K and water soluble K were high during the initial stages and decreased as the crop growth advanced. Ramanathan and Palaniappan (1987) found reduction in exchangeable K in soils growing rice. They also observed the influence of exchangeable K by the release of non-exchangeable form.

2.1.4. Non-exchangeable potassium

Hood *et al.* (1956) reported that the applied K to the soil would be converted into non-exchangeable form if it is not utilised by the plants.

Jeyaraj and Dhanapalan (1973) noted higher non-exchangeable K content with clay and silt fractions than fine and coarse sand fractions. Kansal and Sekhon (1976) also found the increasing trend of non-exchangeable K with increase in the clay and silt contents of soil.

Ekambaram *et al.* (1975) observed that the highest level of K application registered high values of non-exchangeable K. He also found a general decreasing trend of non-exchangeable K with the increasing depth of the profile. Ramanathan (1977) reported that the contribution of non-exchangeable K to total K uptake by rice ranged between 33.7 and 99.4 per cent in a red soil. He also observed lower K uptake when the extent of non-exchangeable K used was higher indicating low availability of non-exchangeable K. Ekambaram and Kothandaraman (1983) noted the highest amounts of non-exchangeable ^K in black soils followed by alluvial and red soils.

2.1.5. Total potassium

Ekambaran and Kothandaraman (1983) reported that black soils contained highest amount of total K followed by alluvial and red soils and application of K resulted in an increase in all the four forms of K in all the soils.

The abundance of different fractions is usually as follows: 90-98 per cent of total K is in mineral form which is relatively inaccessible to a growing crop. Then 1-10 per cent of total K is in the non-exchangeable (fixed) form, that is slowly available and 1-2 per cent of total K is in the exchangeable + water soluble form. Out of this 1-2 per cent, about 90 per cent may be exchangeable and 10 per cent in the soil solution (Tandon and Sekhon, 1988).

2.1.6. Electro-ultrafiltration (EUF) potassium

The electro-ultrafiltration (EUF) method has established itself as a useful tool for the evaluation of soil fertility (Nemeth, 1979). The most important result of EUF research with regard to potassium is the use of the EUF-K-80°C/EUF-K-20°C quotient for characterizing the K status of soils.

Wanasuria *et al.* (1982) reported that EUF extractable soil K correlated highly significantly with the rice yield response to K fertiliser, whereas ammonium acetate extractable K (exchangeable K) did not correlate. They further observed that under limiting K supply in soils, rice yield was dependent more on the EUF-K than on the exchangeable K.

Nemeth (1985) reported that the EUF fraction obtained in 10 minutes at 200 volts and 20°C proved most suitable for characterizing the

concentration of a nutrient in the soil solution at field capacity. He also observed that the major part of fertiliser K was recovered in the EUF-K fraction of 20°C and the EUF-K contents at 20°C were almost equivalent to the contents of exchangeable K.

Subba Rao *et al.* (1988) observed in the usual 35 minute EUF extraction, the bulk of K desorbed was from the exchangeable fraction.

2.2. Potassium in plant

Universally K^+ is present in the cell as the principal cation and linked with almost all phenomena of plant physiology. Consequently it has been possible to attribute a multiplicity of functions to potassium, but hardly possible to endow it with a specific role. It intervenes in the following domains viz., photosynthesis, enzyme activities, metabolism of carbohydrates, organic acids, ~~fat~~ts and nitrogenous compounds, protein synthesis, water use efficiency, cell elongation, resistance to drought, frost, lodging, insects, disease and physiological disorders (Balram *et al.*, 1977).

Potassium affects the development of reproductive organs and filling of the storage tissues with photosynthates. It promotes the development of the proximal, central and distal spikelets. Single grain weight mainly depends on the K^+ status of the plant during flowering stage. Under optimum K^+ nutritional conditions, the senescence of flag leaf is delayed and prolongs leaf area duration which is important for grain development. Influence of K^+ on the translocation of assimilates from the vegetative plant parts towards the ears is well documented. The grain development is not only dependent on the provision of assimilates to the ears but also on the ability of the ears to provide a sink for these assimilates (Mengel and Kirkby, 1980).

2.3. Response of crops to the application of K

Rajendra Prasad and Mahapatra (1970) reported positive responses of different crops to K application on alluvial, deep black, mixed red and black, red and yellow soils. Continuous application of K led to much higher uptake of K by crops (Ghosh and Biswas, 1978). Tiwari and Nigam (1985) studied the response of important cereals, legumes, oilseeds and fodder crops to potassium on a Typic Ustrochrept of Kanpur and reported that K fertilisers markedly increased the yield of grain and dry matter of all crops.

2.3.1. Rice

Submergence creates a unique environment for the growth and nutrition of rice. The availability of K increases with the submergence of soil (Ponnamperuma, 1972). According to Yoshida (1981), concentration of potassium increases in the soil solution after submergence. Panda (1984) reported that flooding enhanced the release of exchangeable K to the soluble form.

In rice soils, both release and fixation of K occur depending upon the water regimes, including continuous submergence or alternate wetting and drying and the periodicity of such cycles (Kadrekar, 1976; Kadrekar and Kibe, 1973; Ramanathan and Palaniappan, 1987).

Vijayan and Sreedharan (1972) reported that the maximum response to K was only at 20 kg $K_2O\ ha^{-1}$ in a rich-K soil. They further reported that the 20 kg level of K resulted in an increase of 270 kg grain ha^{-1} over control and 40 kg level recorded lesser increase of 147 kg grain ha^{-1} over 20 kg level and there was not much response beyond 40 kg level.

Ali et al. (1976) found significant response (202 kg) at the level of 42 kg K ha⁻¹ in new alluvial, red and lateritic and coastal saline soils of West Bengal. They further observed the maintenance of response (200 kg) at the higher level of application (84 kg ha⁻¹) also. Marek and Dhaliwal (1978) advocated application of 30 kg K₂O ha⁻¹ to get a response of 4.9 kg grain per kg K₂O in soils of low to medium available K in Ferozpur district of Punjab.

In alluvial soil of Aduthurai, Venkat^araman (1980) recorded response only upto 25 kg K₂O ha⁻¹. Venkatasubbiah et al. (1982) observed less increase in rice yield with increase in level of K application in a K-depleted soil.

The time series analysis of the data collected from the experiments on cultivators' fields under the All India Coordinated Agronomic Research Project (AICARP) for a 12-year period revealed a fairly progressive increase in crop response to potassium in the presence of N and P (AICARP, 1985).

Application of 100 kg K₂O ha⁻¹ in two splits viz., 50 per cent basal and 50 per cent at panicle initiation stage resulted in the highest yield at Palur (Balasubramanian et al., 1977). In the sandy soils of Meghalaya split application of K increased rice yield by almost 700 kg ha⁻¹ over the same rate applied all before planting. In this, the grain production efficiency per unit potash applied was improved by 73 per cent and potash uptake increased by 110 per cent (Ram and Prasad, 1985).

Senthivel and Palaniappan (1985) observed that application of NK granules in one or two splits in the standing rice crop was more

advantageous than application of entire amount of potassium at transplanting in a soil rich in K content.

Potassium was not considered necessary for promoting the vegetative growth but it might be possible that this nutrient has an indirect influence in increasing the uptake of N which in turn might have contributed to increase in the plant height (Tisdale and Nelson, 1975). Significant increase in dry matter yield was observed at harvesting stage due to K application (Mengel *et al.*, 1976).

Singh and Singh (1972) reported that application of K increased the number of panicles per hill and in combination with N, the number of grains and other yield contributing characters were promoted. Venkatasubbiah *et al.* (1982) recorded significant reduction in the percentage of undeveloped grains due to K fertilisation. Potassium had positive correlation with grain weight (Venkatasubbiah *et al.*, 1982).

There were two peak periods of K uptake, one between 40 to 50 days after planting and second between 60 and 70 days after planting (Sekhon *et al.* 1973). Sharma and Rajendra Prasad (1980) reported that rice crop yielding 50 q of grain removed 80 kg N, 18 kg P and 100 kg K ha^{-1} .

Yoshida (1981) found that the nutrient required to produce one tonne of rough rice in the tropics was 20.5 kg N ha^{-1} , 5.1 kg P ha^{-1} and 44.4 kg K ha^{-1} . Nelson (1982) found the diffusion rate of K to the plant root was accelerated with higher moisture and/or higher levels of K in the soil. He also observed reduction in K uptake at cooler temperature.

Tiwari (1985) observed the rice crop yielding 7.9 t of grain taking 125 kg N, 32 kg P and 156 kg K ha⁻¹.

The results of trials conducted throughout India on high yielding rice revealed that the application of potassium resulted in an additional response of 4.2 kg grain per kg K₂O over a basal application 120 kg N + 60 kg P₂O₅ level (Zende, 1978).

Response yardsticks of crops to potassium application depend also on initial soil fertility. Leelavathi (1986) observed that even in high-K soils, each kg K₂O applied increased rice yield by 4.9 kg in kharif and 5.7 kg in rabi. She also reported that the value-cost ratio of potash application was 4.0-4.6 in low-K soils, 3.6-4.3 in medium K soils and 3.4-3.9 in high-K soils.

2.3.2. Soybean

Chevalier (1977) reported that the total dry matter production was increased by application of 100 kg K ha⁻¹ to soybean in a low K available soil. He also indicated that N, P and K contents of soybean were low in the stem and high in the seed. Zhang and Liu (1982) reported that in order to obtain higher yield, LAI should be maintained within the range of 3 to 6.45.

Application of 30 kg K₂O ha⁻¹ to soybean was found to increase the protein content; the lowest protein content was observed in zero level. Massey (1973) reported increased oil content by K application.

The works of Hanway and Weber (1971), Terman (1977), Chevalier (1977) and Craves *et al.* (1978) revealed that soybean grain yield increased significantly due to K fertilisation. Application of K as top dressing was found to be effective in soybean (Sarmah *et al.*, 1982).

The experiments conducted under the auspices of All India Coordinated Agronomic Research Project showed that for grain legumes (pulses), application of 20 kg K_2O ha^{-1} in combination with 20 kg N + 40 kg P_2O_5 ha^{-1} generated an average response of 2.5 kg grain $kg K_2O^{-1}$ (AICARP, 1985). Nambiar and Ghosh (1987) while reviewing the long term fertiliser experiments under different soil and climatic conditions in India reported ^{that} yield response in soybean was 0.8. The results of fertiliser trial in soybean conducted at Pune showed that 20 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} recorded the highest seed yield of 3322 kg ha^{-1} compared to 1772 kg ha^{-1} in control plot (AICRPS, 1989).

2.3.3. Finger millet

Finger millet yielding above 3600 kg ha^{-1} removed 130 kg N, 30 kg P and 115 kg K (Tirupathi and Morachan, 1973). Ramanathan et al. (1978) reported pronounced influence of N, P and K application on K uptake at tillering stage (25 days after planting) of finger millet. But the K uptake was not influenced at the flowering stage (56th day) of crop growth.

Siddeswaran and Ramaswamy (1987) reported that in finger millet, about 42 per cent of K was taken upto 45th day (maximum tillering) and 44 per cent between 45th and 60th day (peak flowering) and 14 per cent after 60th day.

All India Coordinated Agronomic Project (AICARP) experiments showed significant response upto 60 kg K_2O ha^{-1} for finger millet under irrigated conditions. The magnitude of response was more in light textured soils under humid conditions (AICARP, 1985). Large response to potassium

was obtained for finger millet in K-rich medium black soil of Coimbatore after eight cropping cycles (Sekhon and Puri, 1986).

2.3.4. Cotton

The vegetative characters like plant height were reported to have been affected in plants grown in potassium deficient soil (Faulkner *et al.* 1974). Ravichandran (1981) observed positive response in vegetative structure like plant height and LAI to K fertiliser application.

Pettit (1973) observed lesser number of bolls, incomplete bursting of bolls and many immature locks even within the open bolls which rendered difficult harvesting in K-deficient soils. Faulkner *et al.* (1974) reported that without K, cotton plant failed to produce fruiting points early in the season as compared to K applied plots. Panchakshariah *et al.* (1974) reported that application of 45 kg of K_2O ha^{-1} increased the flower production by about 8 per cent over control.

A greater accumulation of sugars and starch in leaves under K deficiency conditions adversely affected development of bolls (Belousov, 1984). He also stated that the physiological role of K during the fruit formation and maturation periods is mainly expressed in carbohydrate metabolism and translocation of metabolites from leaves and other vegetative organs to the developing bolls.

Sabino *et al.* (1984) reported that in K deficient soils, application of K through fertilisers increased the boll weight. In ^{soils of} low and medium available K, application of increased dose of K considerably increased the boll weight in cotton (Silva *et al.* 1984).

Basset **et al.** (1970) observed that the amounts of NPK accumulated in the above ground parts at first flower were less than 15 per cent of final amounts. The rate of K uptake was slow at the beginning and increased rapidly from flowering and reached its maximum between peak flowering and boll development stage. They also observed that during this period the rate of uptake of K was to the tune of $4.6 \text{ kg ha}^{-1} \text{ day}^{-1}$.

Velu and Balasundaram (1980) observed the peak absorption period for major nutrients was from flowering to first picking.

Ravichandran (1981) concluded that seed index, lint index, fibre fineness, fibre length, bundle strength and maturity coefficient were favourably influenced by the application of higher levels of K.

Balakrishna **et al.** (1977) reported that at higher N levels, a high level of K was needed for increased yield. Added K interfered with the nitrification of NH_4 in the clay minerals by blocking the release of fixed NH_4 on the one hand and reduced the release of non-exchangeable K on the other (Welch and Scott, 1961). Similarly NH_4 also blocked the release of added K that was fixed by the soil indicating the influence of the order of addition of N and K.

Chauhan and Vervan (1974) concluded that N and K applied in the ratio of 1:1 in three splits-half NK basal, one fourth NK at square formation and the remaining one fourth NK at boll formation recorded the highest seed cotton yield. Manoharan (1978) reported that application of 60 kg N and 40 kg $\text{K}_2\text{O ha}^{-1}$ in three splits viz., one third as basal, one third on 45th day and one third on 70th day recorded the maximum income.

Faulkner (1974) noted a quadratic response to K application. An yield increase of about 3.0 kg seed cotton ~~per kg~~¹ of K applied was observed by Kemmler (1975). In K exhaustion experiments conducted over several years, Kemmler and Malicornet (1976) found gradual decrease in yields in control plots after 4 or 5 years but not in the plots applied with 108 kg K_2O ha^{-1} .

The response of cotton to K was high when the exchangeable K in soil was less than 50 ppm and it decreased progressively and no response, could be observed with exchangeable K more than 150 ppm in soil (Harper, 1950).

2.3.5. Groundnut

An investigation conducted on red loam soil with low available K revealed that application of 50 kg K_2O ha^{-1} increased the plant height and number of leaves per plant (Purushothaman *et al.*, 1982).

Gopalaswamy *et al.* (1978) reported that soil dressing of 80 kg K_2O ha^{-1} increased the number of pods per plant. Application of 40 kg K ha^{-1} to groundnut alone increased the number of pods per plant and the test seed weight. A linear response of 100 pod weight to K fertilisation was also observed (Rao *et al.*, 1979).

The natural test weight of pods was significantly increased by K application upto 50 kg K_2O ha^{-1} (Purushothaman, 1982). Devarajan and Kothandaraman (1982) reported that application of K increased the shelling percentage from 75.5 to 80.2 due to good filling and development of kernels. Nandagopalan (1984) reported that application of 30 kg K ha^{-1} was superior to 60 and 90 kg levels in improving the 100 kernel weight.

Nandagopalan (1984) reported that uptake of K increased gradually with the advancement of the age of the crop and the maximum uptake was recorded at harvest. He observed much higher uptake in summer than in kharif due to higher dry matter production and favourable climatic conditions. Tiwari (1985) reported that groundnut crop yielding 4.4 t of pods ha^{-1} removed 270 kg N, 19 kg P and 172 kg K ha^{-1} .

Potassium fertilisation at 60 kg ha^{-1} increased the oil content from 43 per cent (in control) to 46 per cent (Devarajan, 1976). Application of 50 kg K_2O ha^{-1} was optimum in clay loam soil having medium available K for realising higher oil outturn (Ramesh et al., 1984).

Split application of K in 2-3 doses was reported to be superior to a single dose of basal application in light to medium textured soils containing kaolinite and illite clay minerals and in regions of high rainfall (Goswami and Khera, 1981).

Rajendra Prasad and Mahapatra (1970) reported a response of 217 kg of unshelled pods ha^{-1} to the application of 30 kg K_2O ha^{-1} in mixed red soils and black soils resulting in a net profit of Rs.246 ha^{-1} . They further observed that red and alluvial soils gave a response of 206 kg unshelled dry pods ha^{-1} to an application of 30 kg K_2O ha^{-1} which resulted in a net profit of Rs.332 ha^{-1} .

Increasing the levels of K, particularly in low K soils, showed a prominent increase in groundnut yield under different soil types and agroclimatic conditions (Roy et al., 1978; Goswami and Khera, 1981).

Devarajan and Kothandaraman (1982) reported that highest pod and haulms yield were obtained by the combined application of 60 kg P_2O_5 and

90 kg K_2O ha⁻¹ in red non-calcareous soil having 170 ppm available K. The experiment conducted in red calcareous soil with high available K revealed that increased pod yield was obtained by the application of 120 kg K_2O ha⁻¹ (Ramanathan *et al.*, 1982).

A large number of fertiliser trials on farmers' fields in Andhra Pradesh, Karnataka and Tamil Nadu revealed significant response to K in groundnut in kharif and rabi seasons. There was an average increase of groundnut yield by 3 kg pod per kg of potash applied at 40 kg K_2O ha⁻¹ (Kulkarni *et al.*, 1980). Chavan and Kalra (1983) reported that application of 50 kg K_2O ha⁻¹ increased the dry pod yield under high rainfall conditions of Konkan region of Maharashtra.

2.3.6. Maize

Gark *et al.* (1978) observed a significant increase in all the growth attributes when 90 kg N ha⁻¹ was applied along with 0.2 ppm Mg. Sridharan (1984) reported that top dressing K twice along with N increased the LAI in kharif season at Coimbatore.

Singh and Agarwal (1976) observed increased uptake of K by the maize hybrid Ganga 101 due to K application. The maximum uptake of K was observed to be on 40th day and thereafter it decreased. Deb *et al.* (1976) found that K application increased the P and Zn uptake by maize. The antagonism between P and Zn seemed to have been alleviated by K application. Biswas *et al.* (1977) concluded that K might have overcome the retarding effect of applied P on the translocation of Zn from roots to shoots. Madhavi (1987) reported that the higher levels of fertilisers especially 350-175-160 and 275-137.5-120 Kg N, P_2O_5 and K_2O ha⁻¹ respectively improved all the yield components of maize.

Reviewing the results of hundreds of experiments conducted over 25 years, Loue (1980) found positive interaction between N and K. The N:K ratio was important in maize because it took up N and K in similar quantities.

Kranitz (1985) reported that maize crop yielding 12.5 t ha^{-1} required 298 kg N, 128 kg P_2O_5 and 298 kg $\text{K}_2\text{O ha}^{-1}$.

Summing up the results of over a hundred experiments with K application, Loue (1979) found the application of 110, 130 and 156 kg ha^{-1} for rich, medium and poor K soils respectively to attain profitable response in maize. Kranitz (1981) prescribed the ^critical requirements for maximum grain yields in maize as 140 to 150 days of duration, stem height, 180 to 190 cm, cobs 18 to 20 cm long with 16 to 18 grain rows, 300 to 400 g of 1000 grain weight, lodging not exceeding 2 to 5 per cent, 60,000 to 70,000 plants ha^{-1} and N, P_2O_5 and K_2O in the ratio of 1.0:0.6:0.9 at 400 to 600 kg ha^{-1} .

Kapur et al. (1984) reported that maize grain yield response was upto a rate of $90 \text{ kg K}_2\text{O ha}^{-1}$ on low and medium K soils, and upto $60 \text{ kg K}_2\text{O ha}^{-1}$ on soils of high K status. Madhavi (1987) found high level of fertilisation viz., 275 - 137.5 - 120 kg N, P_2O_5 and $\text{K}_2\text{O ha}^{-1}$ was the optimum dose to get maize grain yield exceeding 10 t ha^{-1} . She suggested the application of full P, one third N and K at knee high stage and one third N and K at tasseling stage.

Large responses to potassium were obtained for maize in K-rich medium black soil at Coimbatore after eight cropping cycles (Sekhon and Puri, 1986).

2.3.7. Sesame

Harishankar *et al.* (1975) reported that application of 60 kg K_2O ha^{-1} increased growth characters like plant height, stem girth and dry matter production of sesame in K deficient soil. Balamurugan (1982) observed increased in LAI, stem thickness and DMP by the application of 30 kg K_2O ha^{-1} to sesame in low K red sandy loam soil of Bhavanisagar.

Application of 40 kg K_2O ha^{-1} to sesame increased the number of capsules per plant, seed weight per capsule and seed weight per plant (Gowda and Krishnamurthy, 1977). Balamurugan (1982) found positive response of yield components such as length of capsule, 1000 seed weight to the application of K in low K soil at Bhavanisagar. Majumdar *et al.* (1988) also found more capsules per plant, more seeds per capsule and higher test weight of seeds over control.

Harishankar *et al.* (1975) found increased oil content by the application of 20 kg K_2O ha^{-1} to sesame. Balamurugan (1982) found no increase in oil content due to K application at Coimbatore.

Gowda and Krishnamurthy (1977) recorded the highest yield of 1444 kg ha^{-1} with the application of 40 kg K_2O ha^{-1} . Balamurugan (1982) observed significant increase in yield due to K application in a low K red sandy loam soil of Bhavanisagar.

2.4. Rice based cropping systems

Rice is a component of widely varying cropping systems in India. Rice-rice is the most dominant cropping system under irrigated conditions in south and eastern India, while rice-wheat, rice-groundnut, rice-legume,

rice-mustard and rice-potato are some of the predominant rice based cropping system with 200 per cent cropping intensity in different north Indian states (AICARP, 1978). Various rice based cropping systems with 300 per cent cropping intensity have been reported from different parts of India, ranging from rice-rice-rice (Palaniappan *et al.*, 1978) to rice followed by different cereals, pulses, oilseeds, vegetables and fibre crops (AICARP, 1978). Purushothaman (1979) has listed various rice based cropping systems in India.

Some of the promising cropping systems which are biologically more productive and economically remunerative under adequate input supply were rice-wheat-greengram for North India and rice-rice-cotton/groundnut for Tamil Nadu (Pillai *et al.*, 1985). Rice-rice-pulse is the predominant cropping system of rice growing areas of Tamil Nadu according to Palaniappan (1985). Pandey *et al.* (1986) furnished various region-specific rice based cropping systems followed in India. Palaniappan and Thangamuthu (1987) listed various rice based cropping systems prevalent in Tamil Nadu.

2.4.1. Productivity of the rice based cropping systems

A mutiple cropping system of two rice crops and sweet potato was feasible and more remunerative in Orissa (Singh *et al.* 1974). Thirunavukkarasu and Gouthaman (1977) reported that rice-rice-greengram was a highly productive system for Pondicherry region. At Coimbatore, rice-rice-rice system recorded the maximum production of 13.9 t ha^{-1} of grain (Palaniappan *et al.*, 1978). With rice-rice-rice system highest grain production of 16.8 t ha^{-1} was obtained at Mangalore (Karnataka), 13.4 t ha^{-1} at Bhavanisagar (Tamil Nadu) and 11.9 t ha^{-1} at Bhubaneshwar in Orissa (AICARP, 1978).

Purushothaman (1979) suggested that growing rice in kharif (June to September), a medium duration rice in winter (October to January) and finger millet and greengram in summer (February to June) was the most profitable cropping system for the wetland conditions of Coimbatore.

While reviewing the results of Model Agronomic Experiments, Mahapatra *et al.* (1981) reported that the sequence of rice-wheat-rice for Varanasi and Kalyani centres, rice-finger millet-rice for Marutteru and rice-rice-rice for Bhubaneswar, Karamana and Mangalore centres were the most productive systems.

Morita (1986) observed that three crops of rice in kharif, rabi and summer recorded 20.5 t ha^{-1} of grain against the conventional system of rice-rice in Gujarat. The results of All India Coordinated Agronomic Research Project revealed that finger millet-rice-soybean gave the highest productivity in Thanjavur district (AICARP, 1986).

2.5. Nutrient management in cropping systems

Until recently, crop production research has been focussing attention on individual crops disregarding the fact that each crop is only a component of a cropping system. Nutrient dosage for the individual crops is usually prescribed based on the responses of crops without considering the cropping system as a whole. As a result, rather high and uneconomic recommendations for fertiliser use are made. Hence, fertilisation must be considered not for individual crop, but for cropping system as a whole (Mahapatra *et al.*, 1974).

Swaminathan (1981) emphasised the need for systems approach of nutrient supply to a cropping system as a whole for increasing the fertiliser use efficiency and economising the use of costly mineral fertilisers. Biswas

et al. (1987) observed that while developing a fertiliser schedule, it is necessary to take into account the residual effect of fertilisers applied to the previous crop and the influence of the preceding crop on the succeeding one.

The Food and Agricultural Organization (FAO) has conceptualized the idea of "Systems approach to plant nutrition" (SPAN). The concept of SPAN integrates three systems: (i) integrated plant nutrient system (IPNS); (ii) plant nutrition based on cropping system as a whole rather than on a single crop in the system; and (iii) soil fertility conservation and enhancing soil management system (Roy and Brawn, 1984).

Fertiliser use in high intensive cropping systems has been exhaustively reviewed by numerous researchers in recent years (Bhardwaj and Tandon, 1981; Grewal and Sharma, 1981; Mandal et al. 1981; Meelu and Rekhi, 1981; Tandon, 1983; Prasad and De 1984; Pillai et al. 1985 and Biswas et al., 1987). All of them have opined that the approach of fertiliser prescription for the system as a whole is economical and efficient. They have also claimed considerable scope of mineral fertiliser economy.

2.5.1. Addition of crop residues

Nair et al. (1973) found that intensive rice based cropping systems added 5 to 6 t of residues $\text{ha}^{-1} \text{ year}^{-1}$. Rice, sorghum, maize, cowpea and finger millet left considerable amount of stubbles in the soil and of these finger millet stubbles were the most easily decomposable (Shanmugasundaram et al., 1975).

Purushothaman (1979) reported that rice-rice-finger millet-greengram added a total quantity of 3.65 t of crop residues $\text{ha}^{-1} \text{ year}^{-1}$. Application

of rice crop residues exerted favourable influence on growth, dry matter production, yield components and yield of rice (Ramaswamy, 1982). Ponnamperuma (1984) opined that the yield advantage by rice stubble incorporation might be due to increased nutrient supply. Srinivasulu (1988) observed that the rice crop stubbles contained one per cent K.

2.5.2. Nutrient balance in the cropping system

In the cotton based multiple cropping sequences at Coimbatore, uptake exceeded the addition for N and K, resulting in negative balance. Depletion was much greater in the case of K. Balance for P was positive except in cotton-cotton-bhendi sequence (Venugopal and Palaniappan, 1980). In rice based multiple cropping study conducted at Coimbatore, the nutrient balance was very much influenced by the fertility levels. There was a positive N balance when full N was applied while it was negative when half of N was applied. In the case of P, balance was positive for both full and half the quantity of application. Balance for K was negative with all the fertility levels (Purushothaman and Palaniappan, 1985).-

Manickam (1985) observed negative balance for N and P at 50 per cent NPK level which changed to a positive balance by increasing levels to 100 per cent and 150 per cent NPK in finger millet-cowpea-maize system in medium black soil of Coimbatore. Combined application of NPK and FYM had recorded a build up of all nutrients.

At Coimbatore, there was a positive balance in N and P in maize-wheat system indicating the build up of soil fertility (Ramasamy, 1985). In a three year study at Ludhiana, there was positive P and negative K in maize-wheat-greengram and rice-wheat-greengram systems. Positive N balance

occurred in fodder pearl millet-potato-wheat sequence. The depletion of soil reserve occurred in maize-wheat-greengram sequence (Sharma *et al.*, 1987).

2.6. Potassium in rice based cropping systems

The yield level of 10-15.3 t of cereal grains ha^{-1} year $^{-1}$ have been obtained in multiple cropping systems at different centres of All India Coordinated Experiments. These systems have been reported to remove 500 to 700 kg of macronutrients ha^{-1} year $^{-1}$ and the average quantity of nutrients absorbed by the plants has been worked out to be 1.17 kg N, 0.40 kg P_2O_5 and 1.25 kg K_2O ha^{-1} day $^{-1}$ (Ramamoorthy *et al.*, 1971).

Reviewing the work on residual effect of K fertilisers, Grewal and Sharma (1978) stated that in alluvial soils of Jalandhar, the residual effect of 100 kg K_2O ha^{-1} and that of 30 t FYM ha^{-1} applied to potatoes was sufficient to meet the K needs of the succeeding crops of wheat, maize or rice.

Purushothaman (1979) reported that there was slight decrease in available K in the rice based cropping system at Coimbatore viz., rice-rice-rice, rice-rice-sorghum+cowpea, rice-rice-maize-soybean and rice-rice-finger millet-greengram. The uptake of K by the crops in all the systems was higher than the quantity applied through fertilisers and so the deficit was met from the soil reserves. He also observed that the application of recommended dose of N to each crop and P and K only to summer upland crops gave similar yield as that obtained with the application of full dose of NPK to each crop can be skipped for first two rice crops and restricted to summer crops, saving about 100 kg each of P_2O_5 and K_2O ha^{-1} .

Results from a number of long term fertiliser experiments showed that under optimum rates of potassium application, crop uptake of potassium

exceed the additions of K resulting in negative potassium balance (Tandon and Sekhon, 1988).

The review of available literature amply shows the requirements of different crops for K in varied situations are substantial and the differential response of soils to K fertiliser application and the effectiveness of split application of K. It is evident that research work on K management in terms of quantity, reducing the dose and/or skipping to certain crops in cropping systems context especially rice based cropping systems has not been done. Hence this present investigation was undertaken to understand the effectiveness of K in rice based cropping systems.

M A T E R I A L S A N D M E T H O D S

CHAPTER III

MATERIALS AND METHODS

Field investigations were carried out at Tamil Nadu Agricultural University main campus, Coimbatore and at Agricultural Research Station, Pattukottai with a view to study the effect of different levels of K fertilisation on component crops and to estimate the direct, residual and cumulative effects of K fertilisation on the productivity of rice-based cropping systems.

3.1. MATERIALS

3.1.1. Location

The field experiments were conducted during 1984-85 at B block of Central Farm Wetlands of Tamil Nadu Agricultural University, Coimbatore, situated at 11° N latitude, 77° E longitude and at an altitude of 426 m above MSL. During 1986-87, the field experiments were conducted at G block of Agricultural Research Station, Pattukottai, situated at 11° N latitude, 80° E longitude and at an altitude of 19.8 m above MSL.

3.1.2. Meteorological parameters

The weather parameters prevailed during the cropping periods of 1984-85 and 1986-87 are presented in Appendix Ia and Ib and Fig. Ia and Ib. The abstract of weather parameters is given in Table I.

FIG. 1a WEATHER DURING CROPPING PERIOD - COIMBATORE

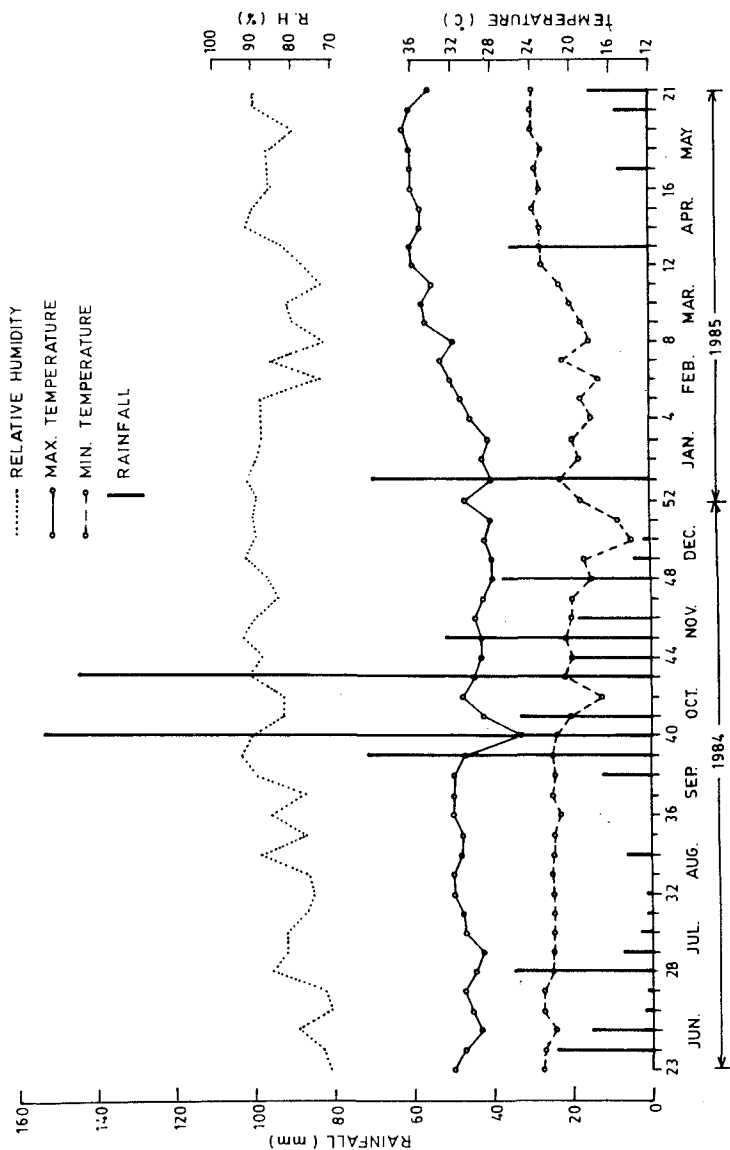


FIG. 1 b. WEATHER DURING CROPPING PERIOD—PATTUKOTTAI

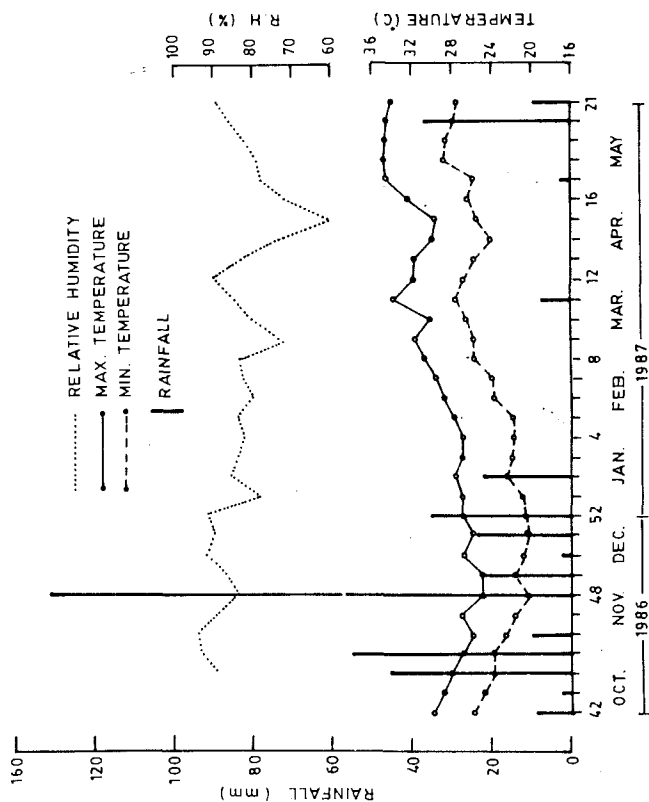


Table 1. Abstract of weather data

COIMBATORE			
Parameters	South West Monsoon (SMW) season, 1984	North East Monsoon (NEM) season, 1984	Summer, 1985
Maximum temperature (°C)	28.6 to 32.3	27.6 to 30.5	32.0 to 36.7
Minimum temperature (°C)	21.1 to 23.3	13.6 to 21.3	16.7 to 24.2
Morning relative humidity (%)	71 to 88	84 to 93	72 to 92
Sunshine hours	1.9 to 10.0	1.2 to 11.0	8.3 to 11.0
Evaporation (mm day ⁻¹)	4.2 to 8.8	1.2 to 6.1	5.0 to 8.2
Rainfall (mm)	92.9	374.1	68.8
Rainy days	12	16	4

PATTUKOTTAI		
Parameters	North East Monsoon (NEM) season, 1986	Summer, 1987
Maximum temperature (°C)	24.9 to 30.2	29.8 to 35.2
Minimum temperature (°C)	20.0 to 25.9	25.5 to 29.0
Morning relative humidity (%)	79 to 94	61 to 89
Evaporation (mm day ⁻¹)	2.5 to 6.0	5.2 to 8.1
Rainfall (mm)	378.0	53.0
Rainy days	27	4

3.1.3. Soil

The soil of the experimental field at Coimbatore was moderately drained and deep clay loam classified as Typic Ustochrept. The soil belonged to Noyyal Series. The soil was low in available N, medium in available P and high in available K. The soil at Pattukottai belonged to Madukkur series. It was well drained and sandy loam classified taxonomically as Udic Haplustalf. It was low in available N and K and medium in available P. The physical and chemical properties of the two soils are furnished in Table 2.

3.1.4. Irrigation water

Irrigation water was analysed for its salt contents (Table 2).

3.1.5. Season and variety

The crops raised in different seasons at Coimbatore and at Pattukottai are listed in Table 3.

3.2. METHODS

3.2.1. Design and layout (Fig. 2a and 2b)

The statistical design and layout details of the field experiments conducted at Coimbatore and at Pattukottai are furnished below.

Location	: Coimbatore
Design	: Split plot
Replication	: Three

Table 2. Soil characteristics of the experimental fields and quality of irrigation water

Particulars		Coimbatore	Pattukottai
<u>Mechanical analysis</u>			
Clay (%)		43.8	12.5
Silt (%)		12.0	5.0
Fine sand (%)		24.5	29.1
Coarse sand (%)		19.4	52.7
Textural class		Clay loam	Sandy loam
Taxonomical name		Type Ustochrept	Udic Haplustalf
<u>Chemical analysis</u>			
<u>Soil</u>			
Alkaline permanganate N (Subbiah and Asija, 1956)	(kg ha ⁻¹)	264.0	124
Available P (Olsen et al. 1954)	(kg ha ⁻¹)	17.2	13.6
Ammonium acetate extractable K (Stanford and English, 1949)	(kg ha ⁻¹)	933.0	98.0
Water soluble K (Stanford and English, 1949)	(ppm)	18.5	7.5
Exchangeable K (Toth and Prince, 1949)	(ppm)	219.0	46.0
Non-exchangeable K (Wood and DeTurk, 1940)	(ppm)	717.0	274.0
Total K (Piper, 1966)	(%)	0.82	0.35
Organic carbon (Walkley and Black, 1934)	(%)	0.598	0.355
pH (1:2 soil water suspension) (Jackson, 1973)		8.1	7.4
EC (Jackson, 1973)	(d S ¹ m ⁻¹)	0.19	0.26
<u>Irrigation water</u>			
pH		7.7	7.1
EC	(d S ¹ m ⁻¹)	0.89	0.54
K	(ppm)	3.00	1.25

Table 3. Season, crop, variety and duration

Location	I SWM season	Field duration (days)	II NEM season	Field duration (days)	III summer	Field duration (days)	Total field duration (days)
Coimbatore	C1: Rice (IR 50) 7.6.84*10.9.84*	96	Rice (Co 43) 7.10.84*/17.1.85*	103	Rice (IR 50) 7.2.85*/8.5.85*	91	290
	C2: Rice (IR 50) 7.6.84*/10.9.84*	96	Rice (Co 43) 7.10.84*/17.1.85*	103	Soybean (Co 1) 6.2.85*/27.5.85*	111	310
	C3: Rice (IR 50) 7.6.84*/10.9.84*	96	Rice (Co 43) 7.10.84*/17.1.85*	103	Finger millet (Co 11) 6.2.85*/8.5.85*	92	291
	C4: Rice (IR 50) 7.6.84*/10.9.84*	96	Rice (Co 43) 7.10.84*/17.1.85*	103	Cotton (MCU 7) 5.2.85*/31.5.85*	116	313
Pattukkottai	I NEM season						
	C1:		Rice (IR 20) 15.1.86*/21.1.87*	99	Groundnut (Co 1) 21.2.87*/23.5.87*	92	191
	C2:		Rice (IR 20) 15.1.86*/21.1.87*	99	Soybean (Co 1) 21.2.87*/18.5.87*	87	186
	C3:		Rice (IR 20) 15.1.86*/21.1.87*	99	Maize (COH 1) 22.2.87*/23.5.87*	91	190
C4:			Rice (IR 20) 15.1.86*/21.1.87*	99	Sesame (TAM 6) 22.2.87*/7.5.87*	75	174

* - Date of sowing

+ - Date of planting

+ - Date of harvest

Main plot treatments : Cropping systems

I Crop		II Crop		III Crop
South West Monsoon (SWM) Season		North East Monsoon (NEM) Season		Summer
JUN-SEP. 1984		OCT. 1984-JAN. 1985		FEB-MAY 1'
C_1	: Rice (IR 50)	-	Rice (Co 43)	- Rice (IR 50)
C_2	: Rice (IR 50)	-	Rice (Co 43)	- Soybean (Co
C_3	: Rice (IR 50)	-	Rice (Co 43)	- Finger mille (Co 11
C_4	: Rice (IR 50)	-	Rice (Co 43)	- Cotton (MC)
Sub plot treatments		: Levels (K) and season of application of K (S)		

K_0 : Control (No K application)

$K_1 S_1$: 50% recommended K to the first (SWM) crop alone

$K_1 S_2$: 50% recommended K to the second (NEM) crop alone

$K_1 S_3$: 50% recommended K to the third (Summer) crop alone

$K_1 S_4$: 50% recommended K to all the three crops

$K_2 S_1$: 100% recommended K to the first (SWM) crop alone

$K_2 S_2$: 100% recommended K to the second (NEM) crop alone

$K_2 S_3$: 100% recommended K to the third (Summer) crop alone

$K_2 S_4$: 100% recommended K to all the three crops

Location : Pattukottai
 Design : Split plot
 Main plot treatments : Cropping systems

I Crop		II Crop	
North East Monsoon (NEM) Season		Summer	
OCT. 1986-JAN. 1987		FEB.-MAY 1987	
C ₁	: Rice (IR 20)	-	Groundnut (Co 1)
C ₂	: Rice (IR 20)	-	Soybean (Co 1)
C ₃	: Rice (IR 20)	-	Maize (CoH 1)
C ₄	: Rice (IR 20)	-	Sesame (TMV 6)

Sub plot treatments : Levels (K) and season of application of K¹(S)

K₀ : Control (No K application)

K₁S₁ : 50% recommended K to the first (NEM) crop alone

K₁S₂ : 50% recommended K to the second (Summer) crop alone

K₁S₃ : 50% recommended K to both the crops

K₂S₁ : 100% recommended K to the first (NEM) crop alone

K₂S₂ : 100% recommended K to the second (Summer) crop alone

K₂S₃ : 100% recommended K to both the crops

Plot size

The gross plot size was uniform for all the crops while the net plot size varied with the crops as detailed below:

Crop	Gross plot	Net plot
Coimbatore		
SWM Rice	5.6 x 3.6 m	5.0 x 3.3 m
NEM Rice	5.6 x 3.6 m	5.0 x 2.8 m
Summer Rice	5.6 x 3.6 m	5.0 x 2.8 m
Soybean	5.6 x 3.6 m	5.0 x 3.3 m
Finger millet	5.6 x 3.6 m	5.0 x 3.3 m
Cotton	5.6 x 3.6 m	5.0 x 2.4 m
Pattukottai		
Rice	5.0 x 4.0 m	4.60 x 3.60 m
Groundnut	5.0 x 4.0 m	4.65 x 3.30 m
Soybean	5.0 x 4.0 m	4.70 x 3.30 m
Maize	5.0 x 4.0 m	4.60 x 2.80 m
Sesame	5.0 x 4.0 m	4.50 x 3.30 m

The layout details are presented in Fig. 2a and 2b.

3.2.2. Field preparation

3.2.2.1. Coimbatore

The previous crop was bulk greengram. The field was initially ploughed well and two puddlings were given with iron plough. Each plot was enclosed by bunds of 20 cm height with a gap of 30 cm buffer channel between two bunds to safeguard against the entry of water and to minimise the movement of nutrients from one plot to another. Then the test crop sequence was raised as described in 3.2.1. Actual experiment was started in June, 1984 with the planting of SWM rice.

3.2.2.1.1. Rice

Rice nursery was raised separately. During SWM season, rice seedlings were planted at a spacing of 15 x 10 cm. After the harvest of SWM rice, water was let in and the plots were prepared by digging with mammutty with manual labour without disturbing the bunds so as to keep the plots intact without the soil of adjacent plots getting mixed up. The rice crop stubbles were incorporated into the soil. The plots were then levelled with hand levelling board. In all the cropping systems during NEM season and in C_1 system during summer, rice seedlings were planted with two seedlings per hill with the spacing of 20 x 10 cm.

3.2.2.1.2. Soybean, Finger millet and Cotton

After the harvest of NEM rice crop, one irrigation was given to all the plots in C_2 , C_3 and C_4 systems. Mammutty digging was given without

FIG. 2 a. EXPERIMENTAL FIELD LAY OUT PLAN- COIMBATORE



R I	C ₁	K ₂ S ₃	K ₁ S ₃	K ₁ S ₄	K ₁ S ₁	K ₂ S ₂	K ₂ S ₄	K ₂ S ₁	K ₀	K ₁ S ₂
	C ₃	K ₂ S ₄	K ₁ S ₄	K ₁ S ₃	K ₂ S ₂	K ₀	K ₂ S ₁	K ₁ S ₂	K ₂ S ₃	K ₁ S ₁
	C ₄	K ₂ S ₃	K ₁ S ₂	K ₁ S ₁	K ₂ S ₂	K ₂ S ₄	K ₀	K ₁ S ₃	K ₂ S ₁	K ₁ S ₄
	C ₂	K ₁ S ₁	K ₂ S ₂	K ₂ S ₄	K ₂ S ₁	K ₁ S ₄	K ₀	K ₁ S ₂	K ₂ S ₃	K ₁ S ₃
R II	C ₁	K ₁ S ₄	K ₁ S ₁	K ₂ S ₃	K ₁ S ₃	K ₂ S ₂	K ₁ S ₂	K ₂ S ₁	K ₀	K ₂ S ₄
	C ₃	K ₂ S ₃	K ₁ S ₁	K ₁ S ₄	K ₂ S ₂	K ₀	K ₂ S ₄	K ₁ S ₂	K ₂ S ₁	K ₁ S ₃
	C ₂	K ₂ S ₁	K ₂ S ₄	K ₁ S ₄	K ₁ S ₃	K ₂ S ₂	K ₁ S ₁	K ₂ S ₃	K ₁ S ₂	K ₀
	C ₄	K ₁ S ₄	K ₂ S ₂	K ₁ S ₃	K ₂ S ₃	K ₂ S ₄	K ₁ S ₁	K ₂ S ₁	K ₁ S ₂	K ₀
R III	C ₂	K ₂ S ₄	K ₁ S ₁	K ₁ S ₂	K ₀	K ₁ S ₃	K ₂ S ₂	K ₂ S ₃	K ₂ S ₁	K ₁ S ₄
	C ₄	K ₂ S ₃	K ₁ S ₄	K ₂ S ₄	K ₀	K ₁ S ₁	K ₂ S ₁	K ₂ S ₂	K ₁ S ₃	K ₁ S ₂
	C ₃	K ₂ S ₁	K ₂ S ₂	K ₁ S ₂	K ₂ S ₄	K ₁ S ₄	K ₁ S ₁	K ₂ S ₃	K ₀	K ₁ S ₃
	C ₁	K ₁ S ₃	K ₂ S ₁	K ₂ S ₂	K ₁ S ₂	K ₁ S ₁	K ₂ S ₃	K ₁ S ₄	K ₀	K ₂ S ₄

3.6 m
5.6 m

FIG. 2 b. EXPERIMENTAL FIELD LAY OUT PLAN - PATTUKOTTAI



R I				R II				R III				E 0.5
C ₂	C ₄	C ₁	C ₃	C ₁	C ₃	C ₂	C ₄	C ₃	C ₁	C ₂	C ₄	
K ₂ S ₃	K ₀	K ₂ S ₂	K ₂ S ₃	K ₁ S ₃	K ₁ S ₁	K ₁ S ₂	K ₀	K ₁ S ₁	K ₂ S ₁	K ₂ S ₂	K ₂ S ₂	4.0m
K ₂ S ₂	K ₂ S ₂	K ₂ S ₁	K ₂ S ₂	K ₀	K ₂ S ₁	K ₂ S ₂	K ₂ S ₃	K ₀	K ₁ S ₁	K ₂ S ₁	K ₂ S ₃	
K ₁ S ₁	K ₁ S ₁	K ₂ S ₃	K ₁ S ₃	K ₂ S ₂	K ₂ S ₂	K ₂ S ₃	K ₂ S ₂	K ₁ S ₂	K ₂ S ₂	K ₁ S ₂	K ₀	
K ₀	K ₂ S ₃	K ₁ S ₃	K ₀	K ₂ S ₃	K ₁ S ₂	K ₀	K ₁ S ₃	K ₂ S ₃	K ₁ S ₃	K ₂ S ₃	K ₁ S ₁	
K ₁ S ₃	K ₂ S ₁	K ₁ S ₁	K ₁ S ₁	K ₁ S ₁	K ₂ S ₃	K ₁ S ₃	K ₁ S ₁	K ₂ S ₁	K ₁ S ₂	K ₀	K ₂ S ₁	
K ₂ S ₁	K ₁ S ₂	K ₁ S ₂	K ₁ S ₂	K ₁ S ₂	K ₀	K ₁ S ₁	K ₁ S ₂	K ₁ S ₃	K ₂ S ₃	K ₁ S ₁	K ₁ S ₂	4.0m
K ₁ S ₂	K ₁ S ₃	K ₀	K ₂ S ₁	K ₂ S ₁	K ₁ S ₃	K ₂ S ₁	K ₂ S ₁	K ₂ S ₂	K ₀	K ₁ S ₃	K ₁ S ₃	

disturbing the bunds. The NEM rice crop stubbles were also incorporated into the soil. Then the clods were broken and levelled by manual labour. A vertical trench of 5 cm width and 45 cm depth was dug up in the buffer channel separating the summer rice crop plots with other gardenland crop plots and thick polythene sheet was inserted in the trench and compacted with soil so as to prevent water entering into the adjacent gardenland crop plots by seepage from the flooded rice crop plots.

In C_2 system, soybean was sown with a spacing of 30 cm between rows and 10 cm between plants.

Finger millet nursery was raised in a well ploughed land. Twenty days old seedlings were transplanted in C_3 system with a spacing of 15 x 15 cm.

Acid delinted cotton seeds were dibbled in dried banana leaf cups filled with red earth and farm yard manure. Twenty five days old seedlings were planted in the main field at 60 x 30 cm spacing.

3.2.2.2. Pattukottai

The previous crop was bulk greengram. The field was ploughed well with bullock drawn borse plough. Water was let into the field and bunds of 15 cm height were formed around each plot with 30 cm buffer channel between adjacent plots. Actual experiment at Pattukottai was started in October, 1986 with the planting of NEM rice.

3.2.2.2.1. Rice

Rice nursery was raised separately. Rice seedlings were planted at

a spacing of 20 x 10 cm.

3.2.2.2.2. Groundnut, Soybean, Maize and Sesame

After the harvest of NEM rice crop, mammutty digging was given to all the plots. The bunds were not disturbed keeping the soil in each plot intact. The rice crop stubbles were incorporated into the soil. Then the clods were broken and levelled by manual labour.

In C_1 system, groundnut was sown with a spacing of 45 x 15 cm.

In C_2 system, soybean seeds were sown with a spacing of 30 cm between rows and 10 cm between plants.

In C_3 system, maize seeds were dibbled at a spacing of 60 x 20 cm.

In C_4 system, sesame seeds were dibbled with 45 x 30 cm spacing.

3.2.3. Fertiliser application

Recommended dose of fertilisers to crops as per Crop Production Manual :

Crop	Fertiliser N	nutrient P_2O_5	($Kg\ ha^{-1}$) K_2O
Rice	100.0	50.0	50.0
Soybean	20.0	80.0	40.0
Finger millet	60.0	30.0	30.0
Cotton	60.0	30.0	30.0
Groundnut	17.5	35.0	54.0
Maize	125.0	52.5	50.0
Sesame	35.0	22.5	24.0

3.2.3.1. Method of fertiliser application

The fertilisers were applied as detailed below:

a. Coimbatore	N	P	K
	(of the total dose)		
Rice - Basal dressing	Half	Full	-
Top dressing - I (25 DAP)	Quarter	-	Half
Top dressing - II (45 DAP)	Quarter	-	Half
Other Crops - Basal dressing	Half	Full	Half
Top dressing - I (25 DAS/ DAP)	Quarter	-	Quarter
Top dressing - II (45 DAS/ DAP)	Quarter	-	Quarter
b. Pattukottai			
Rice - Basal dressing	Half	Full	Half
Top dressing - I (25 DAP)	Quarter	-	Quarter
Top dressing - II (45 DAP)	Quarter	-	Quarter
Other Crops - Basal dressing	Half	Full	Half
Top dressing - I (25 DAS)	Quarter	-	Quarter
Top dressing - II (45 DAS)	Quarter	-	Quarter

Urea containing 46 per cent N, super phosphate with 16 per cent P_2O_5 content and muriate of potash containing 60 per cent K_2O were used for the field experiments.

In rice, fertilisers were broadcast and incorporated into the soil. In other crops, fertilisers were placed in 5 cm deep lines 5 cm away from the seed rows and covered with soil.

Gap filling, thinning, weeding, regular plant protection measures and irrigation were done as per the package of practices for each crop.

3.2.4. Biometric Observations

In the net plot area, five plants per hills were selected at random and tagged. The biometric observations were recorded on the tagged plants and the mean value per plant was worked out.

3.2.4.1. Plant height

The height of the plant in rice, soybean, finger millet, cotton, groundnut, maize and sesame was measured at flowering stage and expressed in cm.

3.2.4.2. Dry matter production (DMP)

For estimating dry matter production, five plants from each plot of rice, soybean, finger millet, cotton, groundnut, maize and sesame were removed at flowering stage and at maturity, air dried and oven dried at 60 °C to a constant weight and the weight was recorded in an electric top pan balance. The dry matter production was calculated for one hectare.

3.2.5. Rice

3.2.5.1. Growth attributes

3.2.5.1.1. Leaf area index (LAI)

Five plants per plot, tagged at random for the estimation of plant height were used for the estimation of LAI by length-width method suggested by Palaniswamy and Gomez (1974).

$$LAI = \frac{L \times W \times K \times \text{Number of leaves/hill}}{\text{Spacing adopted (cm}^2\text{)}}$$

Where L = Length of the third leaf blade from the top (cm)

W = Maximum width of the same leaf blade (cm)

K = A constant factor of 0.75 for wet and 0.73 for dry season

3.2.5.2. Yield attributes

3.2.5.2.1. Number of productive tillers

The average number of productive tillers per hill was recorded at maturity from the tagged plants.

3.2.5.2.2. Percentage of filled grains

At harvest, five panicles were taken from five tagged plants and the number of filled grains per panicle was counted and expressed as percentage of filled grains.

3.2.5.2.3. Thousand grain weight

Thousand well filled grains were collected at harvest from each plot and their weight was determined at 14 per cent moisture.

3.2.5.2.4. Harvest Index (HI)

After the estimation of dry grain weight and total dry weight, the harvest index was worked out as follows:

$$\text{Harvest Index} = \frac{\text{Dry grain weight}}{\text{Total dry weight}}$$

3.2.6. Soybean

3.2.6.1. Growth attributes

3.2.6.1.1. Leaf area index (LAI)

Individual leaf area was measured by using automatic leaf area meter (model L.I.3000). The leaf area index was calculated using the formula given below:

$$LAI = \frac{\text{Total leaf area per plant (cm}^2\text{)}}{\text{Ground area per plant (cm}^2\text{)}}$$

LAI was recorded at peak flowering stage.

3.2.6.2. Yield attributes

3.2.6.2.1. Number of pods per plant

Total number of pods in tagged plants were counted at harvest and recorded.

3.2.6.2.2. Seeds per pod

The average number of seeds in pods from tagged plants were recorded.

3.2.6.2.3. Hundred seed weight

One hundred seeds were taken from each plot and their weight was recorded at 8 per cent moisture.

3.2.6.2.3. Quality characters

3.2.6.2.3.1. Oil content

The oil content of seeds was estimated using the NMR spectroscopy.

3.2.6.3.2. Crude protein content

The seed crude protein was estimated from oil free meal by finding out the nitrogen content as suggested by Humphries (1956) and it was multiplied by the factor 6.25 (Alikhan and Youngs, 1973).

3.2.7. Finger millet

3.2.7.1. Leaf area index (LAI)

Leaf area was computed using the formula: length x breadth of 5th leaf x 8.773. The LAI was calculated by dividing the leaf area by the unit land area occupied by the plant adopting the procedure suggested by Rajappa et al. (1972).

3.2.7.2. Yield attributes

3.2.7.2.1. Number of productive tillers

Total number of productive tillers were counted from the tagged plants at harvest.

3.2.7.2.2. Thousand grain weight

One thousand grains from each plot were counted and weighed.

3.2.8. Cotton

3.2.8.1. Leaf area index (LAI)

Leaf area was measured as suggested by Iruthayaraj and Sivaraj (1979). The LAI was computed by dividing the leaf area of a plant by the land area occupied by it.

3.2.8.2. Yield attributes

3.2.8.2.1. Number of sympodia

The sympodial branches arising from extra-^uaxillary buds were counted at maturity.

3.2.8.2.2. Number of fruiting points

The total number of fruiting points per plant at harvest was recorded.

3.2.8.2.3. Number of bolls per plant

The total number of bolls picked at each picking till the completion of harvest were summed up.

3.2.8.4. Quality characters

3.2.8.4.1. Ginning percentage

Duplicate samples of 100 seed cotton were weighed and the lint and seed were separated in a laboratory gin. The ratio of weight of lint to weight of seed cotton was expressed as percentage (Santhanam, 1976).

3.2.8.3.2. Bartlett's earliness index

Earliness of the crop under various treatments was estimated by

means of assessing Bartlett's index (Bartlett, 1947) having a basis on the quantity of cotton obtained at every picking, and the formula used for computation was as follows:

$$B.I. = P_1 + (P_1 + P_2) + (P_1 + P_2 + P_3) + (P_1 + P_2 + P_3 + \dots + P_n)$$

where B.I. = Bartlett's Index

P_1, P_2, P_3 and P_n = Seed cotton picked in first, second, third and nth picking respectively and

n = Total number of pickings

3.2.8.3.3. Mean fibre length

The mean fibre length was determined by 'Ball's sorter' where the weight ratio method was adopted and expressed in mm (Sundaram and Iyengar, 1968).

3.2.8.3.4. Mean fibre fineness

It is the measure of fibre weight in g per g unit length of fibre. It was determined by air flow method with the help of micronaire.

3.2.8.3.5. Bundle strength

It is the ratio of the breaking strength of a bundle of fibres to its weight. Duplicate tufts of fibres, weighing one mg, were fed into the "Pressley Strength Tester", which gives reading in lb per mg. The value was expressed in g per tex by multiplying the Pressley Strength index with factor 5.36.

3.2.8.3.6. Maturity co-efficient

It is the ratio of the mature, half mature and immature fibres in a sample of lint. It was determined by using micronaire instrument by air flow method as suggested by Sundaram and Iyengar (1968). A sample of 3.24 g of lint was fed into the instrument and compressed air was allowed to pass through the sample with and without spacer and the differences between the two readings were noted and referred to a standard table which gives the maturity co-efficient directly.

The above fibre quality characters were determined at the Cotton Technological Research Laboratory Unit, Tamil Nadu Agricultural University ^{Campus,} Coimbatore.

3.2.9. Groundnut

3.2.9.1. Growth attributes

3.2.9.1.1. Leaf area index (LAI)

Leaf area was calculated by the following method suggested by Saxena et al. (1972).

Leaf area = Length X width at maximum X 0.7651

Then, the leaf area index was computed by dividing the leaf area by the land area occupied by it.

3.2.9.2. Yield attributes

3.2.9.2.1. Shelling percentage

One hundred pods were randomly selected from each plot, weighed, shelled and the weight of the kernels was recorded. From this, shelling per cent was calculated.

3.2.9.22. Hundred kernel weight

The total weight of 100 kernels of representative sample was recorded for each plot.

3.2.9.3. Quality character

The oil content of kernel was estimated by Nuclear Magnetic Resonance Instrument (Bruker mini spec p 20 i) and expressed as percentage.

3.2.10. Maize

3.2.10.1. Growth attributes

3.2.10.1.1. Leaf area index (LAI)

Leaf area was measured by using the method suggested by Hunter et al. (1970). Fourth leaf from the top was taken as the standard leaf for the measurement of maximum length and width.

$$LAI = \frac{L \times B \times 0.75 \times \text{Number of leaves/plant}}{\text{Spacing (cm}^2\text{)}}$$

Where L = Length of the leaf in cm

B = Breadth of the leaf in cm

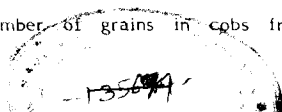
3.2.10.2. Yield attributes

3.2.10.2.1. Number of rows of grain per cob

The total number of rows of grains in cobs collected from the tagged plants were counted and recorded.

3.2.10.2.2. Number of grains per row

The average number of grains in cobs from tagged plants were counted.



3.2.10.2.3. Hundred grain weight

Hundred grains were collected at random from each of the five selected cobs in each plot.

3.2.11. Sesame

3.2.11.1.1. Leaf area index (LAI)

The leaf area on 60th day after sowing was estimated based on the dry weight method as suggested by Winter *et al.* (1956). Then the leaf area was divided by the land area occupied by the plant to estimate the LAI.

3.2.11.2. Yield attributes

3.2.11.2.1. Number of capsules per plant

The total number of capsules in live tagged plants were counted and recorded.

3.2.11.2.2. Length of capsule

Five randomly selected capsules from the tagged plants were taken and the length of capsule was measured.

3.2.11.2.3. Thousand seed weight

One thousand well filled seeds were counted and their weight were recorded.

3.2.11.3. Quality Character

3.2.11.3.1. Oil content

The oil content of seed was estimated by Nuclear Magnetic Resonance Instrument (Bruker mini spec p 20 i) and expressed as percentage.

3.2.12. Crop residue addition

Rice crop residue addition after the harvest of crop was estimated. A sample pit of 50 x 50 cm size and 30 cm depth was dug up and the soil removed from the pit was sieved in water, residues were separated and dried in oven to constant weight. The residues added were accounted for only for the SWM season rice and NEM season rice at Coimbatore and NEM season rice at Pattukottai.

3.2.13. Evaluation of cropping system

3.2.13.1. Biological production potential

Biological production potential of each cropping system was determined by adding the total above ground biomass produced by the component crops and expressed in $t\ ha^{-1}$.

3.2.13.2. Production potential in terms of rice grain equivalent

Rice grain equivalent was worked out by converting the economic yield of crops other than rice in terms of rice grain yield on the basis of marketable price ratio. This was worked out as per the formula:

$$EAY = \frac{VI}{VA}$$

Where, EAY = Main crop equivalent yield

VI = Economic value of crops in the cropping system

VA = Price of paddy grain kg^{-1}

3.2.13.3. Energy efficiency

Cultural energy used through various inputs in each cropping system was computed (Dazhong and Pimental, 1984) and the energy ratio was

worked out as follows :

$$\text{Energy ratio} = \frac{\text{Energy output (MJ ha}^{-1}\text{)}}{\text{Energy input (MJ ha}^{-1}\text{)}}$$

3.2.13.4. Specific energy

Specific energy of each system was calculated in terms of energy required to produce a tonne of economic yield and expressed as (Mega Joules/tonne) MJ t⁻¹.

The energy contents of various inputs are presented in Appendix II. (Mittai *et al.* 1985).

3.2.13.5. Economic evaluation of cropping system

Records of all inputs used, labour employed etc. were maintained for all the crops and the total variable cost (TVC) for each cropping system was worked out in Appendix IIIa and IIIb. In working out gross returns, the by-products were also considered. Prevailing prices of the produces are furnished in Appendix IV. From the gross returns and TVC, net returns and benefit cost ratio were calculated.

3.2.14. Chemical analysis

3.2.14.1. Soil analysis

Pre sowing composite samples collected from the experimental areas were analysed for mechanical and chemical properties such as organic carbon, available N, available P, water soluble K, exchangeable K, non-exchangeable K, total K, pH and EC. Post-harvest soil samples were

collected from each plot, dried under shade and analysed for the following constituents.

3.2.14.1.1. Soil organic carbon

This was estimated by the wet digestion method of Walkley and Black (1934) and expressed in percentage.

3.2.14.1.2. Available N

Available N was estimated by the method suggested by Subbiah and Asija (1956) and expressed in kg ha^{-1} .

3.2.14.1.3. Available P

Available P was estimated by the method of Olsen *et al.* (1954) and expressed as kg ha^{-1} .

3.2.14.1.4. Potassium

Hydrochloric acid extract

The ignited soil sample was digested with 30 ml of concentrated HCl on a sand bath for six hours and the acid extract was filtered, residue was washed free of chloride and made up to 500 ml (Piper, 1966).

3.2.14.1.4.1. Total potassium

Total K was determined in a known volume of HCl extract of the soil after neutralising with ammonia using flame photometer.

3.2.14.1.4.2. Water soluble K

A 10 g soil sample was taken in a shaking bottle and 25 ml of distilled water was added and shaken for one hour. Then it was ^{on} centrifuged and the clear supernatant liquid was filtered completely. The K in this water extract was determined using flame photometer (Stanford and English, 1949).

3.2.14.1.4.3. Exchangeable K

To the above soil in the shaking bottle, 25 ml of neutral normal NH_4OAc solution was added, shaken for five minutes and then filtered. The soil residue in the shaking bottle was completely transferred to the filter paper using small quantities of ammonium acetate solution. Then the soil was washed repeatedly with normal NH_4OAc solution and the volume of the filtrate was made up to 100 ml. Exchangeable K in the solution was estimated by using flame photometer (Toth and Prince, 1949; Stanford and English, 1949).

3.2.14.1.4.4. Available K

The water soluble K and the exchangeable K estimated from the above were added to arrive at the available K.

3.2.14.4.5. Non-exchangeable K

The soil residue in the filter paper obtained after the estimation of exchangeable K was transferred into a conical flask with 25 ml of 1 N HNO_3 . It was boiled for 10 minutes, cooled and filtered. Then the soil was washed a number of times with 0.1 N HNO_3 and the volume of the filtrate was made up to 100 ml and the K in the filtrate was estimated using flame

photometer (Wood and DeTurk, 1940).

3.2.14.1.4.6. Electro-ultrafiltration (EUF) $\pm$ K

Composite soil samples drawn at the commencement of the field experiments and post-harvest of crops in cropping systems were analysed for the EUF-K by using Vogel Model 723 programmed EUF equipment at Potash Research Institute of India, Gurgaon, Haryana. The cell consisted of three detachable compartments. The central compartment contained soil suspension, the two other compartments contained platinum-grid electrodes separated from the soil suspension by specially prepared micropore filters. Voltages applied across the electrodes were 50 V for 0-5 minutes (field strength: 11.1 V cm^{-1}), 200 V for 5-30 minutes (field strength: 44.4 V cm^{-1}) and 400 V for 30-35 minutes (field strength: 88.8 V cm^{-1}). Ions attached to the electrodes were carried through the filters in a steady stream of water by applying negative pressure (Ca. 80 KPa) to the two other compartments. Samples containing 5 g of oven-dry soil ($< 2 \text{ mm}$) were stirred vigorously ($2000 \text{ revolutions min}^{-1}$) with 50 mm^3 distilled water in the central compartment with the temperature held at $20 \pm 2^\circ \text{ C}$ by water cooling. Amounts of K extracted during five minutes intervals (seven fractions of 5 minutes each upto 35 minutes) were plotted against time to give conventional EUF graphs. The rate of desorption of EUF-K was expressed as $\text{mg}/100 \text{ g of soil}/5 \text{ min}$. (Nemeth, 1979).

3.2.14.1.4.7. Soil potassium balance

Soil potassium balance in the cropping systems was worked out as per the procedure adopted by Sadanandan and Mahapatra (1973).

3.2.14.2. Plant analysis

The plant samples collected for dry matter estimation were chopped and ground into fine powder in a Willey mill. The powdered material was used for chemical analysis and to determine the uptake of major nutrients.

3.2.14.2.1. Nitrogen

The N content was estimated by Kjeldahl method (Yoshida *et al.*, 1976) and uptake was computed by multiplying the nutrient content with yield of dry matter and expressed in Kg ha^{-1} .

3.2.14.2.2. Phosphorus

The P content in plants was estimated by Calorimetric method (Yoshida *et al.*, 1976) and uptake expressed in Kg ha^{-1} .

3.2.14.2.3. Potassium

The K content was determined by using flame photometer and uptake expressed in Kg ha^{-1} (Yoshida *et al.*, 1976).

3.2.15. Statistical analysis

The statistical analysis of the data was carried out by adopting the method described by Panse and Sukhatme (1978). The data for the characters studied under different treatments in the individual crops were analysed statistically by factorial randomised block design and the data in respect of cropping systems were analysed by split plot design. Results are presented at 5 per cent probability level uniformly.

RESULTS

CHAPTER IV

RESULTS

The results of the experiments conducted to develop potassium management practices for rice based cropping systems are presented in this chapter.

4.1. Coimbatore

4.1.1. Response of component crops to potassium fertilisation

4.1.1.1. Rice - South West Monsoon (SWM) season

4.1.1.1.1. Growth and yield attributes (Table 4)

Different levels of K did not influence the plant height, Leaf Area Index (LAI) and dry matter production (DMP) at flowering stage and at maturity were positively influenced by K fertilisation. Even though K_{25} and K_{50} were on par, they increased the LAI and DMP at maturity over the control. At flowering stage, K_{50} level increased the DMP over K_{25} level.

Application of $50 \text{ kg } K_2O \text{ ha}^{-1}$ (K_{50}) increased the productive tillers and filled grains compared to control. However, it was on par with K_{25} level in influencing the productive tillers. Potassium fertilisation did not enhance the test grain weight considerably.

4.1.1.1.2. Uptake of nutrients (Table 5)

The K levels (K_{25} and K_{50}) significantly enhanced the uptake of

Table 4. Growth and yield attributes of rice - SWM season, 1984

	At flowering stage		DMP (t ha ⁻¹)	DMP at maturity (t ha ⁻¹)	Productive tillers m ⁻²	Filled grains (%)	1000 grain weight (g)
	Plant height (cm)	LAI					
K ₂₅	62.1	4.93	6.13	12.53	578	84.3	20.31
K ₅₀	62.2	5.01	6.56	12.69	591	88.2	20.49
K ₀	61.4	4.17	5.78	12.10	561	83.6	20.31

	SE _D		CD		SE _D		CD		SE _D		CD		SE _D		CD		SE _D		CD		SE _D		CD	
	(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)		(P=0.05)	
K ₂₅ vs K ₅₀	0.55	NS	0.08	NS	0.100	0.198	0.147	NS	14.7	NS	0.85	1.68	0.13	NS										
K ₂₅ vs K ₀	0.49	NS	0.07	0.14	0.090	0.179	0.132	0.263	13.3	NS	0.77	NS	0.11	NS										
K ₅₀ vs K ₀	0.38	NS	0.06	0.11	0.069	0.137	0.102	0.202	10.2	20.3	0.59	1.17	0.09	NS										

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹.

NPK at flowering stage against the control. However, K_{50} level was superior over K_{25} level in the uptake of P and K.

The highest level of K (K_{50}) resulted in greater uptake of N and K at maturity than that of K_{25} level and control. But it did not differ from K_{25} level in P uptake.

4.1.1.1.3. Grain and straw yields and harvest index (Table 6)

Potassium application considerably increased the grain yield of SWM rice. However, K_{25} and K_{50} levels increased the grain yield in similar magnitudes. The straw yield did not increase due to K fertilisation. The harvest index was positively influenced by K application at K_{25} and K_{50} levels compared to control.

4.1.1.1.4. Post-harvest soil nutrient content (Table 7)

Soil organic carbon content post harvest of SWM rice was significantly increased by K fertilisation. However, K_{25} and K_{50} levels produced comparable increase on soil organic carbon content. The soil available N content exhibited the same pattern as that of soil organic carbon content. The highest level of K (K_{50}) increased the soil available P compared to K_{25} level and control. The soil available K and non-exchangeable K content did not vary considerably due to K fertilisation and K levels.

4.1.1.2. Rice - North East Monsoon (NEM) season

4.1.1.2.1. Growth attributes (Table 8)

The plant height at flowering stage of NEM rice was favourably

Table 6. Grain and straw yields (kg ha^{-1}) and harvest index of rice - SWM season, 1984

	Grain yield	Straw yield	Harvest index
K_{25}	5253	6604	0.443
K_{50}	5351	6664	0.446
K_0	4910	6512	0.430

	SE _D	CD ($P=0.05$)	SE _D	CD ($P=0.05$)	SE _D	CD ($P=0.05$)
K_{25} vs K_{50}	62	NS	91	NS	0.0019	NS
K_{25} vs K_0	56	111	82	NS	0.0017	0.0034
K_{50} vs K_0	43	85	63	NS	0.0013	0.0026

K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1} .

Table 7. Post-harvest soil organic carbon (%), available macronutrients and non-exchangeable (kg ha⁻¹)

- SWM season, 1984

	Organic carbon	Available N	Available P	Available K	Non-exchangeable K					
K ₂₅	0.626	221.8	19.3	458.1	1435					
K ₅₀	0.639	225.4	21.3	462.7	1432					
K ₀	0.606	210.7	19.1	452.4	11429					
	SE _D	CD ⁺ (P=0.05)	SE _D	CD ⁺ (P=0.05)	SE _D	CD ⁺ (P=0.05)				
K ₂₅ vs K ₅₀	0.0085	NS	4.3	NS	0.8	1.6	4.5	NS	2.3	NS
K ₂₅ vs K ₀	0.0077	0.0153	5.4	10.7	0.7	NS	5.1	NS	3.5	NS
K ₅₀ vs K ₀	0.0059	0.0108	4.2	8.3	0.5	1.1	7.3	NS	3.1	NS

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹.

influenced by the application of $50 \text{ K}_2\text{O ha}^{-1}$ (K_{50}). The residual effect (R_1) or direct effect (D) or the cumulative effect (R_1D) did not produce any marked change in plant height.

Higher level of K (K_{50}) recorded higher values of LAI. The cumulative effect of K application (R_1D) registered significantly higher values of LAI compared to the residual effect (R_1) and the direct effect of K (D). At K_{50} level, direct effect (D) and cumulative effect (R_1D) exhibited positive influence on LAI.

4.1.1.2.2. Dry matter production (DMP) (Table 9)

Potassium fertilisation considerably enhanced the DMP at flowering stage as well as at maturity. The K_{50} level increased the DMP over K_{25} level. The cumulative effect of K (R_1D) favourably influenced the DMP. However, it was on par with direct effect of K application (D).

4.1.1.2.3. Yield attributes (Table 10)

Among the yield attributes, the number of productive tillers was favourably influenced by K fertilisation. The test grain weight was not affected by K levels as well as by season of K application. But the K_{50} level increased the number of filled grains compared to that of K_{25} and control. With regard to the season of application, the residual effect (R_1) failed to influence the filled grain percentage favourably. The cumulative effect (R_1D) had a pronounced influence in increasing the filled grain percentage. However, the cumulative effect (R_1D) was on par with the direct effect (D) in influencing the filled grains.

Table 10. Yield attributes of rice - NEM season, 1984

	Productive tillers m ⁻²				Filled grains (%)				1000 grain weight (g)			
	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean
K ₂₅	363	386	391	380	81.7	83.2	84.9	83.2	21.40	21.39	21.40	21.40
K ₅₀	378	388	396	387	84.2	85.3	86.3	85.3	21.57	21.46	21.70	21.58
Mean	371	387	394	384	83.0	84.3	85.6	84.3	21.49	21.43	21.55	21.49
K ₀				372				81.0				21.31
			SE _D	CD (P=0.05)			SE _D	CD (P=0.05)			SE _D	CD (P=0.05)
K levels			9.5	NS			0.69	1.37			0.12	NS
Season of application			11.7	NS			0.85	1.68			0.19	NS
K levels x Season			16.5	NS			1.19	NS			0.21	NS
Control vs Rest			4.6	10.9			0.60	1.19			0.10	NS

R₁ - Residual effect of K applied during SWM season, 1984

D - Direct effect of K applied during NEM season, 1984

R₁D - Cumulative effect of K [Residual (R₁) + Direct (D)]

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹

4.1.1.2.4. Uptake of nutrients (Tables 11a and 11b)

The NPK uptake at flowering stage was favourably influenced by the K fertiliser application at 50 kg $K_2O\ ha^{-1}$ (K_{50}). The cumulative effect of K (R_1D) had pronounced influence on the uptake of NPK. The uptake of NPK nutrients at maturity also followed the same pattern as that observed at flowering stage.

4.1.1.2.5. Grain and straw yields and harvest index (Table 12)

The grain yield from K_{25} level was comparable with that of K_{50} . Both, these levels were superior to control. The direct effect (D) and cumulative effect (R_1D) did not differ in their influence on grain yield. Potassium application at 25 kg $K_2O\ ha^{-1}$ (K_{25}) and at 50 kg $K_2O\ ha^{-1}$ (K_{50}) increased the straw yield over that of control. The direct effect of K (D) had pronounced influence on straw yield than the residual effect (R_1). However, it was comparable with that of cumulative effect (R_1D).

Harvest index of NEM rice was not influenced by K fertilisation as well as by season of application.

4.1.1.2.6. Post harvest soil nutrient content (Table 13a and 13b)

The soil organic carbon content was enhanced with K_{50} treatment. The cumulative effect of K (R_1D) considerably elevated soil organic carbon content as well as available N content.

The post harvest soil available P was higher in control treatment. Application of K at 50 kg $K_2O\ ha^{-1}$ (K_{25}) resulted in higher soil available

Table 11a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of rice - NEM season, 1984

	N				P				K			
	Residual (R_1)		Direct (D)		Residual (R_1)		Direct (D)		Residual (R_1)		Direct (D)	
	Mean	Cumulative ($R_1 D$)	Mean	Cumulative ($R_1 D$)	Mean	Cumulative ($R_1 D$)	Mean	Cumulative ($R_1 D$)	Mean	Cumulative ($R_1 D$)	Mean	Cumulative ($R_1 D$)
K_{25}	70.8	72.6	73.3	72.2	16.3	16.9	17.1	16.8	98.1	102.0	102.6	100.9
K_{50}	76.0	79.5	81.4	79.0	17.4	17.5	18.0	17.6	106.4	111.1	114.1	110.5
Mean	73.4	76.1	77.4	75.6	16.3	17.2	17.6	17.2	102.3	106.6	108.4	105.7
K_0	71.1				16.4				98.5			
	SE _D		CD (P=0.05)		SE _D		CD (P=0.05)		SE _D		CD (P=0.05)	
K levels	1.05		2.48		0.17		0.41		1.61		3.81	
Season of application	1.28		3.03		0.21		0.50		1.97		4.66	
K levels x Season	1.81		NS		0.30		NS		2.78		NS	
Control vs Rest	0.91		2.15		0.15		0.35		1.39		3.30	

R_1 - Residual effect of K applied during SWM season, 1984

D - Direct effect of K applied during NEM season, 1984

$R_1 D$ - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1}

Table 11b. Uptake of macronutrients (kg ha^{-1}) at maturity stage of rice - NEM season, 1984

	N				P				K			
	Residual (R_1)		Cumulative ($R_1 D$)		Residual (R_1)		Cumulative (R_1)		Residual (R_1)		Cumulative ($R_1 D$)	
	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean
K_{25}	87.2	91.9	92.2	90.4	27.8	28.6	28.8	28.4	129.9	137.6	127.9	135.5
K_{50}	91.2	94.2	95.0	93.5	28.4	29.2	30.3	29.3	136.2	139.7	141.5	139.1
Mean	89.2	93.1	93.6	92.0	28.1	28.9	29.6	28.9	133.1	138.7	139.7	137.3
K_0				87.6				27.8				131.0
				SE _D	CD (P=0.05)				SE _D	CD (P=0.05)		
K levels				0.81	1.92				0.18	0.41		
Season of application				0.94	2.22				0.21	0.51		
K levels x Season				1.63	NS				0.30	NS		
Control vs Rest				0.81	1.92				0.15	0.36		
				SE _D	CD (P=0.05)				SE _D	CD (P=0.05)		
K levels				0.81	1.92				1.42	3.37		
Season of application				0.94	2.22				1.74	4.13		
K levels x Season				1.63	NS				2.46	NS		
Control vs Rest				0.81	1.92				1.23	2.92		

R_1 - Residual effect of K applied during SWM season, 1984

D - Direct effect of K applied during NEM season, 1984

$R_1 D$ - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1} .

Table 12. Grain and straw yields (kg ha^{-1}) and harvest index of rice - NEM season, 1984

	Grain yield				Straw yield				Harvest index			
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean
K_{25}	4948	5054	5095	5032	7776	8235	8132	8048	0.389	0.380	0.385	0.385
K_{50}	5002	5162	5254	5139	8124	8417	8152	8231	0.381	0.385	0.392	0.386
Mean	4975	5108	5175	5086	7950	8326	8142	8139	0.385	0.383	0.389	0.386
K_0				4871				7795				0.385
K levels	SE_D			CD (P=0.05)	SE_D			CD (P=0.05)	SE_D			CD (P=0.05)
Season of application	46			NS	105			NS	0.003			NS
K levels x Season	34			80	129			305	0.004			NS
Control vs Rest	69			NS	182			NS	0.005			NS
	53			124	91			216	0.003			NS

R_1 - Residual effect of K applied during SWM season, 1984

D - Direct effect of K applied during NEM season, 1984

R_1D - Cumulative effect of K [$\text{Residual } (R_1) + \text{Direct } (D)$]

K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1} .

Table 13a. Post-harvest soil organic carbon (%) and available N and P (kg ha^{-1}) - NEM season, 1984

	N				P				K			
	Residual (R_1)		Cumulative ($R_1 D$)		Residual (R_1)		Cumulative ($R_1 D$)		Residual (R_1)		Cumulative ($R_1 D$)	
	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean	Direct (D)	Mean
K ₂₅	0.659	0.674	0.698	0.677	208.2	212.9	221.8	214.3	19.0	21.9	22.7	21.2
K ₅₀	0.712	0.721	0.736	0.723	204.3	214.8	225.0	214.7	22.6	24.1	25.3	24.0
Mean	0.686	0.698	0.717	0.700	206.3	213.9	223.4	214.5	20.8	23.0	24.0	22.6
K ₀				0.672				200.3				24.9
K levels	SE _D				SE _D				SE _D			
Season of application	0.008				0.015				6.12			
K levels x Season	0.009				0.019				7.49			
Control vs Rest	0.013				NS				10.59			
	0.007				0.026				5.30			
R ₁	- Residual effect of K applied during SWM season, 1984											
D	- Direct effect of K applied during NEI season, 1984											
R ₁ D	- Cumulative effect of K [Residual (R_1) + Direct (D)]											
K ₂₅	- 25 kg K ₂ O ha ⁻¹ ; K ₅₀ - 50 kg K ₂ O ha ⁻¹ .											

Table 13b. Post harvest soil K (kg ha^{-1}) - NEM season, 1984

	Available K			Non-exchangeable K		
	Residual (R_1)	Direct (D)	Cumulative ($R_1 + D$)	Mean	Residual (R_1)	Direct (D)
K_{25}	452.3	449.1	453.8	451.7	425	428
K_{50}	459.6	451.0	463.4	458.0	427	430
Mean	456.0	450.1	458.6	454.9	426	429
K_0				452.0		
			SE	CD (0.05)		SE
K levels			4.8	NS		2.2
Season of application			8.7	NS		4.2
K levels x Season			10.4	NS		6.0
Control vs Rest			3.9	NS		3.1
						CD (0.05)
						NS
						NS
						NS

K levels

Season of application

K levels x Season

Control vs Rest

 R_1 - Residual effect of K applied during SWM season, 1984

D - Direct effect of K applied during NEM season, 1984

 $R_1 + D$ - Cumulative effect of K [Residual (R_1) + Direct (D)] K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1} .

P compared to K_{25} level.

The post harvest soil available K and non-exchangeable K did not vary due to K fertilisation. The residual (R_1), direct (D) and cumulative (R_1D) effects also did not have any influence on soil available K and non-exchangeable K contents.

4.1.1.3. Rice - Summer, 1985

4.1.1.3.1. Growth attributes (Table 14)

There was marked difference in plant height at flowering stage due to K fertilisation. The cumulative effect of K (R_1R_2D) resulted in taller plants as compared to the residual effect (R_1 or R_2) and direct effect (D).

The K_{50} level recorded the highest LAI followed by K_{25} level and both of them were superior to control. The LAI values resulted from the direct application (D) and cumulative effect (R_1R_2D) were comparable.

4.1.1.3.2. Dry matter production (Table 15)

Higher DMP at flowering stage was recorded with the application of K at $25 \text{ kg } K_2O \text{ ha}^{-1}$ (K_{25}). It was comparable with that of K_{50} . Both of them were superior to control in enhancing the DMP. The cumulative effect (R_1R_2D) considerably increased the DMP compared to that of residual (R_1 and R_2) and direct (D) effects.

Potassium fertilisation appreciably increased the DMP at maturity.

Table 14. Growth attributes at flowering stage of rice - Summer, 1985

	Plant height (cm)				LAI					
	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean
K ₂₅	58.7	59.1	60.2	62.5	60.1	4.79	4.92	5.14	5.18	5.01
K ₅₀	59.7	60.5	63.5	63.9	61.9	5.08	4.99	5.51	5.95	5.38
Mean	59.2	59.8	61.9	63.2	61.0	4.94	4.96	5.33	5.57	5.20
K ₀	57.7									
					SE _D	CD (P=0.05)		SE _D	CD (P=0.05)	
K levels					0.92	NS		0.082	0.173	
Season of application					1.30	2.75		0.116	0.246	
K levels x Season					1.83	NS		0.164	NS	
Control vs Rest					1.37	2.91		0.123	0.260	

R₁ - Residual effect of K applied during SWM season, 1984

R₂ - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual (R₁R₂) + Direct (D)]

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹.

Table 15. Dry matter production ($t\ ha^{-1}$) of rice - Summer, 1985

	At flowering stage				At maturity stage					
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2+D)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2+D)	Mean
K ₂₅	5.57	5.69	5.70	6.02	5.75	13.48	13.59	13.67	14.28	13.76
K ₅₀	5.68	5.78	5.97	6.09	5.88	13.92	13.99	14.11	14.38	14.10
Mean	5.63	5.74	5.84	6.06	5.82	13.70	13.79	13.89	14.33	13.93
K ₀					5.11					12.30
K levels				SE _D	CD (P=0.05)			SE _D	CD (P=0.05)	
Season of application				0.160	NS			0.270	NS	
K levels x Season				0.153	0.323			0.381	NS	
Control vs Rest				0.319	NS			0.539	NS	
				0.239	0.507			0.404	0.857	

R₁ - Residual effect of K applied during SWM season, 1984

R₂ - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual (R_1+R_2) + Direct (D)]

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹.

However, K_{25} and K_{50} levels did not vary in their influence on DMP at maturity. The season of K application did not influence the DMP.

4.1.1.3.3. Yield attributes (Table 16)

Potassium application either at 25 kg $K_2O\ ha^{-1}$ (K_{25}) or at 50 kg $K_2O\ ha^{-1}$ (K_{50}) increased the number of productive tillers substantially. The cumulative effect (R_1R_2D) had positive influence on the productive tiller number. However, this was comparable with that of residual (R_2) and direct (D) effects.

The filled grains were increased by K fertiliser application. The K_{50} level produced higher number of filled grains than the K_{25} level. The season of application had no effect on filled grains.

Potassium fertiliser application at 50 kg $K_2O\ ha^{-1}$ (K_{50}) considerably increased the test grain weight compared to K_{25} level. The direct (D), residual (R_1 and R_2) and cumulative (R_1R_2D) effects did not have any favourable impact on test grain weight.

4.1.1.3.4. Uptake of nutrients (Tables 17a and 17b)

Potassium fertilisation considerably enhanced the uptake of N and K. Nevertheless, K_{25} and K_{50} levels resulted in comparable N and K uptake. The season of K application influenced the uptake of N and P at flowering stage. The cumulative effect of K application (R_1R_2D) resulted in higher uptake of N and P. The season of application did not have any effect on the uptake of K.

Table 16. Yield attributes of rice - Summer, 1985

	Productive tillers m^{-2}				Filled grains (%)				1000 grain weight (g)			
	Residual (R_1)		Cumulative ($R_1 R_2 D$)		Residual (R_1)		Cumulative ($R_1 R_2 D$)		Residual (R_1)		Cumulative ($R_1 R_2 D$)	
	Residual (R_1)	Direct (D)	Residual (R_2)	Mean	Residual (R_1)	Direct (D)	Residual (R_2)	Mean	Residual (R_1)	Direct (D)	Residual (R_2)	Mean
K ₂₅	473	493	507	518	498	84.33	86.17	87.73	86.07	19.37	19.40	19.53
												19.55
K ₅₀	493	517	520	538	517	88.30	90.43	88.97	89.23	19.30	20.07	20.07
												19.97
K ₇₅	483	505	514	528	503	86.32	88.30	88.35	87.65	19.58	19.74	19.99
												19.76
Mean												19.37
K ₀				451				78.13				
												CD (P=0.05)
												SE _D
K levels				SE _D								SE _D
Season of application				14.7	NS							0.18
K levels x Season				15.5	32.9							0.25
Control vs Rest				29.5	NS							0.35
				22.1	46.9							0.26
												NS
												NS
												NS

R_1 - Residual effect of K applied during SEM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 R_2$) + Direct (D)]

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹

Table 17a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of rice - Summer, 1985

Table 17a. Uptake of macronutrients (kg ha ⁻¹) at flowering stage of rice - Summer, 1983																				
	N					P					K									
	Residual (R ₁)		Residual (R ₂)		Mean	Residual (R ₁)		Residual (R ₂)		Mean	Residual (R ₁)		Residual (R ₂)		Mean					
	Direct (D)	Cumulative (R ₁ R ₂ D)	Direct (D)	Cumulative (R ₁ R ₂ D)		Direct (D)	Cumulative (R ₁ R ₂ D)	Direct (D)	Cumulative (R ₁ R ₂ D)											
K ₂₅	57.5	61.9	62.3	69.8	62.9	8.5	8.7	8.7	9.6	10.8	75.6	81.3	84.5	86.3	81.9					
K ₅₀	58.2	62.1	63.9	74.8	64.8	8.7	8.7	8.7	11.7	11.5	79.3	84.0	85.1	89.5	84.4					
Mean	57.9	62.5	63.1	72.3	63.9	8.6	8.7	8.7	10.7	11.2	77.5	82.7	84.8	87.9	83.2					
	51.8					7.8					71.5									
K ₀	SE _D					CD (P=0.05)					SE _D					CD (P=0.05)				
K levels	3.46					NS					0.68					NS				
Season of application	4.89					10.36					0.96					2.04				
K levels x Season	6.91					NS					1.36					NS				
Control vs Rest	5.18					11.00					1.02					NS				

Table 17b. Uptake of macronutrients (kg ha^{-1}) at maturity stage of rice - Summer, 1985

Table 17b. Uptake of macro-nutrients (kg ha ⁻¹) at maturity stage of rice - Summer, 1967															
	N				P				K						
	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	
K ₂₅	80.3	90.3	92.0	98.3	90.2	17.0	16.7	17.3	16.5	16.9	171.9	173.1	177.2	174.9	174.7
K ₅₀	88.3	91.0	101.4	114.2	98.7	17.7	16.3	18.2	17.5	17.4	172.3	176.3	178.2	189.9	179.3
Mean	84.3	90.7	96.7	106.3	94.5	17.3	16.5	17.8	17.0	17.1	172.1	176.0	177.7	182.1	177.0
K ₀					86.2				15.1						163.7
				SE _D		CD (P=0.05)			SE _D		CD (P=0.05)			SE _D	CD (P=0.05)
K levels				2.40	5.09				2.49	NS				1.37	3.96
Season of application				3.40	7.20				5.97	NS				2.44	5.60
K levels x Season				4.81	NS				1.38	NS				3.73	NS
Control vs Rest				3.60	7.64				1.73	NS				2.57	5.94

R₁ - Residual effect of K applied during SWM season, 1984R₂ - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual ($R_1 R_2$) - Direct (D)]K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹.

At maturity, N uptake was markedly enhanced by K_{50} application. The cumulative effect of K (R_1R_2D) was superior to the residual (R_1 or R_2) or direct (D) effects in enhancing the N uptake.

Neither the K levels nor the season of application produced significant effect on P uptake at maturity. The K_{50} level had greater positive influence on the K uptake than the K_{25} level. The cumulative effect of K fertilisation (R_1R_2D) significantly increased the K uptake at maturity compared to the residual (R_1 or R_2) or the direct (D) effects.

4.1.1.3.5. Grain yield, straw yield and harvest index (Table 18)

Potassium application markedly increased the grain yield of summer rice. However, the grain yields from K_{25} and K_{50} treatments were comparable. The cumulative effect (R_1R_2D) had greater positive influence on grain yield.

The straw yield did not increase considerably due to K fertilisation. The season of K application also did not have any impact on straw yield. The harvest index of summer rice also followed the same trend.

4.1.1.4. Soybean

4.1.1.4.1. Growth attributes (Table 19)

The plant height at peak flowering stage was not considerably increased by K levels and season of application. The LAI at peak flowering

Table 18. Grain and straw yields (kg ha^{-1}) and harvest index of rice - Summer, 1985

	Grain yield				Straw yield				Harvest index				
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	
K ₂₅	5039	5135	5268	5304	5187	5186	7208	7421	7329	0.412	0.416	0.415	0.416
K ₅₀	5101	5214	5290	5442	5262	5255	7360	7498	7556	0.413	0.415	0.414	0.415
Mean	5070	5175	5279	5430	5204	5221	7284	7460	7528	0.413	0.416	0.415	0.415
K ₀					4733				6936				0.426
K levels		SE _D	112	NS	CD (P=0.03)		SE _D	152	NS	CD (P=0.03)		SE _D	0.005
Season of application		158	335				216	NS				0.007	NS
K levels x Season		223	NS				305	NS				0.010	NS
Control vs Rest		168	355				229	NS				0.007	NS

 R_1 - Residual effect of K applied during SWM season, 1984 R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

 $R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 R_2$) - Direct (D)] K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1} .

Table 19. Growth attributes at flowering stage of soybean - Summer, 1985

	Plant height (cm)					LAI		
	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ +R ₂ +D)	Mean	Residual (R ₁)	Residual (R ₂)	Direct (D)
								Cumulative (R ₁ +R ₂ +D)
K ₂₀	58.4	59.1	63.2	63.3	61.0	4.93	4.86	5.06
								5.61
K ₄₀	60.9	63.5	63.7	64.1	63.1	4.84	5.11	5.32
								5.62
Mean	59.7	61.3	63.5	63.7	62.1	4.89	4.99	5.19
								5.62
K ₀					58.2			
								4.59
			SE _D	CD (P=0.05)		SE _D	CD (P=0.05)	
K levels			0.58	NS		0.08	NS	
Season of application			1.00	2.12		0.12	0.25	
K levels x Season			1.83	NS		0.16	NS	
Control vs Rest			0.99	2.10		0.12	0.26	
R ₁	- Residual effect of K applied during SWM season, 1984							
R ₂	- Residual effect of K applied during NEM season, 1984							
D	- Direct effect of K applied during Summer, 1985							
R ₁ R ₂ D	- Cumulative effect of K [Residual (R ₁ +R ₂) + Direct (D)]							
K ₂₀	- 20 kg K ₂ O ha ⁻¹ : K ₄₀ - 40 kg K ₂ O ha ⁻¹ .							

phase was markedly increased by K fertilisation. However, the LAI values due to K_{20} and K_{40} levels were comparable with each other. The cumulative effect of K (R_1R_2D) was significantly superior in enhancing the LAI compared to the residual (R_1 or R_2) and direct (D) effects.

4.1.1.4.2. Dry matter production (Table 20)

The dry matter accumulation at flowering stage was considerably increased by K application and by the cumulative effect (R_1R_2D). However, the DMP from the cumulative effect of K was comparable with that of direct effect (D) of K.

The dry matter production at maturity was considerably enhanced by the higher level of K (K_{40}). The cumulative effect of K (R_1R_2D) was comparable with that of direct effect (D) of K.

The cumulative effects of K fertilisation (R_1R_2D) resulted in higher DMP than that by the residual effects (R_1 and R_2). But it was on par with direct effect of K application (D).

4.1.1.4.3. Yield attributes (Table 21)

The number of pods per plant and seeds per pod were favourably influenced by K fertilisation. The residual (R_1 or R_2), direct (D) and cumulative effect of K (R_1R_2D) did not have any effect on pods per plant and seeds per pod. But, the test grain weight was markedly increased due to the cumulative effect of K (R_1R_2D).

Table 20. Dry matter production ($t\ ha^{-1}$) of soybean - Summer, 1985

	At flowering				At maturity					
	Resi- dual (R ₁)	Resi- dual (R ₂)	Direct (D)	Cumula- tive (R ₁ R ₂ D)	Mean	Resi- dual (R ₁)	Resi- dual (R ₂)	Direct (D)	Cumula- tive (R ₁ R ₂ D)	Mean
K ₂₀	2.27	2.28	2.29	2.35	2.30	7.50	7.31	7.36	8.04	7.55
K ₄₀	2.28	2.30	2.32	2.37	2.32	7.56	7.80	8.03	8.05	7.86
Mean	2.28	2.29	2.31	2.36	2.31	7.53	7.56	7.70	8.05	7.71
K ₀					2.17					7.41

	SE _D		CD (P=0.05)		SE _D		CD (P=0.05)	
	Season of application	K levels	Season of application	K levels	Season of application	K levels	Season of application	K levels
K levels								
Season of application								
K levels x Season								
Control vs Rest								

R_1 - Residual effect of K applied during SWM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_1 R_2 D$ - cumulative effect of K [Residual ($R_1 + R_2$) + Direct (D)]

K_{20} - 20 kg $K_2O\ ha^{-1}$; K_{40} - 40 kg $K_2O\ ha^{-1}$.

Table 21. Yield attributes of soybean - Summer, 1985

	Pods/plant				Seeds/pod				100 seed weight (g)			
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2$)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2$)	Mean	Residual (R_1)	Residual (R_2)
K ₂₀	65.3	68.3	66.7	69.7	67.5	2.25	2.31	2.34	2.41	2.33	10.63	10.43
K ₄₀	55.7	65.7	70.3	70.3	65.5	2.29	2.55	2.36	2.39	2.34	10.67	10.57
Mean	60.5	67.0	68.5	70.0	66.5	2.27	2.33	2.35	2.40	2.34	10.65	10.55
K ₀					58.1					2.59		
K levels				SE _D	CD (P=0.05)			SE _D	CD (P=0.05)		SE _D	CD (P=0.05)
Season of application				2.40	NS			0.100	NS		0.18	NS
K levels x Season				3.40	NS			0.097	NS		0.26	0.55
Control vs Rest				4.81	NS			0.138	NS		0.37	NS
				3.61	7.61			0.103	0.219		0.27	NS

R_1 - Residual effect of K applied during SWM season, 1984
 R_2 - Residual effect of K applied during NEAM season, 1984
D - Direct effect of K applied during Summer, 1985
 $R_1 R_2$ - Cumulative effect of K [Residual ($R_1 R_2$) - Direct (D)]
K₂₀ - 20 kg K₂O ha⁻¹ K₄₀ - 40 kg K₂O ha⁻¹

4.1.1.4.4. Quality characters (Table 22)

The K_{40} level of fertilisation enhanced the oil content of seed compared to K_{20} level and control. The cumulative effect of K (R_1R_2D) appreciably enhanced the oil content.

The protein content of seed was not considerably influenced by the K levels and by the season of application.

4.1.1.4.5. Uptake of nutrients (Tables 23a and 23b)

The K_{40} level had significant influence on the uptake of N and K at flowering stage. The P uptake resulted from K_{20} was comparable with that of K_{40} level. The cumulative effect (R_1R_2D) of K significantly enhanced the uptake of NPK.

The interaction effect due to K level and season was significant only for the uptake of N. The residual effects (R_1 and R_2) did not differ due to K levels (K_{20} and K_{40}). On the other hand, the direct effect (D) and cumulative effect (R_1R_2D) resulted in greater uptake of N at K_{40} level of fertilisation.

The higher level of K (K_{40}) enhanced the uptake of N and P at maturity. The cumulative effect (R_1R_2D) increased the uptake of P considerably over that of residual effects (R_1 and R_2). However, it was on par with the direct effect of K (D).

Table 22. Oil and crude protein contents (%) of soybean - Summer, 1985

	Oil content of seed (%)			Crude protein content of seed (%)			
	Resi- dual (R ₁)	Direct (D)	Cumula- tive (R ₁ R ₂ D)	Resi- dual (R ₁)	Direct (D)	Cumula- tive (R ₁ R ₂ D)	Mean
K ₂₀	19.00	19.05	19.27	39.32	39.49	39.30	39.34
K ₄₀	19.53	19.20	19.83	39.33	39.48	40.18	39.62
Mean	19.27	19.13	19.55	39.33	39.49	39.74	39.48
K ₀							39.03
							18.98

	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	0.10	0.21	0.25	NS
Season of application	0.14	0.30	0.35	NS
K levels X Season	0.20	NS	0.50	NS
Control vs Rest	0.15	0.32	0.37	NS

R₁ - Residual effect of K applied during SWM season, 1984

R₂ - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual (R₁+R₂) + Direct (D)]

K₂₀ - 20 kg K₂O ha⁻¹; K₄₀ - 40 kg K₂O ha⁻¹

Table 23a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of soybean - Summer, 1985

Table 23a. Uptake of macronutrients (kg ha ⁻¹ at harvest) 1984														
	N				P				K				Mean	
	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)		
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean		
K ₂₀	31.4	31.2	32.2	32.1	31.7	8.8	9.1	3.7	10.3	9.2	25.4	25.4	29.0	27.0
K ₄₀	31.4	31.7	34.7	36.0	33.5	7.9	9.4	15.6	11.1	9.8	27.3	27.0	32.4	29.8
Mean	31.4	31.5	33.5	34.1	32.6	8.4	9.3	9.7	10.7	9.5	26.6	26.2	30.7	28.4
K ₀					30.2					8.1				24.3
													SE _D	CD (P=0.05)
K levels				SE _D					SE _D				SE _D	CD (P=0.05)
Season of application				0.34	0.72				0.42	NS			1.10	2.33
K levels x Season				0.48	1.02				0.60	1.27			1.55	3.29
Control vs Rest				0.68	1.45				0.84	NS			2.19	NS
				0.51	1.09				0.63	1.34			1.65	3.51
R ₁ - Residual effect of K applied during SWM season, 1984														
R ₂ - Residual effect of K applied during NEM season, 1984														
D - Direct effect of K applied during Summer, 1985														
R ₁ R ₂ D - Cumulative effect of K [(Residual (R ₁ -R ₂)) · Direct (D)]														
K ₂₀ - 20 kg K ₂ O ha ⁻¹ ; K ₄₀ - 40 kg K ₂ O ha ⁻¹ .														

R_1 - Residual effect of N applied during SWM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 R_2$) - Direct (D)]

K₂₀ - 20 kg K₂O ha⁻¹; K₄₀ - 40 kg K₂O ha⁻¹

Table 23b. Uptake of macronutrients (kg ha^{-1}) at maturity stage of soybean - Summer, 1985

	N				P				K						
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2+D)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2+D)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2+D)	
K ₂ O	65.3	64.1	70.6	72.7	68.2	13.1	13.4	17.1	19.0	15.7	66.3	74.9	74.9	73.1	
K ₂ SO ₄	69.3	74.3	77.3	77.6	74.6	16.5	17.6	20.5	21.0	18.9	70.1	72.6	79.4	73.1	
Mean	67.3	69.2	74.0	75.2	71.4	14.8	15.5	18.8	20.0	17.3	68.6	73.8	77.2	74.3	
K ₂					60.5					12.2					65.5
K levels					SE _D					SE _D					SE _D
Season of application					2.20					1.09					2.31
K levels x Season					3.11					1.54					3.55
Control vs Rest					4.40					2.18					5.02
					3.30					1.63					3.76
					CD (P=0.05)					CD (P=0.05)					CD (P=0.05)
					4.66					2.31					NS
					NS					3.26					NS
					NS					NS					NS
					NS					NS					NS
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4.1.1.4.6. Seed yield (Table 24)

The seed yield of soybean was substantially increased by K fertilisation. However the K_{20} level markedly enhanced the grain yield comparable with that of K_{40} level. The cumulative (R_1R_2D) effect favourably influenced the grain yield. It was comparable with that of direct effect (D). Both of them were superior in enhancing soybean seed yield.

4.1.1.5. Finger millet

4.1.1.5.1. Growth attributes (Table 25)

The plant height and LAI at flowering stage of finger millet were favourably influenced by K application. However, the plant height and LAI resulted from the application of K at $15 \text{ Kg } K_2O \text{ ha}^{-1}$ (K_{15}) were comparable with those of $30 \text{ Kg } K_2O \text{ ha}^{-1}$ (K_{30}). The residual (R_1 or R_2), direct (D) and cumulative (R_1R_2D) effects did not have much influence on these growth attributes.

4.1.1.5.2. Dry matter production (DMP) (Table 26)

The DMP at flowering stage and at maturity were substantially increased by K fertilisation. The DMP resulted from K_{15} level was comparable with that of K_{30} level. The season of application did not produce marked effect on DMP.

4.1.1.5.3. Yield attributes (Table 27)

The number of productive tillers was higher due to K fertilisation.

Table 24. Seed yield (kg ha^{-1}) of soybean - Summer, 1985

	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean
K_{20}	2950	3148	3285	3417	3200
K_{40}	3065	3260	3357	3480	3291
Mean	3008	3204	3321	3449	3246
K_0					2858

	SE_D	CD (P=0.05)
K levels	82	NS
Season of application	115	243
K levels x Season	163	NS
Control vs Rest	122	260

R_1 - Residual effect of K applied during SWM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_1 R_2 D$ - Cumulative effect of K [$\text{Residual } R_1 + R_2$] + Direct (D)]

K_{20} - 20 kg K_2O ha^{-1} ; K_{40} - 40 kg K_2O ha^{-1} .

Table 25. Growth attributes at flowering stage of finger millet - Summer, 1985

	Plant height (cm)				LAI			
	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean	Residual (R ₁)	Residual (R ₂)	Direct (D)
K ₁₅	77.6	81.4	84.5	82.5	78.6	5.11	5.48	5.75
K ₃₀	83.2	75.5	81.3	81.9	80.5	5.44	5.69	5.79
Mean	78.8	78.5	82.9	82.2	79.5	5.28	5.59	5.77
K ₀					77.5			
K levels					SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
Season of application					2.3	NS	0.14	NS
K levels x Season					3.2	NS	0.19	NS
Control vs Rest					4.6	NS	0.27	NS
					3.4	1.18	0.20	0.43

R₁ - Residual effect of K applied during SVM season, 1984R₂ - Residual effect of K applied during NEVI season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual (R₁+R₂) + Direct (D)]K₁₅ - 15 kg K₂O ha⁻¹; K₃₀ - 30 kg K₂O ha⁻¹.

Table 26. Dry matter production ($t\ ha^{-1}$) of finger millet - Summer, 1985

	At flowering stage					At maturity stage			
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)
K_{15}	7.10	7.12	7.49	7.70	7.35	10.58	11.25	11.72	11.11
K_{30}	7.18	7.49	7.98	8.09	7.69	10.52	10.60	10.88	11.58
Mean	7.14	7.31	7.74	7.90	7.52	10.55	10.93	11.30	11.35
K_0					7.01				11.11
K levels				SE _D	CD (P=0.05)			SE _D	CD (P=0.05)
Season of application				0.218	NS			0.201	NS
K levels x Season				0.308	NS			0.285	NS
Control vs Rest				0.435	NS			0.402	NS
				0.226	0.479			0.302	0.640

R_1 - Residual effect of K applied during SWM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 + R_2$) + Direct (D)]

K_{15} - 15 kg $K_2O\ ha^{-1}$; K_{30} - 30 kg $K_2O\ ha^{-1}$.

However, the number of productive tillers resulted from K_{15} and K_{30} were comparable. The residual (R_1 or R_2), direct (D) and cumulative (R_1R_2D) effects had no considerable impact on productive tillers.

The levels of K as well as the season of K application had no effect on test grain weight.

4.1.1.5.4. Uptake of nutrients (Tables 28a and 28b)

The K fertiliser application had favourable influence on the uptake of NPK at flowering phase. The K_{15} and K_{30} levels of K application did not differ in their influence on NPK uptake at flowering. The season of K application had no effect on the uptake of nutrients. The NPK uptake at maturity also followed the same trend as that at flowering phase.

4.1.1.5.5. Grain yield and straw yield (Table 29)

Potassium fertilisation significantly increased the grain yield of finger millet. Among the levels, K_{30} produced higher grain yield. The direct effect of K application (D) was superior over residual effect (R_1) in increasing the grain yield. However, the grain yield resulted from the direct effect (D) was comparable with that of cumulative effect (R_1R_2D). The interaction due to K levels and season of application was significant. At K_{30} level, cumulative effect (R_1R_2D) exhibited greater impact on grain yield.

The straw yield was not considerably influenced by K application and by season of application.

Table 28a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of finger millet - Summer, 1985

	N					P					K				
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative (R_1+R_2)	Mean
K ₁₅	89.1	94.0	94.7	94.8	93.2	18.0	17.9	18.6	18.9	18.4	150.4	149.5	155.4	158.7	153.5
K ₃₀	93.5	95.1	96.8	99.0	96.1	17.9	18.6	19.5	19.7	18.9	149.2	155.5	163.2	164.8	158.2
Mean	91.3	94.6	95.8	96.9	94.7	18.0	18.3	19.1	19.3	18.7	149.8	152.5	159.3	161.8	155.9
K ₀					85.5					16.5					134.8
K levels				SE _D	CD (P<0.05)				SE _D	CD (P<0.05)			SE _D	CD (P<0.05)	
Season of application				2.71	NS				0.38	NS			3.94	NS	
K levels x Season				3.82	NS				0.53	NS			4.29	NS	
Control vs Ret				5.84	NS				0.75	NS			6.57	NS	
				4.07	8.63				0.56	1.19			4.55	9.63	

R₁ - Residual effect of K applied during SWM season, 1985R₂ - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual (R₁+R₂) + Direct (D)]K₁₅ - 15 kg K₂O ha⁻¹; K₃₀ - 30 kg K₂O ha⁻¹.

Table 28b. Uptake of macronutrients (kg ha^{-1}) at maturity stage of finger millet - Summer, 1985

	N				P				K			
	Residual (R_1)		Direct (D)		Residual (R_2)		Direct (D)		Residual (R_1)		Direct (D)	
	Mean	Cumulative (R_1, R_2, D)	Mean	Cumulative (R_1, R_2, D)	Mean	Cumulative (R_1, R_2, D)	Mean	Cumulative (R_1, R_2, D)	Mean	Cumulative (R_1, R_2, D)	Mean	Cumulative (R_1, R_2, D)
K_{15}	118.6	119.4	122.4	124.7	121.3	120.7	21.5	21.5	21.5	172.9	177.4	180.1
K_{30}	122.9	122.8	123.6	124.9	123.6	20.8	23.5	21.7	21.9	173.4	179.7	183.2
Mean	120.8	121.1	123.0	124.8	122.5	20.8	22.6	21.6	21.7	172.9	178.6	181.7
K_0					115.6				19.0			163.2
K levels		SE _D		SE _D	CD (P=0.05)		SE _D		CD (P=0.05)		SE _D	
Season of application		1.42		NS	NS		0.74		NS		2.99	NS
K levels x Season		2.00		NS	NS		1.05		NS		4.23	NS
Control vs Rest		2.83		NS	NS		1.48		NS		5.99	NS
		2.12		4.50			1.11		2.35		4.49	9.52

 R_1 - Residual effect of K applied during SWM season, 1984 R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

 R_1, R_2, D - Cumulative effect of K [Residual (R_1, R_2) + Direct (D)] K_{15} - 15 kg K_2O ha⁻¹; K_{30} - 30 kg K_2O ha⁻¹

Table 29. Grain and straw yields (kg ha^{-1}) of finger millet - Summer, 1985

	Grain yield				Straw yield					
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean
K_{15}	1841	1820	1898	1992	1888	7855	8472	8388	8144	8215
K_{30}	1879	1970	2070	2214	2033	8316	7905	7269	7894	7846
Mean	1860	1895	1984	2103	1961	8086	8188	7829	8019	8030
K_0					1696					7609
K levels				SE _D	CD (P=0.05)			SE _D		CD (P=0.05)
Season of application				36	76			213		NS
K levels x Season				51	108			301		NS
Control vs Rest				85	180			425		NS
				54	114			319		NS

R_1 - Residual effect of K applied during SWM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_2 R_2 D$ - Cumulative effect of K [$R_1 + R_2$] + Direct (D)]

K_{15} - 15 kg K_2O ha^{-1} ; K_{30} - 30 kg K_2O ha^{-1} .

4.1.1.6. Cotton

4.1.1.6.1. Growth attributes (Table 30)

The plant height at flowering phase did not vary considerably due to K fertilisation. But the LAI was significantly increased by K application. The season of K application did not produce positive influence on these growth characters.

4.1.1.6.2. Dry matter production (Table 31)

The fertiliser application produced significant impact on DMP at flowering and at maturity. However, the K levels (K_{15} and K_{30}) did not produce significant variation. The season of K application had little effect on DMP.

4.1.1.6.3. Yield attributes (Table 32)

The number of sympodial branches were not affected by potassium fertilisation. The fruiting points and bolls were enhanced by potassium application. The residual (R_1) or direct (D) or cumulative effect (R_1R_2D) of K did not produce marked influence on sympodial branches and fruiting points per plant.

4.1.1.6.4. Quality characters (Table 33a and 33b)

The quality characters viz., ginning percentage, span length, maturity coefficient, uniformity ratio and Bartlett's index were not influenced by K fertiliser application. Nor the season of application produced significant

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Table 30. Growth attributes at flowering stage of cotton - Summer, 1985

	Plant height (cm)				LAI					
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean
K_{15}	63.5	63.5	64.9	68.0	65.0	1.50	1.67	1.72	1.83	1.68
K_{30}	64.1	64.2	66.7	68.7	65.9	1.50	1.68	1.75	1.85	1.70
Mean	63.8	63.9	65.8	68.4	65.5	1.50	1.68	1.74	1.84	1.69
K_0					61.9					1.24

	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	1.3	NS	0.10	NS
Season of application	1.9	NS	0.14	NS
K levels x Season	2.7	NS	0.20	NS
Control vs Rest	2.0	NS	0.15	0.32

R_1 - Residual effect of K applied during SWM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 + R_2$) - Direct (D)]

K_{15} - 15 kg K_2O ha⁻¹; K_{30} - 30 kg K_2O ha⁻¹.

Table 32. Yield attributes of cotton - Summer, 1985

	Sympodial branches/plant					Fruiting points/plant					Number of bolls/plant				
	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 R_2 D$)	Mean
K_{15}	8.27	8.60	8.47	8.40	8.44	23.3	28.9	28.3	29.0	27.4	9.3	9.7	10.2	10.8	10.0
K_{30}	7.80	8.43	8.60	8.73	8.39	25.1	27.5	28.0	28.1	27.2	9.4	10.1	10.5	11.0	10.3
Mean	8.04	8.52	8.54	8.57	8.42	24.2	28.2	28.2	28.6	27.3	9.4	9.9	10.4	10.9	10.2
K_0					8.20					21.0					8.0
K levels				SE _D		CD (P=0.05)			SE _D		CD (P=0.05)			SE _D	CD (P=0.05)
Season of application				0.46	NS				1.34	NS				0.24	NS
K levels x Season				0.64	NS				1.90	NS				0.34	0.70
Control vs Rest				0.91	NS				2.68	NS				0.48	NS
				0.68	NS				2.01	4.26				0.36	0.76

 R_1 - Residual effect of K applied during SWM season, 1984 R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

 $R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 R_2$) + Direct (D)] K_{15} - 15 kg K_2O ha⁻¹; K_{30} - 30 kg K_2O ha⁻¹.

Table 33a. Quality attributes of cotton - Summer, 1985

	Ginning percentage				Splice length (mm)				Bundle strength (g/t)					
	Residual		Cumulative		Residual		Cumulative		Residual		Cumulative			
	(R ₁)	(R ₂)	Direct (D)	Mean (R ₁ R ₂ D)	(R ₁)	(R ₂)	Direct (D)	Mean (R ₁ R ₂ D)	(R ₁)	(R ₂)	Direct (D)	Mean (R ₁ R ₂ D)		
K ₁₅	33.97	34.50	34.00	34.26	34.18	25.97	25.30	25.67	25.13	47.33	48.50	47.33	46.67	47.38
K ₃₀	34.21	34.36	34.87	34.60	34.51	25.47	25.73	25.30	25.40	47.37	47.77	47.17	45.93	47.04
Mean	34.09	34.43	34.44	34.43	34.35	25.72	25.52	25.49	25.27	47.35	48.13	47.25	46.20	47.21
K ₀					34.23				25.33					47.00
K levels				SE _D		CD (P=0.05)		SE _D		CD (P=0.05)		SE _D		CD (P=0.05)
Season of application				0.32		NS		0.23		NS		0.71		NS
K levels x Season				0.45		NS		0.32		NS		1.65		NS
Control vs Rest				0.64		NS		0.46		NS		1.42		NS
				0.48		NS		0.36		NS		1.27		NS

R₁ - Residual effect of K applied during S.W.M. season, 1984R₂ - Residual effect of K applied during N.E.M. season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual (R₁-R₂) + Direct (D)]K₁₅ - 15 kg K₂O ha⁻¹; K₃₀ - 30 kg K₂O ha⁻¹.

Table 3b. Quality attributes of cotton - Summer, 1985

	Maturity coefficient				Uniformity ratio				Bartlett's index						
	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean	Residual (R ₁)	Residual (R ₂)	Direct (D)	Cumulative (R ₁ R ₂ D)	Mean
K ₁₅	0.683	0.667	0.687	0.677	0.679	44.33	43.67	44.67	43.00	44.42	0.566	0.564	0.579	0.592	0.573
K ₃₀	0.680	0.690	0.667	0.680	0.679	44.67	45.00	44.33	44.33	44.38	0.591	0.569	0.601	0.624	0.596
Mean	0.682	0.679	0.677	0.679	0.679	44.50	44.34	44.50	44.67	44.50	0.579	0.567	0.590	0.608	0.586
K ₀					0.687					44.67					0.565
K levels				SE _D	CD (P=0.05)				SE _D	CD (P=0.05)				SE _D	CD (P=0.05)
Season of application				0.009	NS				0.30	NS				0.015	NS
K levels x Season				0.012	NS				0.42	NS				0.021	NS
Control vs Rest				0.017	NS				0.60	NS				0.030	NS
				0.013	NS				0.45	NS				0.023	NS

R₁ - Residual effect of K applied during SEW season, 1984R₂ - Residual effect of K applied during NEW season, 1984

D - Direct effect of K applied during Summer, 1985

R₁R₂D - Cumulative effect of K [Residual (R₁R₂) - Direct (D)]K₁₅ - 15 kg K₂O ha⁻¹; K₃₀ - 30 kg K₂O ha⁻¹

influence on these quality characters.

4.1.1.6.5. Uptake of nutrients (Tables 34a and 34b)

The uptake of N and K at flowering stage was favourably influenced by K application. Season of application had no marked effect on NPK uptake at flowering. The K_{30} level of fertilisation enhanced the K uptake compared to K_{15} level.

The N uptake at maturity was not influenced by K fertiliser application, whereas P uptake and K uptake were increased by application of K fertiliser. However, both the levels had comparable P and K uptake.

4.1.1.6.6. Seed cotton yield (Table 35)

The K fertiliser application had favourable effect on seed cotton yield. However, both the levels of K (K_{15} and K_{30}) had comparable yield levels. The direct (D), the residual (R_1 and R_2) and cumulative (R_1R_2D) effects of K had no marked effect on seed cotton yield.

4.1.2. Productivity of the cropping systems

4.1.2.1. Biological production potential of the cropping systems (Table 36 and Fig. 3)

The total dry matter harvested above ground was considered as the biological production potential. Among the rice based cropping systems, the total biomass production was the highest in C_1 system (rice-rice-rice) followed C_3 system (rice-rice-finger millet) and C_2 system (rice-rice-soybean). The K fertiliser application considerably enhanced the biomass accumulation.

Table 34a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of cotton - Summer, 1985

	N					P					K				
	Residual (R_1)		Direct (D)		Cumulative ($R_1 R_2 D$)	Residual (R_2)		Direct (D)		Cumulative ($R_1 R_2 D$)	Residual (R_2)		Direct (D)		Cumulative ($R_1 R_2 D$)
	Mean	SE _D	Mean	SE _D		Mean	SE _D	Mean	SE _D		Mean	SE _D	Mean	SE _D	
K ₁₅	64.4	64.3	67.7	68.2	66.2	9.5	9.9	9.8	9.8	10.0	9.8	42.6	41.7	43.2	48.0
K ₃₀	66.7	66.5	67.9	74.9	68.5	9.9	9.7	9.9	9.9	10.4	10.0	47.2	47.6	47.3	48.1
Mean	65.6	65.4	67.8	70.6	67.4	9.7	9.8	9.9	9.9	10.2	9.9	44.9	44.7	45.3	48.1
K ₀					60.4					9.9					46.5
K levels															
Season of application															
K levels x Season															
Control vs Rest															
	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D
	1.94	NS	2.74	NS	5.31	NS	2.22	NS	2.22	NS	1.38	NS	2.23	NS	3.35
	3.88	NS	2.91	6.16	6.46	NS	5.31	NS	5.31	NS	2.37	NS	3.16	NS	5.52

R_1 - Residual effect of K applied during SAM season, 1984

R_2 - Residual effect of K applied during NEM season, 1984

D - Direct effect of K applied during Summer, 1985

$R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 R_2$) + Direct (D)]

K₁₅ - 15 kg K₂O ha⁻¹; K₃₀ - 30 kg K₂O ha⁻¹

Table 35. Seed cotton yield (kg ha^{-1}) - Summer, 1985

	Residual (R_1)	Residual (R_2)	Direct (D)	Cumulative ($R_1 + R_2 + D$)	Mean
K_{15}	519	536	517	556	532
K_{30}	517	506	543	544	528
Mean	518	521	530	550	530
K_0					499

SE_D CD (P=0.05)

K levels
Season of application
K levels x Season
Control vs Rest

9.02 NS
12.75 NS
18.03 NS
13.52 28.7

R_1 - Residual effect of K applied during SWM season, 1984
 R_2 - Residual effect of K applied during NEM season, 1984
D - Direct effect of K applied during Summer, 1985
 $R_1 R_2 D$ - Cumulative effect of K [Residual ($R_1 + R_2$) + Direct (D)]
 K_{15} - 15 kg $K_2O \text{ ha}^{-1}$; K_{30} - 30 kg $K_2O \text{ ha}^{-1}$.

Table 36. Dry matter production (t ha⁻¹) in the cropping systems - Coimbatore

Cropping system	K level	S ₁	S ₂	S ₃	S ₄	Mean
Rice-Rice-Rice (C ₁)	K ₁	40.42	40.13	39.49	41.72	40.44
	K ₂	40.70	39.91	40.52	41.94	40.54
	Mean	40.56	39.57	40.51	41.83	40.49
	K ₀					37.72
Rice-Rice-Soybean (C ₂)	K ₁	33.79	33.47	32.94	33.61	33.45
	K ₂	33.30	33.86	32.57	34.76	33.62
	Mean	33.55	33.67	32.76	34.19	33.54
	K ₀					32.33
Rice-Rice-Finger Millet (C ₃)	K ₁	36.30	37.90	36.65	37.99	37.21
	K ₂	37.24	36.75	37.63	38.20	37.46
	Mean	36.77	37.33	37.14	38.10	37.34
	K ₀					36.28
Rice-Rice-Cotton (C ₄)	K ₁	28.82	29.64	28.91	30.43	29.45
	K ₂	30.36	30.50	29.70	30.64	30.30
	Mean	29.59	30.07	29.31	30.54	29.88
	K ₀					29.36
Mean		35.12	35.16	34.81	36.17	
				SE _D	CD (P=0.05)	
Cropping system				0.707	1.729	
K levels				0.196	NS	
Season of application				0.277	0.553	
K levels x Season				0.392	NS	
C at K				0.799	NS	
K at C				0.392	NS	
C at S				0.890	NS	
S at C				0.554	NS	
Control vs Rest				0.294	0.587	
Control vs Rest at C				0.588	1.175	
C at Control vs Rest				1.199	2.868	

S₁ - K applied during SWM season, 1984S₂ - K applied during NEM season, 1984S₃ - K applied during Summer, 1985S₄ - K applied during all the three seasonsK₁ - 50 per cent recommended dose of KK₂ - 100 per cent recommended dose of K

However, the levels of K (50 and 100%) did not differ much among themselves. The fertiliser K applied to all the three crops in the cropping systems produced higher quantity of dry matter as compared to K application to any one crop in the sequences.

In all the cropping systems, K fertilisation increased the dry matter compared to control. Greatest difference between K applied treatments and control could be observed in C_1 system (rice-rice-rice) followed by C_2 system (rice-rice-soybean).

4.1.2.2. Total rice grain equivalent of the cropping systems (Table 37 and Fig. 3)

Total grain equivalent of the cropping systems was worked out by converting soybean grain, finger millet grain and cotton kapas yield into rice grain equivalent yield.

In all the cropping systems, K fertilisation conspicuously enhanced the rice grain equivalent yield. The total rice grain equivalent yield was the highest in C_2 (rice-rice-soybean) system. The total rice grain equivalent from C_1 system (rice-rice-rice) was comparable with that of C_2 system. Both the C_2 and C_1 systems produced grain equivalent yield higher than those from the C_3 and C_4 systems.

Application of 50 per cent or 100 per cent recommended dose of K had little influence on the total rice grain equivalent from the systems.

The season of K application had substantial influence on total grain

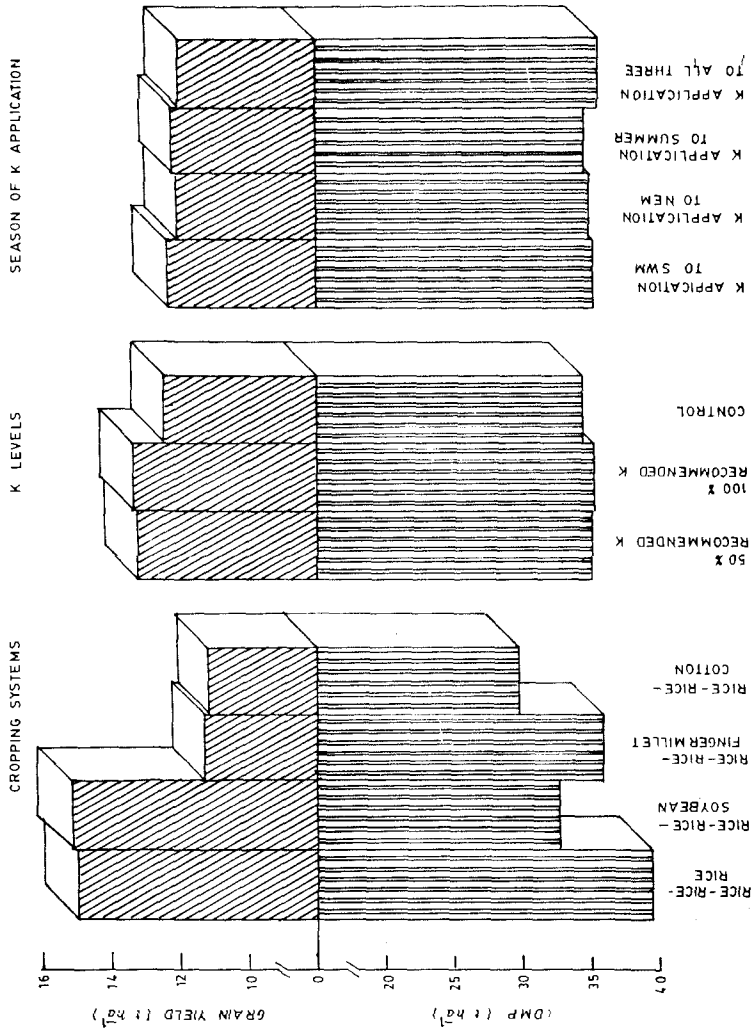
Table 37. Rice grain equivalent yield (kg ha^{-1}) in the cropping systems
- Coimbatore

Cropping system	K level	S_1	S_2	S_3	S_4	Mean
Rice-Rice-Rice (C_1)	K_1	15809	15496	15405	16113	15728
	K_2	15794	15716	15635	16216	15725
	Mean	15802	15556	15420	16165	15937
	K_0					16643
Rice-Rice-Soybean (C_2)	K_1	15987	15180	15813	15918	15725
	K_2	15626	16285	15395	16980	16072
	Mean	15807	15733	15604	16449	15899
	K_0					16820
Rice-Rice-Finger Millet (C_3)	K_1	11785	11348	11343	11862	11585
	K_2	12090	11616	11741	12252	11922
	Mean	11893	11482	11542	12057	11764
	K_0					11329
Rice-Rice-Cotton (C_4)	K_1	11498	11396	11240	12235	11592
	K_2	11994	11817	11576	12312	11923
	Mean	11746	11607	11405	12274	11758
	K_0					11201
	Mean	13812	13294	13493	14236	

	SE_{15}	(D) (P 0.05)
Cropping systems	279	683
K levels	122	NS
Season of application	173	346
K levels x Season	244	NS
C at K	342	798
K at C	244	NS
C at S	413	NS
S at C	244	NS
Control vs Rest	183	266
Control vs Rest at C	165	NS
C at Control vs Rest	242	NS

- S_1 - K applied during SWM season, 1984
 S_2 - K applied during NEM season, 1984
 S_3 - K applied during Summer, 1985
 S_4 - K applied during all the three seasons
 K_1 - 50 per cent recommended dose of K
 K_2 - 100 per cent recommended dose of K

FIG. 3 RICE GRAIN EQUIVALENT YIELD AND DRY MATTER PRODUCTION - COIMBATORE



equivalent yield. Potassium fertiliser application to all the three component crops of the cropping systems resulted in higher total grain equivalent yield than that from the K fertilisation to any one of the crops.

4.1.2.3. Energy budget of the cropping systems (Table 38)

One of the important methods of evaluating cropping systems is to study their energy input - output relations. In the present study an attempt is made to assess the energy flow into the cropping system and to work out the energy input - output ratio.

In the cropping systems, irrigation required the maximum amount of energy input (about 60 per cent). The C_1 system (rice-rice-rice) required 62.9 per cent of the total energy input for irrigation while the C_4 system (rice-rice-cotton) required 56.8 per cent. With rice as component crop in C_1 system, it required the highest energy for irrigation.

Next highest component of energy input was through fertilisers. The energy input through fertilisers ranged from 15.9 per cent in C_1 system to 18.8 per cent in C_3 system.

Third major component of the energy input was from the human labour. The energy from the human labour input ranged from 10.3 per cent in C_1 system to 12.3 per cent in C_4 system. As far as total energy input of the cropping system was concerned, the C_1 system required the highest amount of energy ($125.7 \times 10^3 \text{ M.J.ha}^{-1}$) followed by C_4 system ($100.1 \times 10^3 \text{ M.J.ha}^{-1}$).

Among the cropping systems, C_3 system achieved an energy input - output ratio of 4.62 followed by C_2 system (4.50). The least input - output ratio (3.86) was recorded in C_1 system. Irrespective of the cropping system, energy efficiency was enhanced by K fertilisation. Specific energy was highest in C_4 system which included cotton as one of the component crops. The lowest specific energy was in C_2 system which had soybean as a component crop.

4.1.3. Economic analysis of potassium management in the cropping systems

Various economic parameters worked out for the cropping system as a whole are presented in this section. Cost of cultivation for various treatments are presented in Appendix IIIa. Gross return, net return and benefit-cost ratio worked out for the cropping system are presented in this section.

4.1.3.1. Gross return from the cropping systems (Table 39)

Potassium fertilisation considerably enhanced the gross return from the cropping systems. Among the cropping systems, C_1 system (rice-rice-rice) registered the highest gross returns (Rs.38740 ha^{-1}). The C_2 system (rice-rice-soybean) also recorded comparable gross return (Rs.37379 ha^{-1}). The C_3 system (rice-rice-finger millet) and C_4 system (rice-rice-cotton) system achieved more or less similar gross return, but they were significantly lower than those from the C_1 and C_2 systems.

Application of 50 per cent of the recommended dose of K (K_1) recorded higher gross return than that from the 100 per cent recommended

Table 39. Gross return (Rs.ha⁻¹) from the cropping systems - Coimbatore

Cropping system	K level	S ₁	S ₂	S ₃	S ₄	Mean
Rice-Rice-Rice (C ₁)	K ₁	40150	40396	40636	41314	40674
	K ₂	39092	38945	38325	40633	39249
	Mean	39621	39770	39480	40974	39962
	K ₀					37517
Rice-Rice-Soybean (C ₂)	K ₁	38861	37670	38630	39110	38568
	K ₂	37302	39782	37832	39976	38723
	Mean	38082	38726	38231	39543	38646
	K ₀					36112
Rice-Rice-Finger Millet (C ₃)	K ₁	29469	30064	29581	30494	29927
	K ₂	29080	28583	29539	30393	29399
	Mean	29274	29324	29560	30494	29663
	K ₀					29043
Rice-Rice-Cotton (C ₄)	K ₁	28764	30048	30345	30678	29969
	K ₂	28797	29453	29219	29992	29365
	Mean	28780	29750	29782	30335	29662
	K ₀					28178
Mean		33939	34393	34263	35336	

	SE ₁₁	CD (P 0.05)
Cropping systems	647	1583
K levels	193	387
Season of application	274	567
K levels x Season	387	NS
C at K	739	1262
K at C	387	773
C at S	834	NS
S at C	567	85
Control vs Rest	290	580
C at control vs Rest	1168	NS
Control vs Rest at C	580	NS

- S₁ - K applied during SWM season, 1984
 S₂ - K applied during NEM season, 1984
 S₃ - K applied during Summer, 1985
 S₄ - K applied during all the three seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

dose (K_2).

Potassium fertilisation to all the three crops of the cropping systems resulted in higher gross return than that from K fertiliser application to any one of the crops in the cropping systems.

4.1.3.2. Net return from the cropping systems (Table 40 and Fig.4)

The K fertilisation considerably augmented the net return from the cropping systems. Net return from the cropping systems followed a similar trend as that of gross return from the cropping systems except that the C_2 system (rice-rice-soybean) achieved higher net return than in C_1 system (rice-rice-rice).

4.1.3.3. Benefit cost (B-C) ratio of K management practices in the cropping systems (Table 41 and Fig.4)

The benefit cost (B-C) ratio was conspicuously raised by K fertilisation. The C_2 system (rice-rice-soybean) achieved a B-C ratio of 2.51 while C_1 system (rice-rice-rice) resulted in 2.20. The B-C ratio was the lowest (1.93) in C_3 system (rice-rice-cotton).

The K_1 (50 per cent of the recommended dose of K) level registered B-C ratio 2.28 compared to 2.22 in K_2 (100 per cent recommended dose of K) level.

Among the seasons of application, K fertilisation to each of the three

Table 40. Net return (Rs.ha⁻¹) from the cropping systems - Coimbatore

Cropping system	K level	S ₁	S ₂	S ₃	S ₄	Mean
Rice-Rice-Rice (C ₁)	K ₁	23055	23501	23541	24116	23553
	K ₂	21952	21185	21209	20479	21229
	Mean	22504	22343	23420	22298	22641
	K ₀					20479
Rice-Rice-Soybean (C ₂)	K ₁	24461	23212	24152	24557	24081
	K ₂	22791	25612	23512	24629	24136
	Mean	23596	24412	23832	24593	24108
	K ₀					21710
Rice-Rice-Finger Millet (C ₃)	K ₁	15132	15642	15326	16098	15527
	K ₂	15088	15160	15085	16165	15375
	Mean	15110	15401	15206	16087	15451
	K ₀					14535
Rice-Rice-Cotton (C ₄)	K ₁	14071	15351	14671	15907	15000
	K ₂	14059	14714	14518	15096	14597
	Mean	14065	15033	14595	15502	14799
	K ₀					13549
Mean		18819	19297	19263	19620	

Data not statistically analysed

- S₁ - K applied during NWM season, 1984
 S₂ - K applied during NEM season, 1984
 S₃ - K applied during Summer, 1985
 S₄ - K applied during all the three seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

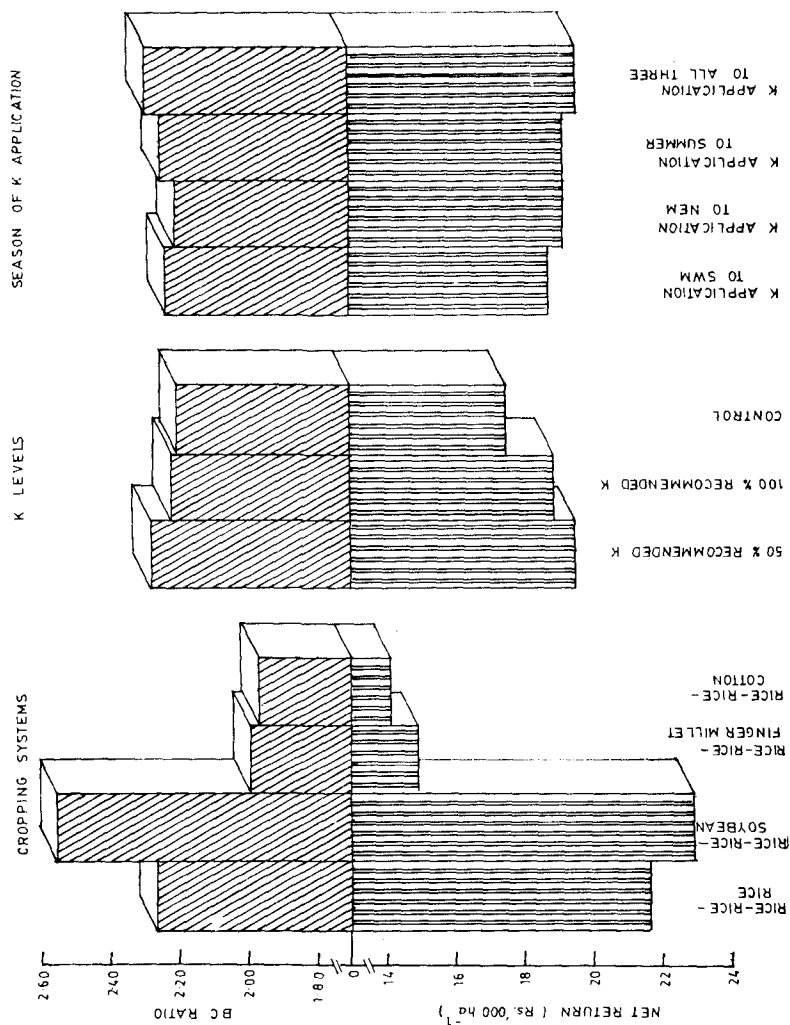
Table 41. Benefit cost ratio of K management practices in the cropping systems
- Coimbatore

Cropping system	K level	S ₁	S ₂	S ₃	S ₄	Mean
Rice-Rice-Rice (C ₁)	K ₁	2.36	2.37	2.38	2.40	2.38
	K ₂	2.38	2.27	2.24	2.34	2.28
	Mean	2.32	2.32	2.31	2.37	2.33
	K ₀					2.20
Rice-Rice-Soybean (C ₂)	K ₁	2.69	2.61	2.67	2.69	2.67
	K ₂	2.57	2.27	2.62	2.68	2.54
	Mean	2.63	2.44	2.65	2.69	2.61
	K ₀					2.51
Rice-Rice-Finger Millet (C ₃)	K ₁	2.06	2.07	2.05	2.09	2.06
	K ₂	2.03	2.04	2.03	2.09	2.05
	Mean	2.04	2.06	2.04	2.09	2.06
	K ₀					2.00
Rice-Rice-Cotton (C ₄)	K ₁	1.95	2.04	2.00	2.08	2.02
	K ₂	1.95	2.00	1.99	2.01	1.99
	Mean	1.95	2.02	2.00	2.05	2.01
	K ₀					1.93
Mean		2.24	2.21	2.25	2.30	

Data not statistically analysed

- S₁ - K applied during SWM season, 1984
 S₂ - K applied during NEM season, 1984
 S₃ - K applied during Summer, 1985
 S₄ - K applied during all the three seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

FIG. 4 BENEFIT COST RATIO AND NET RETURN - COIMBATORE



component crops of the cropping systems (S_4) registered the highest B-C ratio. The B-C ratios obtained from the K fertiliser application to any one crop of the cropping systems (S_1 or S_2 or S_3) were comparable with one another and they were considerably lower than the B-C ratio obtained from the fertilisation of all the three crops of the cropping systems (S_4).

In C_2 system (rice-rice-soybean) which achieved the highest B-C ratio (2.51) among cropping systems, K_1 level (50 per cent recommended dose of K) registered B-C ratio of 2.67 compared to 2.54 in K_2 level (100 per cent recommended dose of K).

4.1.4. Post-harvest soil nutrient status

4.1.4.1. Post-harvest soil organic carbon content (Table 42)

Among the cropping systems, the C_2 system (rice-rice-soybean) left the soil with significantly higher organic carbon content. This was followed by the C_1 system (rice-rice-rice), C_3 system (rice-rice-finger millet) and C_4 system (rice-rice-cotton). In all the cropping systems except C_1 system, K_2 level (100 per cent recommended dose) registered considerably higher organic carbon content after cropping.

Potassium fertilisation to all the three component crops in the cropping systems had appreciable impact on the post-harvest soil organic carbon content. The interaction between K level and season was considerable. Application of 100 per cent recommended dose of K (K_2) to all the component crops resulted in much higher organic carbon content. The recommended level of K in all the systems enhanced the soil organic carbon content.

Table 42. Post-harvest soil organic carbon content (%) in the cropping systems
- Coimbatore

Cropping system	K level	S ₁	S ₂	S ₃	S ₄	Mean
Rice-Rice-Rice (C ₁)	K ₁	0.824	0.846	0.874	0.879	0.855
	K ₂	0.830	0.865	0.905	0.905	0.876
	Mean	0.827	0.855	0.890	0.892	0.866
	K ₀					0.765
Rice-Rice-Soybean (C ₂)	K ₁	0.820	0.853	0.966	1.008	0.911
	K ₂	0.828	0.950	1.105	1.256	1.035
	Mean	0.826	0.902	1.035	1.132	0.973
	K ₀					0.754
Rice-Rice-Finger Millet (C ₃)	K ₁	0.810	0.866	0.876	0.876	0.851
	K ₂	0.853	0.892	0.905	0.960	0.903
	Mean	0.832	0.868	0.890	0.917	0.877
	K ₀					0.633
Rice-Rice-Cotton (C ₄)	K ₁	0.624	0.626	0.632	0.686	0.642
	K ₂	0.630	0.690	0.750	0.784	0.714
	Mean	0.627	0.658	0.691	0.735	0.678
	K ₀					0.596
Mean		0.778	0.820	0.876	0.919	
		N ₁		C.D. (0.05)		
Cropping systems		0.015		0.036		
K levels		0.012		0.024		
Season of application		0.017		0.034		
K levels x Season		0.024		0.068		
C at K		0.023		0.051		
K at C		0.024		0.048		
C at S		0.034		0.070		
S at C		0.034		0.068		
Control vs Rest		0.018		0.036		
Control vs Rest at C		0.035		0.077		
C at Control vs Rest		0.033		0.073		

- S₁ - K applied during SWM season, 1984
 S₂ - K applied during NEM season, 1984
 S₃ - K applied during Summer, 1985
 S₄ - K applied during all the three seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

4.1.4.2. Post-harvest soil available N in the cropping systems (Table 43)

The K fertilisation in cropping systems resulted in higher post harvest soil available N content than that in control. The C_2 system (rice-rice-soybean) left the soil with considerable higher available N in soil. Application of 100 per cent recommended dose of K (K_2) registered significantly higher soil available N than 50 per cent recommended dose of K (K_1).

The season of K application also had greater influence on the post harvest soil available N content. Application of K fertiliser to all the three seasons appreciably enhanced the available N content post-harvest of crops. Irrespective of K levels, the C_2 system (rice-rice-soybean) resulted in improved soil N content.

4.1.4.3. Post-harvest soil available P in cropping systems (Table 44)

Potassium fertilisation significantly enhanced the post-harvest soil available P content. Both the 50 per cent and 100 per cent levels of K had similar effect on soil P content but superior to control. The season of K application had little influence on soil available P. Among the cropping systems, the C_2 system (rice-rice-finger millet) and C_1 system (rice-rice-rice) were superior to the other systems in enhancing the soil available P content.

Except in C_2 system (rice-rice-soybean), the soil available P content was considerably higher in control plot than in K fertilised plots of the C_1 , C_3 and C_4 systems. But in C_2 system, K fertilised plot had higher P content in post-harvest soil than in control plot.

Table 43. Post harvest soilavailable N (kg ha^{-1}) in cropping systems - Coimbatore

Cropping system	K level	S_1	S_2	S_3	S_4	Mean
Rice-Rice-Rice (C_1)	K_1	211.3	216.4	220.6	228.9	217.8
	K_2	216.0	219.9	230.8	235.2	225.5
	Mean	213.7	215.2	225.7	232.1	221.7
	K_0					203.2
Rice-Rice-Soybean (C_2)	K_1	223.5	227.3	230.2	238.0	229.8
	K_2	225.8	230.5	232.7	239.6	232.2
	Mean	224.7	228.9	231.5	238.8	231.0
	K_0					215.5
Rice-Rice-Finger Millet (C_3)	K_1	206.9	210.8	213.7	219.8	212.8
	K_2	207.0	213.1	218.4	224.0	215.6
	Mean	207.0	212.0	216.1	221.9	214.2
	K_0					192.3
Rice-Rice-Cotton (C_4)	K_1	199.6	193.8	198.1	202.4	198.5
	K_2	202.4	201.6	199.5	205.5	202.3
	Mean	201.0	197.7	198.8	204.0	200.4
	K_0					185.5
Mean		211.6	213.3	218.0	224.2	

	SE _D	CD (P=0.05)
Cropping systems	2.59	6.33
K levels	1.67	3.36
Season of application	2.36	5.53
K levels x Season	3.34	NS
C at K	3.62	NS
K at C	3.36	NS
C at S	4.93	10.56
S at C	4.72	9.45
Control vs Rest	2.51	5.91
Control vs Rest at C	5.92	10.93
C at Control vs Rest	5.44	12.27

- S_1 - K applied during SWM season, 1984
 S_2 - K applied during NEM season, 1984
 S_3 - K applied during Summer, 1985
 S_4 - K applied during all the three seasons
 K_1 - 50 per cent recommended dose of K
 K_2 - 100 per cent recommended dose of K

Table 44. Post-harvest soil available P (kg ha⁻¹) in the cropping systems
- Coimbatore

Cropping system	K level	S ₁	S ₂	S ₃	S ₄	Mean
Rice-Rice-Rice (C ₁)	K ₁	19.8	20.0	20.5	20.5	21.2
	K ₂	20.0	22.1	22.8	25.0	22.0
	Mean	20.4	21.1	21.7	25.2	22.1
	K ₀					25.3
Rice-Rice-Soybean (C ₂)	K ₁	17.8	18.2	18.0	18.9	18.2
	K ₂	18.2	18.2	19.5	20.5	19.1
	Mean	18.0	18.2	18.8	19.7	18.9
	K ₀					18.7
Rice-Rice-Finger Millet (C ₃)	K ₁	21.0	20.9	21.4	23.0	21.6
	K ₂	21.6	21.9	22.8	24.4	22.7
	Mean	21.3	21.4	22.1	23.7	22.2
	K ₀					25.4
Rice-Rice-Cotton (C ₄)	K ₁	18.5	18.9	18.7	19.6	18.9
	K ₂	18.6	19.3	18.8	20.4	19.3
	Mean	18.6	19.1	18.8	20.0	19.1
	K ₀					21.6
Mean		19.6	20.0	20.4	22.2	

SE_D CD (P=0.05)

Cropping systems	0.57	1.41
K levels	0.63	NS
Season of application	0.87	NS
K levels x Season	1.22	NS
C at E	1.06	2.27
K at C	1.23	2.00
C at S	1.62	3.34
S at C	1.73	3.46
Control vs Rest	0.92	1.84
Control vs Rest at C	1.84	3.68
C at control vs Rest	1.59	3.42

- S₁ - K applied during SWM season, 1984
 S₂ - K applied during NEM season, 1984
 S₃ - K applied during Summer, 1985
 S₄ - K applied during all the three seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

4.1.4.4. Post-harvest soil available K in the cropping systems (Table 45 and Fig. 5)

Potassium fertilisation considerably influenced the available K status of post-harvest soil. Nevertheless both the 50 per cent and 100 per cent levels of K (K_1 and K_2) in different cropping systems resulted in comparable post-harvest soil available K contents.

The direct effect (D) and cumulative effect (R_1R_2D) increased the available K content of post-harvest soil considerably compared to the residual effects (R_1 and R_2). Different cropping systems did not produce significant variations in available K content of soil.

4.1.4.5. Post-harvest soil non-exchangeable K in the cropping systems (Table 46)

The post-harvest soil non-exchangeable K of the C_2 system (rice-rice-soybean) was considerably higher than that in other systems. However C_1 system (rice-rice-rice) also had comparable non-exchangeable K. Application of 50 per cent K (K_1) or 100 per cent K (K_2) had little influence on the non-exchangeable K. However both these levels of K were superior to control. The season of K application also had negligible influence on the non-exchangeable K.

4.1.4.6. EUF-K of post-harvest soil (Fig. 6 and Appendix V)

Pooled soil samples from all the replications for selected treatments were analysed for EUF-K upto 35 minutes.

Table 45. Post-harvest soil available K (kg ha⁻¹) in the cropping systems
- Coimbatore

Cropping system	K level	S ₁	S ₂	S ₃	S ₄	Mean
Rice-Rice-Rice (C ₁)	K ₁	433	430	436	441	435
	K ₂	431	427	442	445	436
	Mean	432	429	439	443	436
	K ₀					423
Rice-Rice-Soybean (C ₂)	K ₁	445	439	448	453	446
	K ₂	447	440	457	460	451
	Mean	446	440	453	457	449
	K ₀					435
Rice-Rice-Jinger Millet (C ₃)	K ₁	391	395	399	399	396
	K ₂	385	382	393	403	391
	Mean	393	389	396	397	394
	K ₀					383
Rice-Rice-Cotton (C ₄)	K ₁	392	397	398	400	397
	K ₂	390	393	399	404	397
	Mean	391	395	399	402	397
	K ₀					379
Mean		416	413	422	425	

	SE _D	CD (P=0.05)
Cropping systems	23.8	NS
K levels	2.0	NS
Season of application	2.9	5.7
K levels x Season	4.1	NS
C at K	25.9	NS
K at C	4.1	NS
C at S	25.7	NS
S at C	4.1	NS
Control vs Rest	3.0	6.1
Control vs Rest at C	6.1	NS
C at control vs Rest	38.1	NS

- S₁ - K applied during SWM season, 1984
 S₂ - K applied during NEM season, 1984
 S₃ - K applied during Summer, 1984
 S₄ - K applied during all the three seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

FIG. 5 DYNAMICS OF SOIL AVAILABLE K IN THE CROPPING SYSTEMS-COIMBATORE

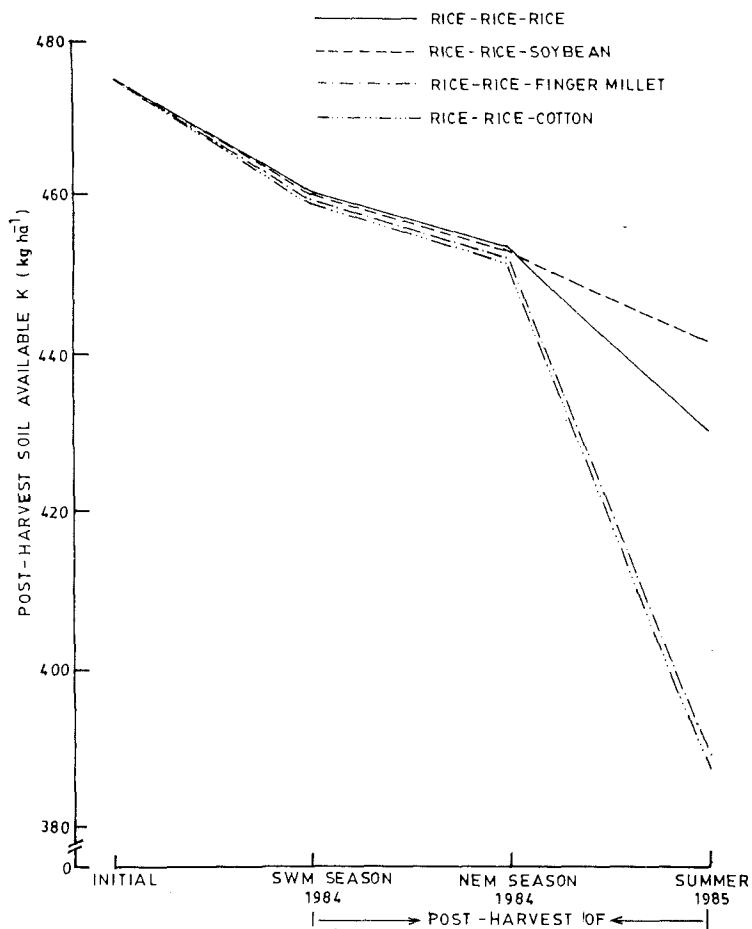


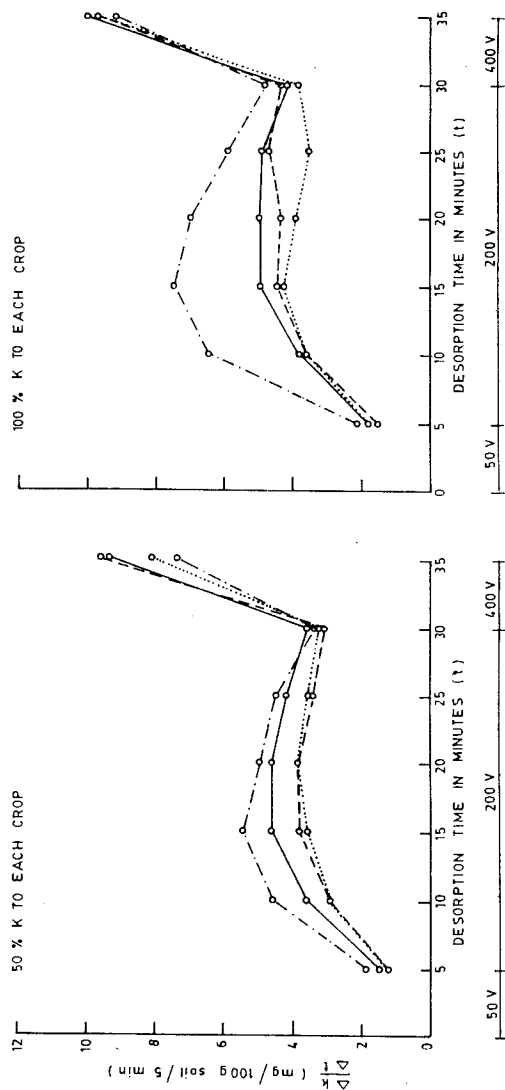
Table 46. Post-harvest soil non-exchangeable K (kg ha^{-1}) in the cropping systems
- Coimbatore

Cropping system	K level	S_1	S_2	S_3	S_4	Mean
Rice-Rice-Rice (C_1)	K_1	1404	1400	1410	1414	1407
	K_2	1408	1402	1420	1422	1413
	Mean	1406	1401	1415	1418	1410
	K_0					1396
Rice-Rice-Soybean (C_2)	K_1	1420	1414	1426	1432	1423
	K_2	1424	1418	1432	1432	1427
	Mean	1422	1416	1429	1432	1425
	K_0					1414
Rice-Rice-Finger Millet (C_3)	K_1	1378	1376	1378	1372	1376
	K_2	1364	1362	1376	1386	1372
	Mean	1371	1368	1377	1379	1374
	K_0					1358
Rice-Rice-Cotton (C_4)	K_1	1364	1372	1386	1378	1375
	K_2	1366	1366	1378	1388	1375
	Mean	1365	1369	1382	1383	1375
	K_0					1368
Mean		1391	1389	1401	1403	

	SE _D	C.D. (P=0.05)
Cropping systems	13.1	NS
K levels	8.8	NS
Season of application	11.0	NS
K levels x Season	12.1	NS
C at K	13.6	NS
K at C	8.5	NS
C at S	15.8	NS
S at C	12.0	NS
Control vs Rest	6.9	14.9
Control vs Rest at C	16.8	NS
C at Control vs Rest	17.2	NS

- S_1 - K applied during SWM season, 1984
 S_2 - K applied during NEM season, 1984
 S_3 - K applied during Summer, 1985
 S_4 - K applied during all the three seasons
 K_1 - 50 per cent recommended dose of K
 K_2 - 100 per cent recommended dose of K

FIG. 6 EUF-K DESORPTION IN POST-HARVEST SOIL - COIMBATORE



The K desorption followed almost the same pattern in all the cropping systems. The rate of desorption increased upto 15 minutes and then decreased till 30 minutes and the extraction from 30 to 35 minutes exhibited steep rise. The post-harvest soil of the C_3 system (rice-rice-finger millet) had higher EUF-K fractions followed by C_1 system (rice-rice-rice). This trend was more pronounced when the component crops of the systems were applied with 100 per cent of recommended K fertiliser than with 50 per cent.

The K desorption was higher in 100 per cent K fertiliser applied treatments than in 50 per cent fertiliser treatments. The total EUF-K was the highest in C_3 system (rice-rice-finger millet) followed by C_1 system (rice-rice-rice) and then by C_2 system (rice-rice-soybean).

4.1.5. Potassium balance in the cropping systems (Table 47).

The amount of K fertiliser applied to the component crops, contribution from irrigation water and crop stubbles of SWM and NEM seasons were added to arrive at the total potassium addition in the balance sheet.

Since the post-harvest soil samples were collected immediately after the harvest of the summer crops, the addition of summer crop stubbles in the systems was not taken into consideration.

Among the cropping systems, C_1 system (rice-rice-rice) extracted higher amount of K through uptake followed by C_3 system (rice-rice-finger millet), C_2 system (rice-rice-soybean) and C_4 system (rice-rice-cotton).

The computed balance showed that C_3 system (rice-rice-finger millet) foraged the soil of its K considerably compared to the other systems. This was followed by C_1 system (rice-rice-rice). The C_2 system (rice-rice-soybean) foraged the soil of its K with least amount.

There was net loss of soil available K in all the systems. The net loss was the least in C_2 system (rice-rice-soybean) followed by C_1 system (rice-rice-rice).

Potassium fertilisation, with 50 per cent or 100 per cent to the crops, considerably reduced the net loss of soil available K compared to control.

4.2. Pattukottai

4.2.1. Response of component crops to potassium fertilisation

4.2.1.1. Rice - North East Monsoon (NEM) season

4.2.1.1.1. Growth and yield attributes (Table 48)

The K fertiliser application did not increase the plant height at flowering stage considerably. The leaf area index (LAI) was favourably influenced by the K fertilisation. The K_{50} level was superior than K_{25} level in enhancing the LAI.

The DMP at flowering and maturity was positively influenced by K fertiliser application. Application of K_{50} resulted in higher DMP at flowering compared to K_{25} level. The DMP at maturity resulted from K_{25} and K_{50} levels were comparable with each other.

The productive tiller number was enhanced by K fertilisation. The

Table 48. Growth and yield attributes of rice - NEM season, 1986

	At Flowering Stage				DMP at maturity (t ha ⁻¹)	Filled grain (%)	Productive tillers m ⁻²	100% grain weight (g)						
	Plant height (cm)	LAI	DMP (t ha ⁻¹)											
K ₂₅	68.3	4.81	6.27	12.69	85.2	371	20.33							
K ₅₀	69.3	5.05	7.02	12.82	87.5	389	20.49							
K ₀	67.5	4.63	5.97	12.31	83.1	347	20.05							
K ₂₅ vs K ₅₀	SE _D 1.19	CD (P=0.05) NS	SE _D 0.09	CD (P=0.05) 0.18	SE _D 1.43	CD (P=0.05) 283	SE _D 0.123	CD (P=0.05) NS	SE _D 1.08	CD (P=0.05) 2.13	SE _D 8.0	CD (P=0.05) 15.9	SE _D 0.192	CD (P=0.05) NS
K ₂₅ vs K ₀	SE _D 1.08	CD (P=0.05) NS	SE _D 0.08	CD (P=0.05) 0.16	SE _D 1.29	CD (P=0.05) 256	SE _D 0.111	CD (P=0.05) 0.220	SE _D 0.98	CD (P=0.05) 1.93	SE _D 7.2	CD (P=0.05) 14.5	SE _D 0.174	CD (P=0.05) NS
K ₅₀ vs K ₀	SE _D 0.83	CD (P=0.05) NS	SE _D 0.06	CD (P=0.05) 0.12	SE _D 0.99	CD (P=0.05) 196	SE _D 0.085	CD (P=0.05) 0.169	SE _D 2.12	CD (P=0.05) 4.20	SE _D 5.5	CD (P=0.05) 11.0	SE _D 0.133	CD (P=0.05) 0.265
K ₂₅ - 25 kg K ₂ O ha ⁻¹ ; K ₅₀ - 50 kg K ₂ O ha ⁻¹ .														

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹.

K₅₀ level increased the productive tillers considerably over K₂₅ level. The K₅₀ level had greater positive effect on the filling up of grains compared to K₂₅ level and control. The test grain weight was also favourably influenced by K fertiliser application.

4.2.1.1.2. Uptake of nutrients (table 49)

The NPK uptake at flowering stage was augmented by K fertilisation. The K₅₀ level had greater positive influence on NPK uptake than the K₂₅ level.

There was considerable increase in the uptake of NPK at maturity due to K fertilisation. The K₅₀ level recorded greater P uptake compared to K₂₅ level. The K₂₅ and K₅₀ levels increased the N and K uptake in comparable magnitudes.

4.2.1.1.3. Grain, straw yields and harvest index (Table 50)

The grain yield of NEM rice was appreciably enhanced by the K fertiliser application. However, there was significant increase in grain yield in K₅₀ level over that of K₂₅ level.

The straw yield was comparable in K₂₅ and K₅₀ levels. Both the levels were superior to control. Harvest index also followed a similar trend as that of grain yield.

4.2.1.1.4. Post-harvest soil nutrient content (Table 51)

The post-harvest soil organic carbon content was higher in treatments which received K fertiliser at 50 kg K₂O ha⁻¹ (K₅₀). The available N and P contents were not influenced by the levels of K fertiliser application. The

Table 49. Uptake of macronutrients (kg ha^{-1}) of rice - NEM Season, 1986

	At flowering stage				At maturity stage			
	N	P	K		N	P	K	
K_{25}	70.3	14.9	81.9		109.6	21.1	145.7	
K_{50}	80.1	16.1	88.9		112.8	22.2	151.0	
K_0	60.5	13.8	77.7		107.8	20.1	135.1	
N_{25} vs K_{50}	SE _D	CD ($P=0.05$)	SE _D	CD ($P=0.05$)	SE _D	CD ($P=0.05$)	SE _D	CD ($P=0.05$)
	1.83	3.80	0.39	0.78	2.29	4.55	2.26	NS
K_{25} vs K_0	1.65	3.43	0.36	0.71	2.07	4.11	2.09	NS
K_{50} vs K_0	1.27	2.64	0.27	0.54	1.59	3.17	1.54	3.04
$K_{25} - 25 \text{ kg } K_2O \text{ ha}^{-1}$								
$K_{50} - 50 \text{ kg } K_2O \text{ ha}^{-1}$								

Table 50. Grain, straw yields (kg ha^{-1}) and harvest index of rice - NEM Season, 1986

	Grain yield	Straw yield	Harvest index	
K ₂₅	4969	6802	0.422	
K ₅₀	5085	6849	0.426	
K ₀	4595	6393	0.418	
	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K ₂₅ vs K ₅₀	51	101	77	0.0014
K ₂₅ vs K ₀	46	91	69	0.0013
K ₅₀ vs K ₀	35	70	53	0.0010

K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1} .

post-harvest soil available K was more in K fertiliser applied treatments than in control. However, K_{25} and K_{50} levels resulted in soil available K in comparable magnitudes. The non-exchangeable K followed similar trend.

4.2.1.2. Groundnut

4.2.1.2.1. Growth attributes (Table 52)

Potassium fertilisation considerably increased the plant height at flowering stage. Nevertheless, the levels of K (K_{27} and K_{54}) did not differ on their effect on plant height. The cumulative effect of K application (R_1D) resulted in taller plants compared to residual effect (R_1), but it was on par with direct effect (D).

The LAI at flowering stage was markedly increased by K fertilisation. However, K_{27} and K_{54} levels were on par with each other. The cumulative effect (R_1D) was superior in enhancing the LAI compared to the residual (R_1) and direct (D) effects.

4.2.1.2.2. Dry matter production (DMP) (Table 53)

Potassium application enhanced the dry matter production at flowering stage. The dry matter production resulted from K_{27} was comparable with that of K_{54} level. The cumulative effect of K application (R_1D) resulted in greater accumulation of dry matter. However, DMP achieved from direct effect of K application was comparable with that of cumulative effect. The DMP at maturity followed the same pattern as that at flowering stage.

4.2.1.2.3. Yield attributes (Table 54)

Application on K exerted significant influence on shelling percentage. The K_{27} and K_{54} levels did not differ in their effect on shelling

Table 52. Growth attributes at flowering stage of groundnut - Summer, 1987

	Plant height (cm)				LAI	
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)
K ₂₇	43.1	24.9	25.9	24.6	3.73	3.79
K ₅₄	26.1	27.7	28.2	27.3	3.87	3.95
Mean	24.6	26.3	27.1	25.9	3.80	3.87
K ₀				20.6		3.62
K levels			SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
Season of application			2.35	NS	0.15	NS
K levels x Season			1.11	2.31	0.07	0.14
Control vs Rest			1.49	NS	0.11	NS
			2.17	4.55	0.10	0.21
R ₁	Residual effect of K applied during NEM season, 1986					
D	Direct effect of K applied during Summer, 1987					
R ₁ D	Cumulative effect of K [Residual (R_1) + Direct (D)]					
K ₂₇	27 kg K ₂ O ha ⁻¹ ; K ₅₄ - 54 kg K ₂ O ha ⁻¹					

Table 53. Dry matter production (t ha^{-1}) of groundnut - Summer, 1987

	At flowering stage				At maturity stage			
	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean
K ₂₇	4.34	4.57	4.63	4.52	7.50	7.75	7.97	7.74
K ₅₄	4.49	4.63	4.70	4.61	7.74	7.74	8.02	7.83
Mean	4.42	4.60	4.68	4.57	7.62	7.75	8.00	7.79
K ₀				4.29				7.13
K levels			SE _D	CD (P=0.05)			SE _D	CD (P=0.05)
Season of application			0.060	NS			0.071	NS
K levels x Season			0.073	0.154			0.087	0.183
Control vs Rest			0.104	NS			0.123	NS
			0.052	0.109			0.061	0.125

R_1 - Residual effect of K applied during NEM season, 1986
 D - Direct effect of K applied during Summer, 1987
 $R_1 D$ - Cumulative effect of K [Residual (R_1) + Direct (D)]
 K_{27} - 27 kg K_2O ha $^{-1}$; K_{34} - 34 kg K_2O ha $^{-1}$.

Table 54. Yield attributes of groundnut - Summer, 1987

	Shelling percentage			100 kernel weight (g)				
	Residual (R _I)	Direct (D)	Cumulative (R _I D)	Mean	Residual (R _I)	Direct (D)	Cumulative (R _I D)	Mean
K ₂₇	69.37	69.57	70.80	69.91	29.20	29.61	30.30	29.79
K ₅₄	70.47	71.00	70.90	70.79	30.48	30.38	30.60	30.49
Mean	69.92	70.29	70.85	70.35	29.84	30.00	30.58	30.14
K ₀				68.42				28.98

CD
(P=0.05)

SE_D
(P=0.05)

SE_D

K levels

Season of application

K levels x Season

Control vs Rest

NS
NS
NS
0.487
0.596
0.843
0.421

0.302
NS
0.371
NS
0.524
0.262
0.550

R_I - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R_ID - Cumulative effect of K [Residual (R_I) + Direct (D)]

K₂₇ - 27 kg K₂O ha⁻¹; K₅₄ - 54 kg K₂O ha⁻¹

percentage.

The hundred kernel weight was increased by K fertiliser application. Higher kernel weight was recorded by K fertilisation at $54 \text{ kg K}_2\text{O ha}^{-1}$ (K_{54}). The residual (R_1), direct (D) and cumulative (R_1D) effects did not vary in their influence on these yield attributes.

4.2.1.2.4. Quality characters (Table 55)

Potassium fertiliser application considerably increased the oil content of kernels. However, K_{27} and K_{54} levels increased the oil content in comparable magnitudes. The residual (R_1), direct (D) and cumulative (R_1D) effects did not influence the oil content.

The crude protein content of kernels was not influenced by the K fertiliser application. The residual (R_1), direct (D) and cumulative (R_1D) effect of K application also did not exert considerable effect.

4.2.1.2.5. Uptake of nutrients (Table 56a and 56b).

The uptake of major nutrients at flowering stage was favourably influenced by K application. The direct effect (D) and cumulative effect (R_1D) exerted comparable effect on the NPK uptake. Both the direct effect (D) and cumulative effect (R_1D) were superior to the residual effect (R_1).

The uptake of NPK at maturity was significantly influenced by K fertiliser application. The K_{54} level exerted greater positive effect than K_{27} level. The cumulative effect of K (R_1D) exerted considerable impact on the uptake of NPK. Nevertheless, it was on par with the direct effect (D).

Table 55. Oil and crude protein contents of groundnut - Summer, 1987

	Oil content (%)			Crude protein content (%)			
	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)
K ₂₇	48.5	48.9	49.5	49.0	25.16	25.37	25.88
K ₅₄	49.5	49.8	50.8	50.0	24.97	25.23	25.04
Mean	49.0	49.4	50.3	49.1	25.07	25.30	25.46
K ₀				48.2			24.35
K levels			SE _D	CD (P=0.05)		SE _D	CD (P=0.05)
Season of application			0.42	NS		0.545	NS
K levels x Season			0.52	NS		0.668	NS
Control vs Rest			0.74	NS		0.944	NS
			0.37	0.77		0.472	NS

R₁ - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R₁D - Cumulative effect of K [Residual (R₁) + Direct (D)]K₂₇ - 27 kg K₂O ha⁻¹; K₅₄ - 54 kg K₂O ha⁻¹.

Table 56a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of groundnut - Summer, 1987

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	N			P			K					
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	
K ₂₇	99.9	106.4	106.8	104.4	5.7	6.0	6.1	5.9	68.5	72.6	73.0	71.4
K ₅₄	103.2	105.1	108.1	105.5	5.9	6.0	6.1	6.0	70.7	72.0	74.1	72.3
Mean	101.6	105.8	107.5	105.0	5.8	6.0	6.1	6.0	69.6	72.3	73.6	71.9
K _C				98.7				5.6				67.4

	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	1.38	NS	0.08	NS	0.91	NS
Season of application	1.69	3.54	0.10	0.20	1.11	2.33
K levels x season	2.38	NS	0.14	NS	1.57	NS
Control vs Rest	1.19	2.51	0.07	0.14	0.79	1.65

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied Summer, 1987

R_1D - Cumulative effect of K [R_1 + Direct (D)]

K₂₇ - 27 kg K₂O ha⁻¹; K₅₄ - 54 kg K₂O ha⁻¹.

R; - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied Summer. 1987

$$R_j D_j - \text{Cumulative effect of } K_j [\text{Residual } (R_j) + \text{Direct } (D_j)]$$
$$K_{27} - 27 \text{ kg K}_2\text{O ha}^{-1}; \quad K_{54} - 54 \text{ kg K}_2\text{O ha}^{-1}.$$

Table 56b. Uptake of macronutrients (Kg ha^{-1}) at maturity stage of groundnut - Summer, 1987

	N				P				K			
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean
K_{27}	169.9	179.0	184.5	177.7	9.6	10.1	10.4	10.0	115.1	118.1	118.5	117.2
K_{54}	173.8	183.5	190.1	182.5	10.0	10.3	10.8	10.4	118.0	119.9	122.2	120.0
Mean	171.9	181.3	187.1	180.1	9.8	10.2	10.6	10.1	116.6	119.0	120.4	118.6
K_c				164.5				9.1				107.3
K levels			SE_D	CD ($P=0.05$)			SE_D	CD ($P=0.05$)			SE_D	CD ($P=0.05$)
Season of application			2.32	4.88			0.11	0.22			1.08	2.27
K levels x Season			2.85	5.99			0.12	0.25			1.32	2.78
Control vs Rest			4.03	NS			0.20	NS			1.87	NS
			2.01	4.23			0.10	0.21			0.94	1.97

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R_1D - Cumulative effect of K [(Residual (R_1) + Direct (D))

K_{27} - 27 kg K_2O ha^{-1} ; K_{54} - 54 kg K_2O ha^{-1} .

4.2.1.2.6. Pod and haulms yield (Table 57)

The pod yield of groundnut was markedly increased by K fertilisation. The K_{54} level appreciably enhanced the pod yield compared to K_{27} level. The cumulative effect of K application (R_1D) increased the pod yield significantly. However, it was on par with direct effect of K (D) in influencing the pod yield.

The haulms yield was favourably influenced by K fertiliser application. The K_{54} level had greater impact on haulms yield than K_{27} level. The season did not have any influence on haulms yield.

4.2.1.3. Soybean

4.2.1.3.1. Growth attributes (Table 58)

The plant height at peak flowering stage was considerably increased by K application. However, the plant height achieved by the K_{20} level was comparable with that of K_{40} level. The season of application had little effect of plant height. The LAI at flowering also followed a similar trend as that of plant height.

4.2.1.3.2. Dry matter production (DMP) (Table 59)

The DMP at flowering phase was not enhanced by K fertiliser application. The season of K application too did not influence the DMP.

Potassium fertiliser application considerably augmented the DMP at harvest. However, DMP resulted from K_{20} was comparable with that of K_{40} . The direct effect of (D) and the cumulative effect (R_1D) had comparable impact on DMP, but they were superior to control.

Table 57. Pod and haulms yield (kg ha^{-1}) of groundnut - summer, 1987.

	Pod yield			Haulms yield				
	Residual (R_I)	Direct (D)	Cumulative ($R_I D$)	Mean	Residual (R_I)	Direct (D)	Cumulative ($R_I D$)	Mean
K_{27}	2139	2278	2305	2241	2795	2810	2899	2835
K_{54}	2281	2513	2573	2456	3066	3171	3191	3143
Mean	2210	2396	2439	2349	2988	2991	2985	2989
K_0				1940				2663
K levels			SE _D	CD (P=0.05)		SE _D	CD (P=0.05)	
Season of application			83	174		98	267	
K levels x Season			101	214		121	NS	
Control vs Rest			143	NS		171	NS	
			72	150		85	179	

R_1 - Residual effect of K applied during NEA1 season, 1986

D - Direct effect of K applied during Summer, 1987

$R_1 D$ - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{27} - 27 kg $K_2O \text{ ha}^{-1}$; K_{54} - 54 kg $K_2O \text{ ha}^{-1}$.

Table 58. Growth attributes at flowering stage of soybean - Summer, 1987

	Plant height (cm)				LAI	
	Residual (R_I)	Direct (D)	Cumulative ($R_I D$)	Mean	Residual (R_I)	Direct (D)
K_{20}	58.4	59.5	60.9	59.6	3.81	3.83
K_{40}	59.8	60.1	61.4	60.4	3.90	4.08
Mean	59.1	59.8	61.2	60.0	3.86	3.96
K_0				52.3		
					SE _D	CD (P=0.05)
K levels					0.83	NS
Season of application					1.13	NS
K levels x Season					0.95	NS
Control vs Rest					1.61	3.39
					SE _D	CD (P=0.05)
R_I					0.13	NS
D					0.18	NS
$R_I D$					0.17	NS
K_{20}					0.09	0.19

R_I - Residual effect of K applied during NEAI season, 1986

D - Direct effect of K applied during Summer, 1987

$R_I D$ - Cumulative effect of K [Residual (R_I) + Direct (D)]

K_{20} - 20 kg K_2O ha⁻¹; K_{40} - 40 kg K_2O ha⁻¹.

4.2.1.3.3. Yield attributes (Table 60)

The number of pods per plant was favourably influenced by the K fertilisation, with K_{20} and K_{40} levels producing comparable number of pods per plant. The direct effect (D) and cumulative effect (R_1D) considerably increased the number of seeds per pod compared to the residual effect (R_1). The levels of K did not vary in their influence on seed weight of soybean.

4.2.1.3.4. Quality characters (Table 61)

The oil content and crude protein content of soybean were not influenced by potassium application. The season of K application also did not produce significant effect on these quality characters.

4.2.1.3.5. Uptake of nutrients (Table 62a and 62b)

Potassium fertilisation augmented the N and P uptake at flowering stage. Considerable increase in K uptake due to K application could not be observed. The season of application did not exert appreciable effect on the uptake of NPK.

The uptake of NPK at maturity was considerably enhanced by K application. However, K_{20} and K_{40} levels increased the yield in comparable magnitudes. The cumulative effect of K application exerted considerable influence on P and K uptake. Nevertheless the P uptake resulted from the direct effect (D) was comparable with that of cumulative effect (R_1D).

4.2.1.3.6. Seed yield (Table 63)

The seed yield of soybean was considerably increased by K fertilisation. However, K_{40} level enhanced the seed yield markedly over K_{20}

Table 60. Yield attributes of soybean - Summer, 1987

	Pods/plant				Seeds/pod				100 seed weight (g)			
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean
K_{20}	36.7	44.3	49.0	43.3	2.34	2.43	2.48	2.42	9.46	9.56	9.47	9.50
K_{40}	41.3	50.3	50.7	47.4	2.21	2.47	2.51	2.40	9.19	9.69	9.32	9.40
Mean	39.0	47.3	49.9	45.4	2.28	2.45	2.50	2.41	9.33	9.63	9.40	9.45
K_C				37.1				2.46				9.30

SE_D CD (P=0.05) SE_D CD (P=0.05) SE_D CD (P=0.05)

K levels

Season of application

K levels x Season

Control vs Rest

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R_1D - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{20} - 20 kg K_2O ha⁻¹; K_{40} - 40 kg K_2O ha⁻¹

Table 61. Oil and crude protein content (%) of soybean - Summer, 1987

	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean
K_{20}	19.40	19.73	19.20	19.44	38.51	38.71	39.23	38.8
K_{40}	19.37	19.20	19.60	19.39	38.79	38.85	39.47	39.0
Mean	19.39	19.47	19.40	19.42	38.7	38.8	39.4	38.9
K_0				19.53				38.5
K levels			SE_D	CD (P=0.05)			SE_D	CD (P=0.05)
Season of application			0.247	NS			0.22	NS
K levels x Season			0.302	NS			0.26	NS
Control vs Rest			0.428	NS			0.35	NS
			0.214	NS			0.29	NS

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

$R_1 D$ - Cumulative effect of K [$Residual (R_1) + Direct (D)$]

K_{12} - 12 kg K_2O ha⁻¹; K_{24} - 24 kg K_2O ha⁻¹.

Table 62a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of soybean - Summer, 1987

	N				P				K			
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean
K_{20}	29.0	35.0	35.5	33.2	6.7	7.1	7.3	7.0	19.7	23.3	23.6	22.2
K_{40}	33.6	31.8	35.0	33.5	6.8	7.4	7.4	7.2	23.0	23.8	23.9	23.6
Mean	31.3	33.4	35.3	33.4	6.8	7.3	7.4	7.1	21.4	23.6	23.8	22.9
K_0				28.1				6.2				19.7
	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	2.39	NS			0.24	NS			1.77	NS		
Season of application	2.92	NS			0.30	NS			2.17	NS		
K levels x Season	4.14	NS			0.42	NS			3.06	NS		
Control vs Rest	2.07	4.34			0.21	0.44			1.53	NS		

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R_1D - Cumulative effect of $K[\text{Residual } (R_1) + \text{Direct } (D)]$

K_{20} - 20 kg $K_2O \text{ ha}^{-1}$; K_{40} - 40 kg $K_2O \text{ ha}^{-1}$.

Table 62b. Uptake of macronutrients (kg ha⁻¹) at maturity stage of soybean - Summer, 1987

	N			P			K		
	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)
K ₂₅	61.1	60.7	65.8	62.5	13.3	14.8	16.1	14.7	53.9
K ₄₅	61.5	63.3	65.2	63.3	13.6	15.2	15.9	14.9	55.0
Mean	61.3	62.0	65.5	62.9	13.5	15.0	16.0	14.8	54.5
K ₀				56.6				13.1	

	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	1.57	NS	0.63	NS	2.49	NS
Season of application	1.93	NS	0.76	1.63	3.04	6.40
K levels x Season	2.72	NS	1.10	NS	4.31	NS
Control vs Rest	1.36	2.86	0.55	1.15	2.15	4.52

R₁ - Residual effect of K applied during NEA1 season, 1986

D - Direct effect of K applied during Summer, 1987

R₁D - Cumulative effect of K [Residual (R₁) + Direct (D)]

K₂₀ - 20 kg K₂O ha⁻¹; K₄₀ - 40 kg K₂O ha⁻¹.

Table 63. Seed yield (kg ha^{-1}) of soybean - Summer, 1987

	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean
K_{20}	1568	1612	1646	1609
K_{40}	1679	1689	1765	1711
Mean	1624	1651	1706	1660
K_0				1493

CD (P=0.05)

SE_D

K levels	45	95
Season of application	78	NS
K levels x Season	111	NS
Control vs Rest	55	117

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

$R_1 D$ - Cumulative effect of K [R_1 + Direct (D)]

K_{20} - 20 kg K_2O ha^{-1} ; K_{40} - 40 kg K_2O ha^{-1} .

level. The residual (R_1), direct (D) and cumulative effects (R_1D) did not influence the seed yield.

4.2.1.4. Maize

4.2.1.4.1. Growth attributes (Table 64)

Potassium fertilisation resulted in taller plants at silking stage. The plant height achieved due to K_{25} application was comparable with that of K_{50} level.

The K_{50} level enhanced the LAI at silking stage compared to K_{25} level but both the levels of K were superior to control. The season of K application exerted negligible influence on LAI.

4.2.1.4.2. Dry matter production (Table 65)

The DMP at silking stage and at maturity was considerably augmented by K fertiliser application, with K_{25} and K_{50} levels recording comparable DMP. The residual (R_1), direct (D) and cumulative (R_1D) effects had little influence on DMP at silking stage as well as at maturity.

4.2.1.4.3. Yield attributes (Table 66)

The yield components viz., rows of grain per cob, number of grains per row and the hundred grain weight were significantly increased by K fertilisation. The levels of K (K_{25} and K_{50}) did not differ in their influence on these yield attributes. The residual (R_1), direct (D) and cumulative effects (R_1D) did not produce appreciable enhancement of yield attributes.

4.2.1.4.4. Uptake of nutrients (Tables 67a and 67b)

Potassium application had significant positive influence on the uptake

Table 64. Growth attributes at silking stage of maize - Summer, 1987

	Plant height (cm)			LAI				
	Residual (R _I)	Direct (D)	Cumulative (R _I D)	Mean	Residual (R _I)	Direct (D)	Cumulative (R _I D)	Mean
K ₂₅	205.3	202.4	204.9	204.2	4.96	5.01	5.05	5.01
K ₅₀	203.2	203.3	205.4	204.0	5.15	5.30	5.54	5.33
Mean	204.3	202.9	205.2	204.1	5.06	5.16	5.30	5.17
K ₀				192.1				4.82
			SE _D	CD (P=0.05)			SE _D	CD (P=0.05)
K levels			3.9	NS			0.12	0.26
Season of application			4.8	NS			0.15	NS
K levels x Season			6.8	NS			0.21	NS
Control vs Rest			3.4	7.2			0.11	0.23

R_I - Residual effect of K applied during NEM season. 1986

D - Direct effect of K applied during Summer, 1987

R_ID - Cumulative effect of K [Residual (R_I) + Direct (D)]

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹.

Table 65. Dry matter production ($t\ ha^{-1}$) of maize - Summer, 1987

	At flowering stage				At maturity stage			
	Residual (R_I)	Direct (D)	Cumulative ($R_I D$)	Mean	Residual (R_I)	Direct (D)	Cumulative ($R_I D$)	Mean
K_{25}	4.26	4.23	4.42	4.30	10.70	10.83	11.26	10.93
K_{50}	4.43	4.14	4.43	4.33	10.50	10.87	11.28	10.88
Mean	4.35	4.19	4.43	4.32	10.60	10.85	11.27	10.91
K_0				4.11				10.24

	SE_D	CD ($P=0.05$)	SE_D	CD ($P=0.05$)
K levels	0.094	NS	0.281	NS
Season of application	0.116	NS	0.344	NS
K levels x Season	0.163	NS	0.486	NS
Control vs Rest	0.082	0.172	0.243	0.511

R_I - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

$R_I D$ - Cumulative effect of K [Residual (R_I) + Direct (D)]

K_{25} - 25 kg $K_2O\ ha^{-1}$; K_{50} - 50 kg $K_2O\ ha^{-1}$.

Table 66. Yield attributes of maize - Summer, 1987

	Rows of grain/cob			Number of grains/row			100 grain weight (g)		
	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)
K ₂₅	13.3	13.1	12.9	13.1	32.1	32.9	32.6	20.73	21.04
K ₅₀	13.2	13.3	13.5	13.3	31.5	35.0	33.9	21.33	21.35
Mean	13.3	13.2	13.2	13.2	31.8	34.0	33.3	21.03	21.20
K ₀				12.5			30.2		20.65
K levels			SE _D	CD (P=0.05)		SE _D	CD (P=0.05)		SE _D
Season of application			0.33	NS		1.30	NS		0.266
K levels x Season			0.41	NS		1.59	NS		0.326
Control vs Rest			0.58	NS		2.24	NS		0.461
			0.29	0.61		1.12	2.36		0.230

R₁ - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R₁D - Cumulative effect of K [Residual (R₁) + Direct (D)]

K₂₅ - 25 kg K₂O ha⁻¹; K₅₀ - 50 kg K₂O ha⁻¹

Table 67a. Uptake of macronutrients (kg ha^{-1}) at silking stage of maize - Summer, 1987

	N				P				K			
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean
K_{25}	40.5	41.9	42.0	41.5	14.3	14.4	14.9	14.5	81.0	80.5	84.2	81.9
K_{50}	42.1	42.9	44.9	43.2	14.9	13.9	14.9	14.6	80.9	81.5	84.3	82.2
Mean	41.3	42.4	43.5	41.7	14.6	14.2	14.9	14.6	81.0	81.0	84.3	82.1
K_0				39.1				13.9				78.3
K levels			SE _D	CD (P=0.05)			SE _D	CD (P=0.05)			SE _D	CD (P=0.05)
Season of application			0.91	NS			0.32	NS			1.64	NS
K levels x Season			1.11	NS			0.39	NS			2.01	NS
Control vs Rest			1.57	NS			0.56	NS			2.85	NS
			0.79	1.65			0.28	0.59			1.42	2.99

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R_1D - Cumulative effect of K Residual (R_1) + Direct (D)

K_{25} - 25 kg $K_2O \text{ ha}^{-1}$; K_{50} - 50 kg $K_2O \text{ ha}^{-1}$.

Table 67b. Uptake of macronutrients (kg ha^{-1}) at maturity stage of maize - Summer, 1987

	N			P			K		
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)
K_{25}	127.3	128.9	133.9	130.0	18.8	19.5	20.3	19.5	90.8
									92.2
									96.1
									93.0
K_{50}	124.6	129.1	134.3	129.3	19.3	19.6	20.3	19.7	89.8
									92.8
									96.3
									93.0
Mean	126.0	129.0	134.1	129.7	19.0	19.6	20.3	19.6	90.3
									92.5
									96.2
									93.0
K_0				121.7				13.4	
									87.2

	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	3.34	NS	0.49	NS	2.28	NS
Season of application	4.09	NS	0.60	NS	2.79	NS
K levels x Season	5.78	NS	0.85	NS	3.94	NS
Control vs Rest	2.89	6.08	0.43	0.90	1.97	4.14

R_j - Residual effect of K applied during NE1 season, 1986

D - Direct effect of K applied during Summer, 1987

R_1D - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{25} - 25 kg K_2O ha^{-1} ; K_{50} - 50 kg K_2O ha^{-1} .

of NPK nutrients at silking stage of maize. Considerable increase in the uptake of NPK nutrients at maturity also could be observed with the K fertilisation. The uptake of NPK was comparable in K_{25} and K_{50} levels. The season of K fertilisation did not influence the uptake of all the three major nutrients.

4.2.1.4.5. Grain and straw yields (Table 68)

The grain yield of maize was considerably enhanced by K fertilisation. The K_{50} level produced significantly higher grain yield than K_{25} level, but both the levels were significantly superior to control in enhancing the grain yield. The K levels and the season of application did not produce significant variation in straw yield.

4.2.1.5. Sesame

4.2.1.5.1. Growth attributes (Table 69)

The K_{24} level had favourable influence on plant height and LAI at flowering stage of sesame compared to K_{12} level, but both the levels were superior to control. The season of K fertilisation did not exert significant influence on these growth attributes.

4.2.1.5.2. Dry matter production (Table 70)

The DMP at peak flowering stage as well as at maturity was favourably influenced by K fertilisation. The season of K fertilisation had no significant effect on DMP.

4.2.1.5.3. Yield attributes (Table 71)

The number of capsules per plant, length of capsule and the thousand

Table 68. Grain and straw yield (kg ha^{-1}) of maize - Summer, 1987

	Grain yield				Straw yield			
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean
K_{25}	3233	3353	3617	3401	6147	6167	6463	6259
K_{50}	3352	3555	3760	3556	6225	6258	6479	6321
Mean	3293	3454	3663	3479	6186	6213	6471	6290
K_0				3201				5919
K levels			SE _D	CD (P=0.05)			SE _D	CD (P=0.05)
Season of application			66	143			238	NS
K levels x Season			166	NS			316	NS
Control vs Rest			235	NS			447	NS
			118	247			223	NS

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R_1D - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{25} - 25 kg $K_2O \text{ ha}^{-1}$; K_{50} - 50 kg $K_2O \text{ ha}^{-1}$.

seed weight were considerably augmented by K fertilisation. The season of K fertilisation did not alter these yield attributes markedly.

4.2.1.5.4. Oil content of seed (Table 71)

The oil content of sesame was not influenced by K fertilisation. The K levels and season of K application also did not produce considerable effect on oil content of seeds.

4.2.1.5.5. Uptake of nutrients (Table 72a and 72b)

The uptake of N and K at peak flowering stage was positively influenced by K fertiliser application with K_{12} and K_{24} levels resulting in comparable N and K uptake. The residual (R_1), direct (D) and cumulative effects (R_1D) did not produce considerable variation in NPK uptake.

The uptake of P and K at maturity stage was increased by K fertilisation, whereas the N uptake was not affected by K application. Among the K levels, K_{24} level resulted in the higher uptake of N. The positive influence by the cumulative effect of K fertilisation (R_1D) could be observed only for P uptake. The higher levels of K (K_{12} and K_{24}) resulted in comparable P and K uptake at maturity.

4.2.1.5.6. Seed yield (Table 73)

The seed yield of sesame was appreciably enhanced by K fertilisation. The K_{24} level had greater positive influence on seed yield, compared to K_{12} level. The residual effect (R_1), direct effect (D) and cumulative effect (R_1D) were not significant in influencing the seed yield.

Table 71. Yield attributes and oil content of sesame - Summer, 1987

	Capsules/plant				Length of capsules (cm)				1000 seed weight (g)				Seed oil content (%)			
	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean	Residual (R ₁)	Direct (D)	Cumulative (R ₁ D)	Mean
K ₁₂	67.5	74.9	85.4	75.9	2.5	2.6	2.5	2.5	3.09	3.16	3.07	3.11	49.33	48.97	48.77	49.09
K ₂₄	73.7	79.7	86.5	80.0	2.6	2.6	2.7	2.6	3.13	3.14	3.12	3.13	50.20	48.37	49.33	49.37
Mean	70.6	77.3	86.0	78.0	2.6	2.6	2.6	2.6	3.11	3.15	3.10	3.12	49.57	48.77	49.03	49.23
K ₀				65.1				2.4				3.06				49.13
K levels	SE _D			NS	SE _D			NS	SE _D			NS	SE _D			NS
Season of application	6.36			NS	0.414			NS	0.029			NS	0.029			NS
K levels x Season	7.92			NS	0.051			NS	0.35			NS	0.35			NS
Control vs Rest	11.20			NS	0.072			NS	0.040			NS	0.040			NS
	3.60			11.8	0.036			0.075	0.025			0.052	0.025			0.052

R₁ - Residual effect of K applied during NEA season, 1986

D - Direct effect of K applied during Summer, 1987

R₁D - Cumulative effect of K [Residual (R₁) + Direct (D)]K₁₂ - 12 kg K₂O ha⁻¹; K₂₄ - 24 kg K₂O ha⁻¹.

Table 72a. Uptake of macronutrients (kg ha^{-1}) at flowering stage of sesame - Summer, 1987

	N			P			K		
	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)	Direct (D)	Cumulative (R_1D)	Mean	Residual (R_1)
K_{12}	31.9	30.9	31.9	31.6	4.1	4.1	4.5	4.2	20.1
K_{24}	32.4	32.9	33.7	33.0	4.4	4.4	4.5	4.4	20.7
Mean	32.2	31.9	32.8	32.3	4.3	4.3	4.5	4.3	20.4
K_0				30.1				4.2	

	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	0.82	NS	0.11	NS	0.51	NS
Season of application	1.00	NS	0.14	NS	0.62	NS
K levels x Season	1.42	NS	0.19	NS	0.88	NS
Control vs Rest	0.71	1.49	0.10	NS	0.44	0.92

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

R_1D - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{12} - 12 $\text{kg K}_2\text{O ha}^{-1}$; K_{24} - 24 $\text{kg K}_2\text{O ha}^{-1}$.

Table 72b. Uptake of macronutrients (kg ha^{-1}) at maturity stage of sesame - Summer, 1987

	N			P			K		
	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean	Residual (R_1)
K_{12}	38.4	40.3	40.8	39.8	5.3	5.3	5.6	5.4	31.0
K_{24}	39.8	43.5	48.5	43.9	5.3	5.5	5.8	5.5	33.8
Mean	39.1	41.9	44.4	41.9	5.3	5.4	5.7	5.5	32.4
K_0				39.2				5.1	

	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)	SE _D	CD (P=0.05)
K levels	1.62	3.40	0.10	NS	0.82	NS
Season of application	1.98	NS	0.12	0.24	1.00	NS
K levels x Season	2.81	NS	0.16	NS	1.42	NS
Control vs Rest	1.40	NS	0.10	0.71	0.71	1.49

R_1 - Residual effect of K applied during NEA season, 1986

D - Direct effect of K applied during Summer, 1987

$R_1 D$ - Cumulative effect of K [R_1 Residual (R_1) + Direct (D)]

K_{12} - 12 kg K_2O ha^{-1} ; K_{24} - 24 kg K_2O ha^{-1}

Table 73. Seed yield (kg ha^{-1}) of sesame - Summer, 1987

	Residual (R_1)	Direct (D)	Cumulative ($R_1 D$)	Mean
K_{12}	907	947	1021	902
K_{24}	984	1012	1093	1030
Mean	946	980	1057	966
K_0				850

CD ($P=0.05$)

SE_D

K levels	56	108
Season of application	69	NS
K levels x Season	98	NS
Control vs Rest	49	103

R_1 - Residual effect of K applied during NEM season, 1986

D - Direct effect of K applied during Summer, 1987

$R_1 D$ - Cumulative effect of K [Residual (R_1) + Direct (D)]

K_{12} - 12 kg $K_2O \text{ ha}^{-1}$; K_{24} - 24 kg $K_2O \text{ ha}^{-1}$.

4.2.2. Productivity of the cropping system

4.2.2.1. Biological production potential of the cropping systems (Table 74 and Fig.7)

Potassium fertilisation considerably promoted the biomass production of the cropping systems. Among the cropping systems, total biomass production was the highest in C_3 system (rice-maize) which was superior to C_1 system (rice-groundnut). The C_2 system (rice-soybean) was poor in biomass production.

Total biomass production of the cropping systems by the application of 50 per cent and 100 per cent recommended K were comparable. But they considerably increased the biomass production of the systems over control.

In C_3 system (rice-maize), the increase in biomass production due to K fertilisation was the greatest (1.666 t ha^{-1}) compared to 0.462 t ha^{-1} in C_1 system (rice-groundnut).

4.2.2.2. Total rice grain equivalent of the cropping systems (Table 75 and Fig.7)

Total rice grain equivalent yield was the highest in C_1 system (rice-groundnut). It was followed by C_4 system (rice-sesame) with grain equivalent production of 8559 kg ha^{-1} . Lowest total grain equivalent yield was registered in C_2 system (rice-soybean).

Potassium fertilisation considerably enhanced the total rice grain equivalent yield of the systems. Fertilisation with 100 per cent recommended dose of K was superior in influencing total grain equivalent (8758 kg ha^{-1}) compared to 50 per cent recommended dose of K (8450 kg ha^{-1}).

Table 70. Dry matter production ($t\ ha^{-1}$) in the cropping systems - Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	19.91	19.35	20.57	19.94
	K ₂	20.57	19.43	21.09	20.33
	Mean	20.24	19.39	20.79	20.14
	K ₀				19.68
Rice-Soybean (C ₂)	K ₁	15.42	15.60	16.45	15.82
	K ₂	15.86	15.99	16.62	16.16
	Mean	15.64	15.80	16.54	15.99
	K ₀				15.19
Rice-Maize (C ₃)	K ₁	23.70	22.66	24.30	23.55
	K ₂	23.14	22.69	24.40	23.38
	Mean	23.42	22.63	24.35	23.47
	K ₀				21.80
Rice-Sesame (C ₄)	K ₁	19.38	17.96	20.03	19.12
	K ₂	19.97	18.77	19.99	19.58
	Mean	19.68	18.37	20.01	19.35
	K ₀				18.58
Mean		19.75	19.05	20.42	

	SE _D	CD (P=0.05)
Cropping systems	0.214	0.524
K levels	0.136	NS
Season of application	0.166	0.352
K levels x Season	0.235	NS
C at K	0.325	NS
K at C	0.272	NS
C at S	0.378	NS
S at C	0.333	NS
Control vs Rest	0.118	0.235
Control vs Rest at C	0.236	0.470
C at Control vs Rest	0.282	0.645

S₁ - K applied during NEM season, 1986

S₂ - K applied during Summer, 1987

S₃ - K applied during both the seasons

K₁ - 50 per cent recommended dose of K

K₂ - 100 per cent recommended dose of K

Table 75. Rice grain equivalent yield (Rs ha^{-1}) in the cropping systems
- Pattukottai

Cropping system	K level	S_1	S_2	S_3	Mean
Rice-Groundnut (C_1)	K_1	9329	8816	9741	9295
	K_2	10312	9536	10211	10019
	Mean	9821	9173	9976	9557
	K_0				8862
Rice-Soybean (C_2)	K_1	7552	7545	7848	7648
	K_2	7952	7865	8193	7953
	Mean	7752	7675	7976	7801
	K_0				7329
Rice-Maize (C_3)	K_1	8122	7703	8390	8072
	K_2	7946	7543	8694	7992
	Mean	8031	7623	8442	8032
	K_0				7454
Rice-Sesame (C_4)	K_1	8748	8698	8995	8784
	K_2	9036	8644	9531	9070
	Mean	8892	8671	9218	8927
	K_0				8190
Mean		8624	8286	8903	
		SE_D		CD (P=0.05)	
Cropping systems		183		999	
K levels		96		191	
Season of application		118		234	
K levels x Season		166		NS	
C at K		262		619	
K at C		192		383	
C at S		295		NS	
S at C		235		NS	
Control vs Rest		85		166	
Control vs Rest at C		166		NS	
C at Control vs Rest		277		NS	

S_1 - K applied during NEM season, 1986

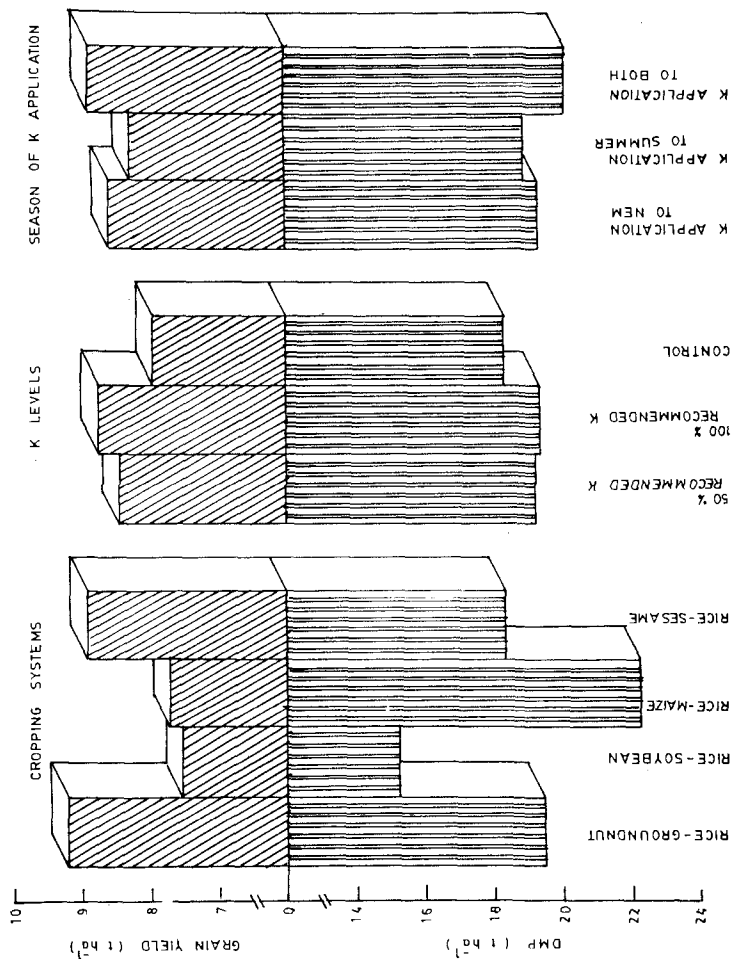
S_2 - K applied during Summer, 1987

S_3 - K applied during both the seasons

K_1 - 50 per cent recommended dose of K

K_2 - 100 per cent recommended dose of K

FIG. 7 RICE GRAIN EQUIVALENT YIELD AND DRY MATTER PRODUCTION- PATTUKOTTAI



Among the seasons of K application, fertilisation to both the crops of the systems enhanced the total grain equivalent yield compared to fertilisation to only one crop of the systems.

Irrespective of K levels, C_1 system (rice-groundnut) achieved total rice grain equivalent yield of 9557 kg ha^{-1} compared to 7801 kg ha^{-1} in C_2 system (rice-soybean), 8927 kg ha^{-1} in C_4 system (rice-sesame). Regardless of the cropping systems, K_2 level (100 per cent recommended dose of K) recorded higher total rice grain equivalent yield except in C_3 system, in which K_1 level (50 per cent recommended dose) registered higher total grain equivalent yield.

4. 2.3. Economic analysis of potassium management in the cropping systems

4.2.3.1. Gross return from the cropping systems (Table 76)

Potassium fertilisation considerably increased the gross return from the cropping systems. The C_1 system (rice-groundnut) recorded the highest gross return followed by the C_4 system (rice-sesame).

Application of 100 per cent recommended dose of K (K_2) recorded higher gross return than that from 50 per cent K (K_1).

Potassium application to both the crops in the cropping systems resulted in higher gross return than that from K application to any one crop in the systems.

4.2.3.2. Net return from the cropping systems (Table 77 and Fig.8)

Potassium fertiliser application considerably augmented the net return from the cropping systems. Net return from the cropping system followed a

Table 76. Gross return (Rs ha⁻¹) from the cropping systems - Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	23060	21801	24537	23113
	K ₂	25633	23817	25945	26464
	Mean	24316	22809	24991	24039
	K ₀				21751
Rice-Soybean (C ₂)	K ₁	17585	17555	18265	17802
	K ₂	18487	18321	20020	18943
	Mean	18036	17938	19143	18373
	K ₀				17082
Rice-Maize (C ₃)	K ₁	19543	18523	20166	19411
	K ₂	19692	19136	20393	19567
	K ₀	19318	18840	20280	19679
	Mean				17918
Rice-Sesame (C ₄)	K ₁	20290	20107	20663	20353
	K ₂	20996	20958	22003	21319
	Mean	20643	20533	21333	20819
	K ₀				18977
Mean		20578	20030	21437	

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Cropping systems	545	1332
K levels	198	NS
Season of application	469	929
K levels x Season	611	1253
C at K	658	1631
K at C	783	556
C at S	502	1113
S at C	325	651
Control vs Rest	537	1068
Control vs Rest at C	652	NS
C at Control vs Rest	423	NS

- S₁ - K applied during NEM season, 1986
 S₂ - K applied during Summer, 1987
 S₃ - K applied during both the seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

Table 77. Net return (Rs ha⁻¹) from the cropping systems - Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	12746	11545	14235	12842
	K ₂	15331	13513	15049	14631
	Mean	14039	12529	14642	13737
	K ₀				11543
Rice-Soybean (C ₂)	K ₁	8968	8947	9611	9175
	K ₂	9824	8676	11283	9928
	Mean	9396	8812	10447	9552
	K ₀				8511
Rice-Maize (C ₃)	K ₁	9773	8753	10350	9625
	K ₂	9276	8340	10485	9367
	Mean	9525	8547	10418	9496
	K ₀				8194
Rice-Sesame (C ₄)	K ₁	11881	11722	12232	11945
	K ₂	12541	11551	13504	12532
	Mean	12211	11637	12868	12239
	K ₀				10614
Mean		11293	10381	12094	

Data statistically not analysed

S₁ - K applied during NEM season, 1986S₂ - K applied during Summer, 1987S₃ - K applied during both the seasonsK₁ - 50 per cent recommended dose of KK₂ - 100 per cent recommended dose of K

similar trend as that of gross return. However, the C_3 systems (rice-maize) which registered higher gross return than in C_2 system (rice-soybean), resulted in the lowest net return.

4.2.3.3. Benefit cost ratio (B-C) ratio of K management practices in the cropping systems (Table 78 and Fig. 8)

The B-C ratio was substantially increased by K fertilisation. The C_4 system (rice-sesame) achieved a B-C ratio of 2.36 compared to 2.24 in C_1 system (rice-groundnut).

The K_2 level (100 per cent recommended dose of K) too C_1 system (rice-groundnut) and C_4 system (rice-sesame) recorded higher B-C ratio compared to K_1 level (50 per cent recommended dose of K).

Potassium fertilisation to both the component crops (S_3) registered higher B-C ratio than that of K application in any one crop (S_1 or S_2) in the systems.

4.2.4. Post-harvest soil nutrient status

4.2.4.1. Post-harvest soil organic carbon (Table 79)

Potassium fertilisation considerably increased the post-harvest soil organic carbon content. Among the cropping systems, C_2 (rice-soybean) resulted in higher soil organic carbon followed by C_1 system (rice-groundnut).

Application of 50 per cent and 100 per cent recommended doses of K had the comparable influence on soil organic carbon content. The season of K application did not alter the organic carbon status of the soil.

Table 78. Benefit cost ratio of K management practices in the cropping systems
- Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	2.24	2.13	2.38	2.25
	K ₂	2.49	2.31	2.45	2.42
	Mean	2.37	2.22	2.42	2.34
	K ₀				2.13
Rice-Soybean (C ₂)	K ₁	2.04	2.39	2.11	2.18
	K ₂	2.13	2.00	2.29	2.13
	Mean	2.09	2.20	2.20	2.16
	K ₀				1.99
Rice-Maize (C ₃)	K ₁	2.09	1.90	2.05	1.98
	K ₂	1.94	1.85	2.06	1.95
	Mean	1.97	1.88	2.06	1.97
	K ₀				1.84
Rice-Sesame (C ₄)	K ₁	2.41	2.40	2.45	2.42
	K ₂	2.48	2.37	2.59	2.48
	Mean	2.45	2.39	2.52	2.45
	K ₀				2.27
Mean		2.22	2.17	2.30	

Data statistically not analysed

S₁ - K applied during NEM season, 1986

S₂ - K applied during Summer, 1987

S₃ - K applied during both the seasons

K₁ - 50 per cent recommended dose of K

K₂ - 100 per cent recommended dose of K

FIG. 8 BENEFIT COST RATIO AND NET RETURN - PATTUKOTTAI

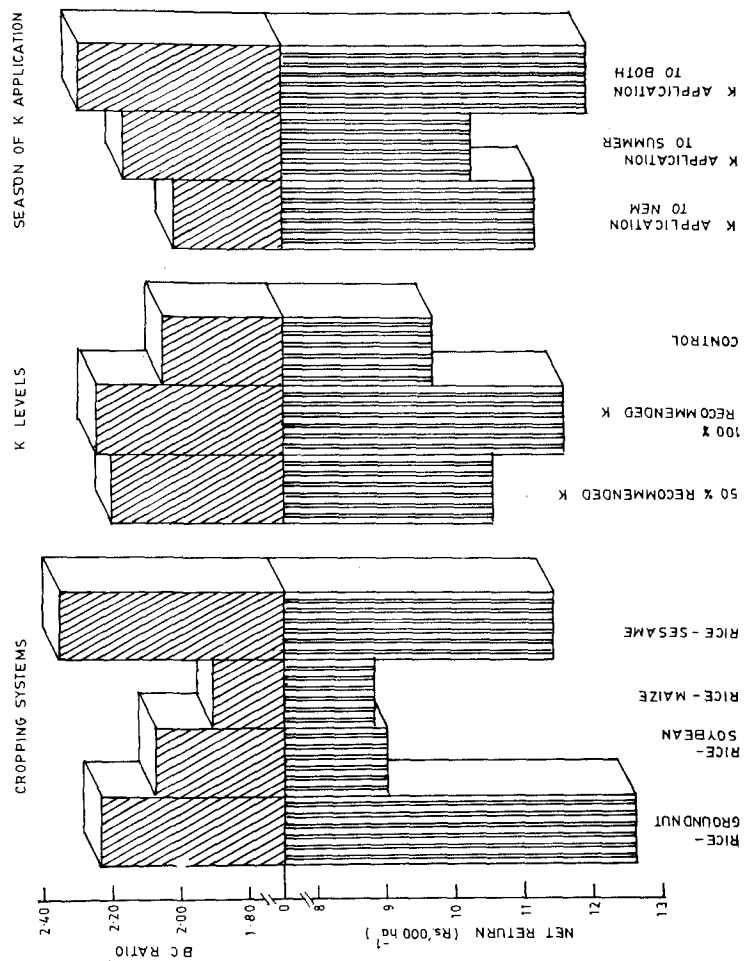


Table 79. Post-harvest soil organic carbon (%) in the cropping systems
- Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	0.573	0.607	0.606	0.595
	K ₂	0.607	0.635	0.667	0.636
	Mean	0.590	0.621	0.637	0.616
	K ₀				0.559
Rice-Soybean (C ₂)	K ₁	0.684	0.684	0.706	0.691
	K ₂	0.693	0.686	0.723	0.700
	Mean	0.689	0.685	0.714	0.696
	K ₀				0.580
Rice-Maize (C ₃)	K ₁	0.490	0.493	0.504	0.496
	K ₂	0.486	0.497	0.502	0.495
	Mean	0.488	0.495	0.503	0.496
	K ₀				0.486
Rice-Sesame (C ₄)	K ₁	0.573	0.603	0.603	0.593
	K ₂	0.615	0.630	0.615	0.620
	Mean	0.594	0.617	0.609	0.607
	K ₀				0.543
Mean		0.590	0.604	0.616	

	SE _(D)	CD (P 0.05)
Cropping systems	0.008	0.021
K levels	0.010	NS
Season of application	0.012	NS
K levels x Season	0.017	NS
C at K	0.017	NS
K at C	0.019	NS
C at S	0.022	NS
S at C	0.024	NS
Control vs Rest	0.008	0.017
Control vs Rest at C	0.017	0.034
C at Control vs Rest	0.015	0.032

S₁ - K applied during NEM season, 1986

S₂ - K applied during Summer, 1987

S₃ - K applied during both the seasons

K₁ - 50 per cent recommended dose of K

K₂ - 100 per cent recommended dose of K

Irrespective of K levels, C₂ system (rice-soybean) recorded higher soil organic carbon. It also produced the greatest difference between K applied treatments and control.

4.2.4.2. Post-harvest soil available N (Table 80)

Among the cropping systems, C₂ system (rice-soybean) resulted in higher available N content of post-harvest soil. The C₄ system (rice-sesame) resulted in the lowest available N content of soil.

There was no significant variation in soil available N content due to the application of 50 per cent (K₁) or 100 per cent (K₂) recommended dose of K to the crops. Application of K fertiliser to both the crops (S₃) made the soil richer in available N compared to K fertilisation to any one crop (S₁ or S₂) of the sequences.

The K level and season interaction was significant. The K₂ level (100 per cent recommended dose) applied to both the crops (S₃) resulted in higher soil available K content.

Irrespective of K levels, the C₂ system (rice-soybean) resulted in higher soil available N. Even in control also, the C₂ system left the soil richer in N compared to control plots in other systems.

4.2.4.3. Post-harvest soil available P (Table 81)

Potassium fertilisation considerably influenced the post-harvest soil available P content. Among the cropping systems, C₁ system (rice-groundnut) resulted in higher available P content of soil. The post-harvest soil available P content was lowest in C₃ system (rice-maize).

Table 80. Post-harvest soil available N (kg ha^{-1}) in the cropping systems
- Pattukottai

Cropping system	K level	S_1	S_2	S_3	Mean
Rice-Groundnut (C_1)	K_1	73.6	75.6	84.0	77.7
	K_2	95.2	84.0	95.2	91.5
	Mean	84.4	79.8	89.6	84.6
	K_0				83.5
Rice-Soybean (C_2)	K_1	95.2	89.6	100.8	95.2
	K_2	84.0	92.3	90.0	88.8
	Mean	89.6	91.0	95.4	92.0
	K_0				90.7
Rice-Maize (C_3)	K_1	81.2	96.4	75.6	84.4
	K_2	72.8	81.2	100.8	84.9
	Mean	77.0	88.8	88.2	84.7
	K_0				85.9
Rice-Sesame (C_4)	K_1	81.2	75.6	67.2	74.7
	K_2	53.2	77.6	86.8	72.5
	Mean	67.2	76.6	77.0	73.6
	K_0				78.4
Mean		79.6	84.0	87.6	

SE_D C/D ($P=0.05$)

Cropping systems	1.8	4.4
K levels	1.2	NS
Season of application	1.4	2.9
K levels x Season	2.0	4.1
C at K	2.8	6.3
K at C	2.4	4.7
C at S	3.2	7.1
S at C	2.9	5.8
Control vs Rest	1.0	NS
Control vs Rest at C	2.0	NS
C at Control vs Rest	2.4	NS

S_1 - K applied during NEM season, 1986

S_2 - K applied during Summer, 1987

S_3 - K applied during both the seasons

K_1 - 50 per cent recommended dose of K

K_2 - 100 per cent recommended dose of K

Table 81. Post-harvest soil available P (Kg ha⁻¹) in the cropping systems - Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	17.4	16.9	17.7	17.3
	K ₂	17.1	17.8	18.1	17.7
	Mean	17.3	17.4	17.9	17.5
	K ₀				16.5
Rice-Soybean (C ₂)	K ₁	15.5	17.3	17.5	16.8
	K ₂	18.0	18.2	19.2	18.6
	Mean	16.8	17.8	18.6	17.7
	K ₀				15.9
Rice-Maize (C ₃)	K ₁	13.6	12.6	13.9	13.4
	K ₂	14.2	13.7	14.5	14.1
	Mean	13.9	13.2	14.2	13.8
	K ₀				13.4
Rice-Sesame (C ₄)	K ₁	14.6	14.1	15.9	14.9
	K ₂	15.6	15.3	16.0	15.6
	Mean	15.1	14.7	16.0	15.3
	K ₀				14.1
Mean		15.8	15.8	16.7	

	SE _D	CD (P 0.05)
Cropping systems	0.68	1.66
K levels	0.59	NS
Season of application	0.72	NS
K levels x Season	1.03	NS
C at K	1.18	NS
K at C	1.17	NS
C at S	1.44	NS
S at C	1.44	NS
Control vs Rest	0.45	0.92
Control vs Rest at C	0.51	1.02
C at Control vs Rest	1.01	NS

S₁ - K applied during NEM season, 1986

S₂ - K applied during Summer, 1987

S₃ - K applied during both the seasons

K₁ - 50 per cent recommended dose of K

K₂ - 100 per cent recommended dose of K

Application of 50 per cent recommended dose of K (K_1) resulted in higher soil available P which was comparable with that of 100 per cent recommended dose of K (K_2).

Application of K to both the component crops (S_3) of the cropping systems resulted in much higher soil available P content than K fertilisation to any one crop of the systems (S_1 or S_2).

Regardless of K levels, the C_1 system (rice-groundnut) resulted in higher soil available P content. Irrespective of cropping system, K fertilisation to both the crops of the cropping systems (S_3) left the soil rich in soil available P.

4.2.4.4. Post-harvest soil available K (Table 82 and Fig. 9)

Potassium fertilisation considerably increased the available K content of post-harvest soil. Application of 100 per cent of recommended K resulted in higher post-harvest soil available K.

Among the cropping systems, the C_2 system (rice-soybean) resulted in higher soil available K in post-harvest soil. The season of application of K did not influence the post-harvest soil available K.

4.2.4.5. Post-harvest soil non-exchangeable K (Table 83)

Potassium application did not influence the non-exchangeable K content of post-harvest soil. Only the cropping systems exerted considerable influence on non-exchangeable K. The C_2 system (rice-soybean) had higher non-exchangeable K in the post-harvest soil.

Table 82. Post-harvest soil available K (Kg ha⁻¹) in the cropping systems
Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	34.3	38.9	36.5	36.6
	K ₂	37.5	32.7	34.9	35.0
	Mean	35.9	35.8	35.7	35.8
	K ₀				28.6
Rice-Soybean (C ₂)	K ₁	35.7	34.0	39.5	36.4
	K ₂	41.0	41.6	45.0	42.5
	Mean	38.4	37.8	42.3	39.5
	K ₀				40.5
Rice-Maize (C ₃)	K ₁	23.0	21.0	24.6	22.9
	K ₂	22.0	25.9	28.8	25.6
	Mean	22.5	23.5	26.7	24.3
	K ₀				21.8
Rice-Sesame (C ₄)	K ₁	29.6	27.7	28.8	28.7
	K ₂	32.5	30.0	36.0	32.8
	Mean	31.1	28.9	32.4	30.8
	K ₀				30.6
Mean		32.0	31.5	34.3	

	SE _D	CD (P=0.05)
Cropping systems	2.3	5.6
K levels	1.2	2.4
Season of application	2.3	NS
K levels x Season	3.3	NS
C at K	3.9	NS
K at C	3.8	NS
C at S	4.8	NS
S at C	4.7	NS
Control vs Rest	0.9	1.7
Control vs Rest at C	1.4	NS
C at Control vs Rest	1.6	NS

S₁ - K applied during NEM season, 1986

S₂ - K applied during Summer, 1987

S₃ - K applied during both the seasons

K₁ - 50 per cent recommended dose of K

K₂ - 100 per cent recommended dose of K

FIG. 9 DYNAMICS OF SOIL AVAILABLE K IN THE CROPPING SYSTEMS-FATTUKOTTAI

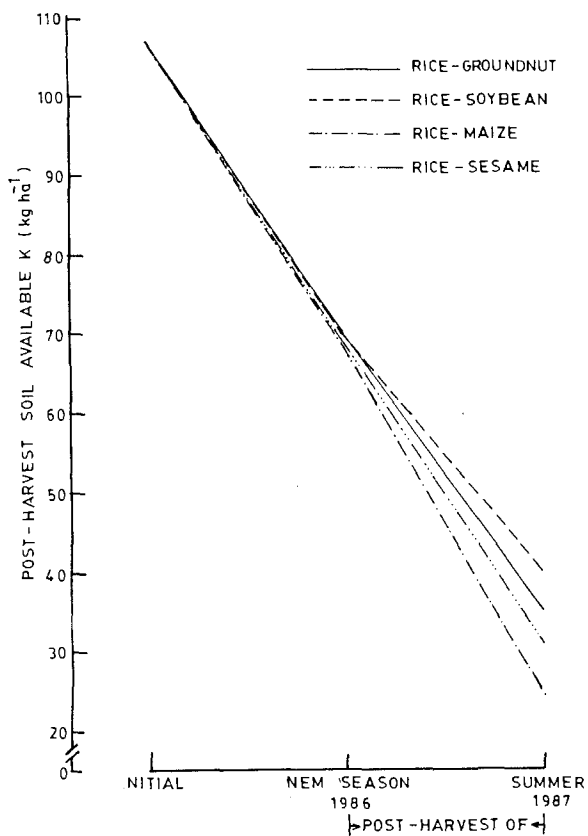


Table 83. Post-harvest soil non-exchangeable K (Kg ha⁻¹) in the cropping systems
- Pattukottai

Cropping system	K level	S ₁	S ₂	S ₃	Mean
Rice-Groundnut (C ₁)	K ₁	419	418	422	418
	K ₂	428	416	414	419
	Mean	421	417	418	419
	K ₀				406
Rice-Soybean (C ₂)	K ₁	416	410	426	417
	K ₂	430	438	440	438
	Mean	423	424	433	428
	K ₀				426
Rice-Maize (C ₃)	K ₁	400	388	390	393
	K ₂	382	392	402	392
	Mean	391	390	396	392
	K ₀				390
Rice-Sesame (C ₄)	K ₁	410	406	408	408
	K ₂	416	414	422	417
	Mean	413	410	415	413
	K ₀				400
Mean		412	410	416	

	SE _D	C.D. (P=0.05)
Cropping systems	8.9	21.8
K levels	3.8	NS
Season of application	9.2	NS
K level x Season	10.5	NS
C at K	11.6	NS
K at C	11.1	NS
C at S	9.7	NS
S at C	8.8	NS
Control vs Rest	5.2	NS
Control vs Rest at C	9.3	NS
C at Control vs Rest	8.5	NS

- S₁ - K applied during NEM season, 1986
 S₂ - K applied during Summer, 1987
 S₃ - K applied during both the seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

4.2.4.7. EUF-K of post-harvest soil (Appendix V and Fig.10)

Soil samples pooled together of all the replications for selected treatments were analysed for EUF-K fractions upto 35 minutes.

All the cropping systems resulted in similar pattern of K desorption of post-harvest soil. The rate of desorption increased upto 10 minutes and progressively decreased till 30 minutes and then steeply increased till 35 minutes.

The EUF-K obtained upto 10 minutes of extraction was almost the same in all the cropping systems. However EUF-K from 30 minutes of extraction were more in C_1 system (rice-groundnut) which was comparable with C_2 system (rice-soybean). Both of them were superior to C_3 system (rice-maize) and C_4 system (rice-sesame) when 50 per cent K was applied both the crops in the systems. But, when 100 per cent K fertiliser was applied to both the crops in the systems, C_4 (rice-sesame) and C_1 (rice-groundnut) were superior to C_3 (rice-maize) and C_2 (rice-soybean) systems.

The total EUF-K extracted upto 35 minutes was considerably more in C_1 system (rice-groundnut) and C_2 system (rice-soybean) than in C_4 system (rice-sesame) and C_3 system (rice-maize).

4.2.4.8. Potassium balance in the cropping systems (Table 84)

The potassium fertiliser applied to the component crops, contribution from irrigation water and rice crop stubbles of NEM season were taken into account in the preparation of balance sheet. Since the post-harvest soil

FIG. 10 EUF - K DESORPTION IN POST-HARVEST SOIL - PATTUKOTTAI

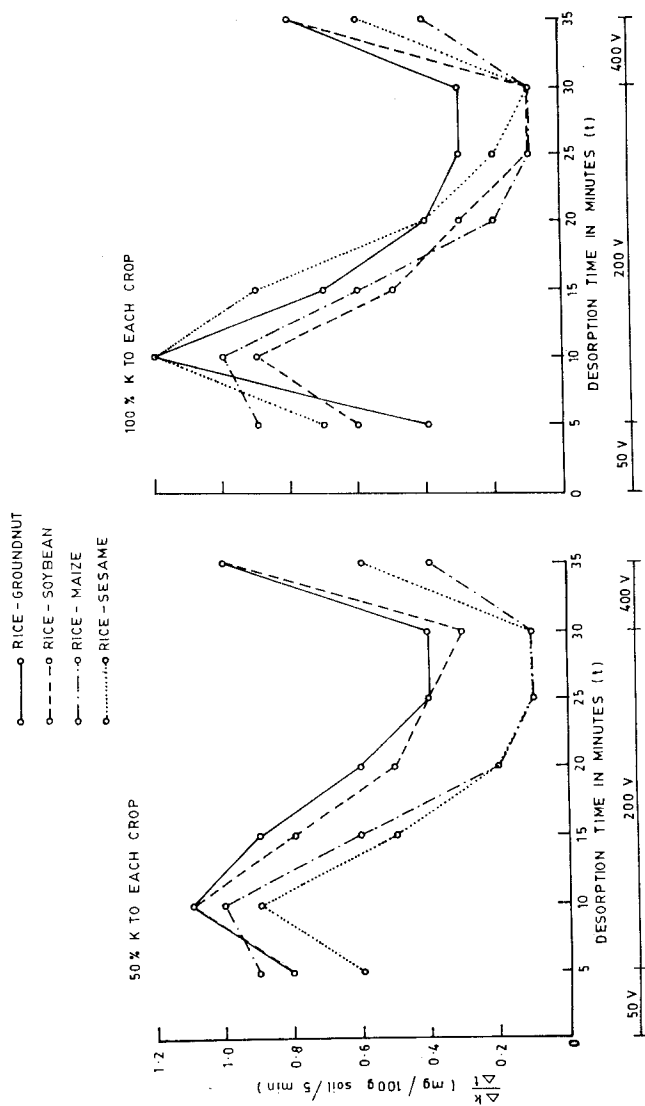


Table 84. Soil available K balance in the cropping systems (kg ha⁻¹) Pattukotai

Cropping system	Initial soil K	K applied to crops		K added through irrigation water		K added through crop residues		Total K applied	K uptake by crops		Total K removal	Computed balance	Actual balance	Net balance
		NEW	Summer	Summer	Summer	NEW	Summer		NEW	Summer				
Rice-Groundnut	K _{1S}	107	20.8	0.0	11.0	12.2	48.9	168.3	115.1	263.4	-216.3	35	-72	
	K _{1S1}	107	0.0	22.4	11.0	4.9	49.8	136.4	118.1	254.5	-204.7	39	-65	
	K _{1S2}	107	20.8	22.4	11.0	11.5	71.4	168.1	118.5	266.6	-193.2	37	-72	
	K _{1S3}	107	41.6	0.0	4.9	12.3	70.5	150.9	118.0	268.9	-198.4	38	-69	
	K _{1S4}	107	0.0	44.8	11.0	11.5	72.2	136.9	119.9	256.8	-184.6	33	-74	
Rice-Soybean	K _{2S}	107	41.6	0.0	4.9	11.5	113.6	132.3	122.2	275.0	-159.9	33	-72	
	K _{2S1}	107	0.0	44.8	11.0	11.5	113.6	132.3	122.2	275.0	-159.9	33	-72	
	K _{2S2}	107	41.6	44.8	11.0	11.5	113.6	132.3	122.2	275.0	-159.9	33	-72	
	K _{2S3}	107	0.0	0.0	11.0	4.9	16.8	26.7	191.7	127.3	249.0	-222.3	29	-78
	K ₀	107	0.0	0.0	11.0	4.3	48.5	142.2	53.9	196.1	-147.6	36	-71	
Rice-Soybean	K _{3S}	107	20.8	0.0	11.0	12.4	48.5	142.2	53.9	196.1	-147.6	36	-71	
	K _{3S1}	107	0.0	16.6	11.0	4.3	43.7	140.1	58.6	198.7	-155.2	35	-73	
	K _{3S2}	107	20.8	16.6	11.0	4.3	12.4	65.1	63.0	208.1	-144.5	35	-67	
	K _{3S3}	107	41.6	0.0	4.3	13.2	70.1	147.9	55.0	202.9	-132.3	31	-66	
	K _{3S4}	107	0.0	33.2	11.0	11.6	60.1	141.7	60.3	202.0	-141.3	32	-62	
Rice-Maize	K _{4S}	107	41.6	33.2	11.0	13.3	103.6	140.0	63.1	212.1	-103.3	33	-72	
	K ₀	107	0.0	0.0	11.0	11.3	26.6	138.7	51.8	190.5	-163.3	31	-66	
	K _{5S}	107	20.8	0.0	11.0	12.0	54.2	122.9	40.8	243.7	-194.3	23	-51	
	K _{5S1}	107	0.0	20.8	11.0	12.2	59.4	139.1	92.2	231.3	-181.9	31	-62	
	K _{5S2}	107	20.8	20.8	11.0	12.1	70.1	152.1	96.1	248.2	-175.1	25	-54	
Rice-Maize	K _{6S}	107	41.6	0.0	11.0	12.5	70.3	149.1	59.8	238.9	-168.1	22	-53	
	K _{6S1}	107	0.0	41.6	11.0	11.1	69.1	138.0	92.8	236.8	-161.1	25	-51	
	K _{6S2}	107	41.6	41.6	11.0	13.3	112.9	155.6	46.3	250.9	-135.2	25	-51	
	K ₀	107	0.0	0.0	11.0	10.7	27.1	135.3	57.2	222.3	-193.1	27	-52	
	K _{7S}	107	20.8	0.0	11.0	12.3	27.2	150.7	51.0	181.7	-136.3	32	-52	
Rice-Sesame	K _{8S}	107	0.0	13.3	11.0	11.6	39.0	137.9	51.1	169.0	-130.2	25	-54	
	K _{8S1}	107	20.8	13.3	11.0	12.3	60.5	140.5	44.2	184.7	-124.2	29	-53	
	K _{8S2}	107	41.6	0.0	11.0	12.9	55.6	151.9	33.3	185.2	-117.1	33	-52	
	K _{8S3}	107	0.0	26.6	11.0	11.5	52.2	136.1	33.3	169.4	-117.1	32	-52	
	K _{8S4}	107	41.6	26.6	11.0	13.3	93.6	151.8	33.4	185.2	-89.5	36	-51	
K ₀	107	0.0	0.0	11.0	10.9	25.0	136.6	35.4	167.0	-142.0	31	-54		

S₁ - K applied during NEW season, 1986

S₂ - K applied during Summer, 1987

S₃ - K applied during both the seasons

K₁ - 50 per cent recommended dose of K

K₂ - 100 per cent recommended dose of K

samples were collected immediately after the summer crops, the addition of summer crop stubbles in the systems were not taken into consideration.

Among the cropping systems, the C_1 system (rice-groundnut) recorded higher uptake of K followed by C_3 system (rice-maize). However, the post-harvest soil available K was higher in C_1 system (rice-groundnut) than in C_3 system (rice-maize). The net loss of available K was the greatest in C_3 system (rice-maize). The C_2 system (rice-soybean) resulted in the least net loss of available K.

Application of 100 per cent recommended dose of K (K_2) resulted in higher soil available K than that from 50 per cent K (K_1). The season of application did not alter the post-harvest soil available K in the systems.

DISCUSSION

CHAPTER V

DISCUSSION

Field experiments were conducted at Tamil Nadu Agricultural University Main Campus, Coimbatore and at the Agricultural Research Station, Pattukottai to develop potassium management strategy for rice based cropping systems. The experimental results presented in Chapter IV are discussed in this chapter.

Rice based cropping systems with rice during SWM season and NEM season and rice, soybean, finger millet and cotton during summer were raised with and without potassium application at Coimbatore. Rice during NEM season followed by groundnut, soybean, maize and sesame during summer as component crops of rice based cropping systems were evaluated with and without potassium application at Pattukottai.

5.1. Seasonal effect

At Coimbatore, the experiments were conducted during SWM season, NEM season and summer of 1984-85.

In general, the maximum and minimum temperature and the morning relative humidity (RH) prevailed during SWM season were almost similar to normal. The maximum and minimum temperatures ranged from 28.6 to 32.3°C and 21.1 to 23.3°C respectively. The morning RH ranged from 71 to 88 per cent. The SWM rice received 93 mm of rainfall in 12 rainy days. This rainfall was 29 per cent below normal.

During NEM season, the maximum and minimum temperatures ranged from 27.6 to 31.5°C and from 13.6 to 21.3°C respectively. The minimum

temperature was lower by 2.3°C compared to the normal. The minimum temperature touched a low level of 13.6°C in December, when the NEM rice crop was in boot leaf stage. The morning RH was in the range of 84 to 93 per cent which was higher by two per cent than the normal. A total of 374 mm of rainfall was received in 16 rainy days accounting 13 per cent more than the normal for the season (330 mm).

In summer season, the ranges of maximum and minimum temperatures were 32.0 to 36.7°C and 16.7 to 24.2°C respectively. The morning RH ranged from 72 to 92 per cent. During the season, 69 mm of rainfall was received in 4 rainy days which was deficient by 49 per cent of the normal.

The sunshine hours and evaporation values during the cropping seasons did not differ much from the average values of these parameters.

At Pattukottai, the experiments were conducted during NEM season and summer 1986-87. During NEM season, the maximum and minimum temperatures ranged from 24.9 to 30.2°C and from 20.4 to 25.9°C respectively. The morning RH during this period was 79 to 94 per cent. The amount of rainfall was 378 mm received in 27 rainy days. This rainfall was 42 per cent deficient of the normal rainfall.

During summer, the maximum and minimum temperatures were in the range of 28.8 to 34.0°C and 24.0 to 29.0°C respectively. The morning RH ranged from 61 to 69 per cent. The rainfall during the cropping period was 53 mm received in 4 rainy days which was 50 per cent below normal.

Comparison of weather parameters at Coimbatore and Pattukottai showed that the maximum temperature was lower by 1.3°C and the minimum

temperature was higher by 4.8°C at Pattukottai during NEM season. In summer, the maximum temperature was higher by 1.9°C and the minimum temperature was lower by 6.8°C at Coimbatore.

Among the component crops, soybean was raised during summer both at Coimbatore and Pattukottai. The seed yield of soybean at Pattukottai centre was only about half the seed yield obtained at Coimbatore. This reduction in seed yield could be attributed to the variations in the weather prevailed besides comparatively less fertile soil conditions at Pattukottai. At Coimbatore, the maximum and minimum temperatures during the crop period ranged from 32.0 to 36.7°C and from 16.7 to 24.2°C respectively, while at Pattukottai, the maximum temperature ranged from 30.2 to 36.3°C and the minimum temperature was in the range of 25.5 to 29.0°C. In general, there was an increase in mean maximum temperature by 3.1°C and reduction in minimum temperature by 6.8°C at Coimbatore as compared to Pattukottai. The morning RH was lower (75 per cent) at Pattukottai compared to that at Coimbatore (82 per cent). These variations in weather might have caused reduction in seed yield of soybean at Pattukottai. Singh (1988) also observed enhanced expression of yield components and seed yield of soybean in summer when the maximum temperature was higher by 2°C than in kharif.

In addition, the soybean crop at Coimbatore had a field duration of 111 days compared to 87 days at Pattukottai. The longer grain filling period might have resulted in enhanced yield components and consequent higher seed yield at Coimbatore.

5.2. Effect of potassium application on the component crops in the cropping systems

Potassium application considerably increased the grain yield of SWM,

NEM and summer rices at Coimbatore. This could be attributed to the enhanced uptake of NPK nutrients at flowering and maturity stages which improved growth components such as plant height, LAI and dry matter production. As a result, the yield components like productive tillers and filled grains were markedly increased. The increase in filled grains might have been due to the enhanced translocation of photosynthates to the spikelets. Under optimal K nutritional conditions, the influence of K^+ on the translocation of assimilates from the vegetative structures towards the ears has been well documented (Mengel and Kirkby, 1980).

The initial soil K status of the experimental field was high and yet a marked response to application of $25 \text{ kg K}_2\text{O ha}^{-1}$ was observed. But increasing the dose further did not result in proportionate increase in rice grain yield during SWM season.

In NEM rice, application of 50 per cent of recommended K ($25 \text{ kg K}_2\text{O ha}^{-1}$) resulted in grain yield comparable with that of application of 100 per cent recommended level of K ($50 \text{ kg K}_2\text{O ha}^{-1}$). The cumulative effect of K which included the residual effect of SWM season and the direct effect of NEM season considerably increased the DMP, uptake of major nutrients and yield components and consequently enhanced the grain yield.

In summer rice too, application of $25 \text{ kg K}_2\text{O ha}^{-1}$ resulted in grain yield comparable with that of $50 \text{ kg K}_2\text{O ha}^{-1}$. The improved yield components such as productive tillers, filled grain and thousand grain weight might have contributed substantially to the increased grain yield. The residual effect resulting from the K application either during SWM season or

NEM season was not sufficient to produce grain yield equal to that of direct application and cumulative effect of K application.

The post-harvest soil after summer rice showed higher organic carbon content compared to that after finger millet and cotton. The direct and cumulative effects of K application resulted in much higher organic carbon content of soil post-harvest of summer rice. Higher available N and K contents in soil post-harvest of summer rice could also be observed. The lowland condition of soil during the crop period and higher quantity of irrigation to summer rice might have induced greater availability of nutrients to rice compared to other crops.

At Pattukottai, application of $50 \text{ kg K}_2\text{O ha}^{-1}$ considerably increased the NEM rice grain yield over $25 \text{ kg K}_2\text{O ha}^{-1}$ and control. The increase in grain yield could be attributed to the enhancement of yield contributing factors such as productive tillers, filled grain percentage and seed weight. All these yield contributing factors in turn were influenced by improvement in plant structures such as leaf area and DMP.

The post-harvest soil analysis showed increase in organic carbon and available K contents by K fertilisation. This might be due to the large quantities of crop residues added into the system after the harvest of rice crop.

Comparison of the performance of rice at Coimbatore in a rich-K soil and at Pattukottai in a low-K soil revealed that the K fertiliser treatments had significant positive influence on grain yield, with a response upto 25 kg level at Coimbatore and 50 kg at Pattukottai. The yield level

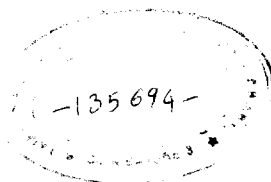
at Coimbatore was higher than at Pattukottai indicating the favourable influence of initial fertility status of soil. With rich available K soil at Coimbatore, the grain yield even in control was 280 kg more than that in control at Pattukottai.

It is probable that some amounts of added potassium might have lost through leaching in the sandy loam soil at Pattukottai compared to the clay loam soil at Coimbatore. This also resulted in comparatively poor organic carbon content and major nutrients of post-harvest soil.

The grain yield of soybean was considerably enhanced by K fertilisation at Coimbatore. Higher LAI which was indicative of larger photosynthetic area resulted in greater accumulation of dry matter. This coupled with increased uptake of major nutrients might have improved the yield contributing characters like pods per plant and seed weight. These yield components contributed substantially to the increased grain yield in K fertiliser treatments - 20 and 40 kg K_2O ha^{-1} . Zhang and Liu (1982) observed similar higher seed yield in soybean as a consequence of higher LAI.

The residual effects of K application during SWM season and NEM season were not sufficient to produce comparable yield levels with those of direct effect and cumulative effect.

The post-harvest soil analysis showed the superiority of soybean over other crops during summer in enhancing the fertility status of the soil. The organic carbon, available N and K contents were markedly higher in soil where soybean was raised. Soybean being a legume might have fixed



atmospheric nitrogen in its root nodules. The leaf fall and the disintegration of root nodules in the soil might have improved the soil fertility substantially.

The seed yield of soybean was significantly enhanced by K fertiliser application, especially at $40 \text{ kg K}_2\text{O ha}^{-1}$ at Pattukottai. Because of the sandy nature of soil the grain yield of soybean was only about half the grain yield at Coimbatore. This was because of low soil available N and K status, along with low level of organic carbon content. These factors influenced the performance of soybean at Pattukottai by reducing the vegetative growth and yield. The higher minimum temperature (6.8°C), the lower maximum temperature (3.1°C) and lower relative humidity (7 per cent) compared to those at Coimbatore might have contributed their share in the poor performance of soybean crop at Pattukottai.

In addition, the soybean crop at Coimbatore had a field duration of 111 days compared to 87 days at Pattukottai. The longer grain filling period resulted in enhanced expression of yield components and consequent higher seed yield at Coimbatore.

The initial soil level also exerted greater positive influence on growth parameters like LAI and DMP at Coimbatore compared to that at Pattukottai. With low-K soil, soybean at Pattukottai responded to the K application of $40 \text{ kg K}_2\text{O ha}^{-1}$ compared to the response upto $20 \text{ kg K}_2\text{O ha}^{-1}$ in rich-K soil at Coimbatore.

Potassium fertiliser application significantly increased the grain yield of finger millet. The highest level of $30 \text{ kg K}_2\text{O ha}^{-1}$ registered higher grain yield than the application of $15 \text{ kg K}_2\text{O ha}^{-1}$. Finger millet being a

tillering crop like rice, produced significantly higher DMP than soybean or cotton. More ramification of the finger millet root system foraged the soil of the major nutrients especially P and K. The P uptake was higher than in rice, soybean and cotton. Profuse rooting and greater uptake of nutrients might have improved the yield components and enhanced the grain yield (Beringer, 1983).

The residual effect of K application during SWM alone or NEM season alone without current application was not enough to meet the requirements of summer finger millet. The cumulative effect of K was equal to the direct effect of K application in enhancing grain yield.

Post-harvest soil analysis revealed that the soil contained higher organic carbon, available N and P contents than in soil where cotton was raised. The EUF-K analysis showed the superiority of finger millet over the other summer crops in releasing higher amounts of K fractions and total EUF-K. Since the post-harvest soil was taken immediately after the harvest of finger millet, the soil analysis did not show the contribution of subsequent disintegration of finger millet stubbles in the system. Shanmugasundaram *et al.* (1976) observed the substantial contribution of finger millet stubbles by easy disintegration.

Application of $15 \text{ kg K}_2\text{O ha}^{-1}$ significantly increased the seed cotton yield. Higher LAI in K fertiliser treatments might have induced greater DMP and enhanced the expression of yield components like number of fruiting points and bolls per plant. This probably raised seed cotton yield.

Initial soil available K content also played an important role in deciding the plant size as exhibited by growth characters including DMP.

With available K status at a very high level after the incorporation of rice stubbles of previous SWM rice and NEM rice, the response to added K fertiliser was very much limited. The residual effects of K application applied to previous rice crops were sufficient to produce seed cotton yields comparable with those of direct effect and cumulative effect.

Post-harvest soil analysis revealed that cotton depleted the soil of its available NPK more intensely than the other summer crops.

The pod yield of groundnut was favourably influenced by application of $54 \text{ kg K}_2\text{O ha}^{-1}$. Higher uptake of major nutrients especially N and K with higher level of K application might have increased the DMP. In addition greater translocation of photosynthates as indicated by higher shelling per cent and higher kernel weight probably led to the enhanced pod yield.

The residual effects of K fertiliser application during NEM season did not achieve pod yield comparable with that of direct or cumulative effect of K application. Very little K fixation in sandy soil has been very well established. In the present study also, the residual effects of K application were not considerable to sustain higher crop yields.

Groundnut as a legume crop fixed atmospheric N as revealed by greater uptake of N and higher post-harvest soil available N. Along with N, uptake was also considerably higher when compared to other summer crops. This probably induced greater accumulation of dry matter compared to soybean and sesame. The post-harvest soil analysis revealed higher soil organic carbon, available N and P contents indicating the superiority of

inclusion of groundnut in the rice based cropping systems in improving the soil fertility. The total EUF-K content was also considerably higher in post-harvest soil.

Application of $50 \text{ kg K}_2\text{O ha}^{-1}$ significantly increased the grain yield of maize. Marked increase in growth parameters such as plant height and LAI induced greater DMP. Maize as a cereal with fibrous root system might have foraged comparatively more of soil K (Beringer, 1983) in addition to the applied K as indicated in the balance sheet of available potassium.

The higher DMP probably resulted in higher uptake of other major nutrients also leading to the improvement of yield components like rows of grain per cob, grains per row and grain weight and finally enhancement of grain yield.

The efficient mining of soil reserve K was probably resulted in the residual effects producing comparable yield levels with that of direct and cumulative effects. The post-harvest soil analysis revealed the lowest values of organic carbon, available N, P and K compared to other summer season crops. Maize seemed to be an exhaustive crop of nutrients compared to legumes (groundnut and soybean) and oilseed crop (sesame).

The seed yield of sesame was considerably improved by the application of $24 \text{ kg K}_2\text{O ha}^{-1}$. Increased uptake of nutrients especially N and P might have contributed to the increased seed yield by improving the yield components such as capsules per plant, length of capsules and seed weight.

Sesame was also efficient in mining soil available N and P as

reflected in the post-harvest analysis. This resulted in the residual effect producing comparable seed yield with that of direct effect and cumulative effect. Shorter duration (75 days) and lesser water requirement of sesame had an added advantage of its inclusion in rice-fallow conditions of Cauvery delta zone of Tamil Nadu where water availability is limited during summer.

5. 3. Influence of potassium on the production potential of cropping systems

5.3.1. Total biomass production

The total dry matter harvested above ground provides a uniform means of comparison of the cropping systems especially when the component crops are of diverse nature. The analysis of biomass accumulation is also useful to judge the efficiency of the cropping systems, to utilise the solar radiation, water and nutrient.

At Coimbatore, rice-rice-rice system produced the highest biomass followed by rice-rice-finger millet system. The results of the present study indicated cropping systems involving cereals and millets resulted in higher biomass production. Evidently, crops such as rice and finger millet are profusely tillering crops, contributing substantially to the total biomass production of the systems.

In addition, the fertility management plays a dominant role in influencing the DMP. In the present study, K fertiliser application considerably enhanced the DMP due to increased uptake of nutrients especially N and K.

In a sequential cropping system, the residual and cumulative effects have to be considered. In this regard, K fertiliser applied to all the three crops in the cropping systems (cumulative effect of K) produced higher quantity of dry matter as compared to K application to any one crop in the systems. This indicates the additive effect of K fertilisation in increasing the size of vegetative structures and consequently DMP.

At Pattukottai, rice-maize system registered the highest DMP. Rice and maize as cereal crops with fibrous root systems foraged the soil of its nutrients especially N and K and probably influenced higher DMP. In this centre also, the residual effect had pronounced effect on DMP of all component crops.

The results of the present study conducted at Coimbatore and at Pattukottai having different soil types revealed that millet/cereal crops in the rice based cropping systems could be included for efficient DMP. Further, residual and cumulative effects became more pronounced in augmenting the DMP than K application to any one crop of the systems.

5.3.2. Rice grain equivalent yield of the cropping systems

Total rice grain equivalent yield of the cropping systems were worked out by converting the soybean seed, finger millet grains, seed cotton, groundnut pod, maize grain and sesame seed into rice grain equivalent.

At Coimbatore, rice-rice-soybean system recorded the highest rice grain equivalent yield over other systems which involved rice/finger millet/cotton. The increase in rice grain equivalent yield could be attributed to

the relatively higher price and higher yield of soybean. The results revealed that rice grain equivalent yield was mostly influenced by the component crops included in the system.

Similar to total biomass production of the cropping systems, K application irrespective of levels to each crop in the systems (cumulative effect) resulted in greater rice grain equivalent yield.

At Pattukottai, rice-groundnut system recorded the highest grain equivalent yield followed by rice-sesame system. Higher groundnut pod yield coupled with relatively higher price of the produce, resulted in increased rice grain equivalent yield. Sesame with higher price brought the rice-sesame system to the second position. Similar to biomass production, rice grain equivalent yield was considerably higher when each crop in the cropping system was fertilised with K fertiliser.

5.3.3. Energy budget of the cropping systems

Among the four cropping systems evaluated at Coimbatore, rice-rice-rice system consumed the highest amount of energy input and the same system produced the highest energy output also. Since rice was grown in all the three seasons in that system, the water requirement of the system was comparatively higher consuming 60 per cent of the total energy input. The energy requirement for irrigation of rice-rice-soybean system was lesser by 31 per cent when compared to the rice-rice-rice system.

The human labour requirement was comparatively higher by 12 per cent in rice-rice-finger millet and rice-rice-cotton systems. This was due to increase in manual labour from operations like planting and harvesting in

finger millet and cotton compared to rice and soybean.

The energy efficiency (output input ratio) was the highest in rice-rice-finger millet system, with rice-rice-rice system occupying a comparable position. The inclusion of either cereal or millet whose biomass production was superior resulted in higher energy output also as the straw also contributed substantially for the enhancement of energy output.

Specific energy to produce one tonne of economic produce was the lowest in rice-rice-soybean system followed by rice-rice-finger millet system. In other words, rice-rice-cotton and rice-rice-rice system required comparatively higher specific energy to produce the same quantity of economic produce.

Considering the entire spectrum of energy budget, rice-rice-soybean with lowest energy consumption and specific energy was the best among the four cropping systems. Mahendra Pal et al. (1985) also observed much less energy expenditure by legumes than cereals.

5.4. Economic analysis of potassium management in the cropping systems

Gross return was the highest in rice-rice-rice system followed by rice-rice-soybean system. With rice as component crop in all the three seasons and with inclusion of rice straw in working out the gross return, rice-rice-rice system registered the highest gross return. In rice-rice-soybean system, soybean with comparatively higher seed yield and higher price of the seed placed the system in the second position next to rice-rice-rice system.

Application of 50 per cent recommended dose of K to all the three crops in the cropping systems resulted in higher gross return than K

fertiliser application to any one crop in the systems. This was primarily due to the increased economic yield of the component crops of the systems.

At Pattukottai, the highest gross return was obtained in rice-groundnut system followed by rice-sesame system. Groundnut and sesame as commercial oilseed crops had higher monetary outturn as compared to maize and soybean.

The net return was the highest in rice-rice-soybean system followed by rice-rice-rice systems and then by rice-rice-finger millet system. Even though rice-rice-rice system produced the highest gross return, the net return of the system was lesser than in rice-rice-soybean system due to higher cost of cultivation. The reduction in cost of cultivation in rice-rice-soybean system by 15 per cent compared to rice-rice-rice system coupled with remunerative price of soybean seed resulted in the highest net return of rice-rice-soybean system. With lesser cost of cultivation and higher seed yield, soybean among the gardenland crops evaluated at Coimbatore during summer season was the best in terms of net return.

At Pattukottai, the rice-groundnut system registered the highest net return followed by rice-sesame system. Sesame with comparatively higher price of seed and lesser cost of cultivation resulted in higher net return of the system next only to rice-groundnut system.

Application of 100 per cent recommended K fertiliser to each of the component crops in the cropping systems resulted in higher net returns for sandy loam soil with low available K. This may be due to the higher monetary outturn registered by the component crops of the systems compared to 50 per cent K fertiliser application.

At Coimbatore centre, the benefit cost ratio was the highest in rice-rice-soybean system followed by rice-rice-rice system. The results of the present study clearly indicated that for high available K soil conditions of Coimbatore, application of 50 per cent recommended K fertiliser to each of the component crops of the rice-rice-soybean system was highly remunerative. In areas with abundant water supply throughout the year, rice-rice-rice system with 50 per cent K fertiliser application to each of the component crops was the best system.

At Pattukottai, the benefit cost ratio of rice-sesame system was the highest followed by rice-groundnut system. For low K soil with sandy loam nature of Cauvery Mettur Project area of Thanjavur district, rice-sesame system with 100 per cent recommended K fertiliser application to each of the crops was the best system. Sesame as a rice fallow crop which can be raised under limited water availability conditions is the best choice. When water availability is a little more liberal, rice-groundnut system with 100 per cent K fertiliser application was the best one.

5.5. Dynamics of soil fertility in the cropping systems

The organic carbon content of post-harvest soil after each component crop in the cropping systems was improved in all the treatments. Soil organic carbon status after the harvest of last component crop (summer crop) of the cropping systems revealed that the rice-rice-soybean system produced 7 per cent higher organic carbon than that in rice-rice-rice system and 14 per cent over that of rice-rice-finger millet system. Soybean, being a legume might have enriched the soil by shedding of leaves at maturity

and fixation of atmospheric N through root nodules and disintegration of root nodules in the soil.

Potassium application at 100 per cent recommended level produced higher organic carbon content than 50 per cent K application. Potassium application to all the three crops in the cropping systems resulted in higher soil organic carbon content than K fertilisation to any one crop of the systems. This could be attributed to the increased quantity of crop residues incorporated into the systems.

In general, the uptake of nutrients was higher in K fertilised treatments than in control (Ramanathan, 1977). This resulted in higher dry matter accumulation of crops which was indicative of larger plant size with larger root systems. When the SWM rice and NEM rice crop stubbles was incorporated into the soil, they considerably improved the organic carbon content. Purushothaman (1979) and Srinivasulu (1988) observed significant contribution of rice crop stubbles in the improvement of organic carbon status of soil.

At Pattukottai also, there was progressive improvement in soil organic carbon content in different cropping systems. Among the cropping systems evaluated, rice-soybean system produced significant improvement in the soil organic carbon content. As observed at Coimbatore, this crop might have enriched the soil by fixation of atmospheric N in its root nodules and disintegration of root nodules later on. Rice-groundnut system and rice-sesame system had comparable position in their influence on soil organic carbon content.

There was progressive reduction in the soil available N from the initial level to the post-harvest of crops. The reduction was least in K fertilised treatments than in control. The post-harvest soil available N also followed the same trend as that of organic carbon content. At Coimbatore centre, rice-rice-soybean system and at Pattukottai centre, rice-groundnut system resulted in higher soil available N than the other systems. At both the centres, inclusion of soybean crop in the system enriched the soil with higher available N. Fixation of atmospheric N by soybean in its nodules and subsequent disintegration of root nodules in the soil might have influenced the improvement in soil available N in these systems.

The soil available P increased progressively. Potassium fertilisation enhanced the post-harvest soil P in all the systems. The rice-rice-rice system and rice-rice-finger millet system at Coimbatore and rice-groundnut system and rice-soybean system at Pattukottai resulted in higher soil available P indicating the positive influence of rice, soybean and groundnut crops on the build-up of soil available P.

The cropping systems exerted considerable influence on the available K and non-exchangeable K contents and EUF-K fractions. The balance sheets of available K at both the centres showed the uptake of K by component crops of cropping systems far exceeded the application rates. However, the reduction in available K as well as non-exchangeable K were far lower than the computed balance indicating the dynamic equilibrium between the different forms of K in soil. The millets and cereals of the systems foraged the soils of its K more intensely than the pulses or oilseed crops.

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From the foregoing discussion, the following inferences can be drawn. Rice-rice-soybean system with 50 per cent recommended dose of K to each crop in the system for high-K soils of Coimbatore is the most profitable one. Rice-groundnut system with 100 per cent recommended dose of K to each crop in the system for adequate water availability situations and rice-sesame system with 100 per cent recommended dose of K to each crop in the system for water constraint situations and low-K soil conditions of Pattukottai are highly remunerative.

S U M M A R Y

CHAPTER VI

SUMMARY

Field experiments were conducted at Tamil Nadu Agricultural University Central Farm, Coimbatore during 1984-85 and at the Agricultural Research Station, Pattukottai during 1986-87 with the objective to develop potassium management practices in rice based cropping systems. Experiments were laid out in split plot design with three replications at both the centres. At Coimbatore, the main plot treatments comprised of four rice based cropping systems with rice crops during SWM and NEM seasons. The third component crops in summer were rice, soybean, finger millet and cotton. The sub-plot treatments consisted of 50 per cent and 100 per cent recommended doses of K for the respective crops with a control. In addition, the treatments included skipping of K application to any two of the crops in the cropping systems and K application to all the three crops in the cropping systems. At Pattukottai, four rice based cropping systems with rice during NEM season in all the systems and groundnut, soybean, maize and sesame during summer season were assigned to the main plots. The sub-plot treatments comprised of 50 per cent and 100 per cent K application with a control and skipping of K application to any one crop in the systems and application to both the crops in the cropping systems. The conclusions drawn from the results of the experiments are summarised hereunder:

1. Application of 25 kg K_2O ha⁻¹ at Coimbatore and application of 50 kg K_2O ha⁻¹ at Pattukottai promoted the growth and yield components, improved the uptake of major nutrients and enhanced the grain yield of rice.

2. Potassium application at 20 kg K_2O ha⁻¹ at Coimbatore and 40 kg K_2O ha⁻¹ at Pattukotai positively influenced the growth and yield contributing characters of soybean, besides uptake of NPK nutrients leading to increased seed yield. The cumulative effect of potassium application exhibited greater influence on seed yield at Coimbatore while, the residual effect was equally effective with the direct and the cumulative effects at Pattukottai.

3. In finger millet the growth characters including DMP, productive tillers and uptake of NPK nutrients at flowering and at maturity were significantly increased leading to enhanced grain yield by the application of 30 kg K_2O ha⁻¹. The cumulative effect of potassium application was significantly superior to other direct and cumulative effects in promoting the grain yield.

4. The LAI, DMP, fruiting points and bolls per plant were improved, the uptake of NPK was enhanced and the seed cotton yield was significantly increased by potassium fertilisation at 15 kg K_2O ha⁻¹. The residual effects were comparable with the direct and cumulative effects.

5. At Pattukottai, application of 54 kg K_2O ha⁻¹ promoted the growth attributes, biomass production, NPK uptake and enhanced the pod and haulms yield of groundnut. Potassium application increased the oil content of kernels. The cumulative effect of potassium application exhibited significant positive influence on pod yield.

6. The growth characters and the yield components along with the uptake of major nutrients were substantially improved leading to enhanced

grain yield of maize by the application of $50 \text{ kg K}_2\text{O ha}^{-1}$. The residual effect was equal with direct and cumulative effects.

7. In sesame, application of $15 \text{ kg K}_2\text{O ha}^{-1}$ improved the growth components, like LAI, plant height, DMP and yield components like capsule number, capsule length and seed weight and uptake of N and K at flowering and P and K maturity and finally seed yield.

8. At Coimbatore, rice-rice-rice system produced significantly higher biomass, while rice-groundnut system resulted in higher biomass production at Pattukottai. The cumulative effect exhibited greater influence on biomass accumulation in the systems at both the centres.

9. Rice-rice-soybean system at Coimbatore and rice-groundnut system at Pattukottai were superior in terms of rice grain equivalent yield. Similar to biomass production, the cumulative effect exerted considerable influence on rice grain equivalent yield.

10. Energy budget of the cropping systems at Coimbatore revealed that the rice-rice-soybean system registered the lowest energy expenditure among the cropping systems. This system also recorded the lowest specific energy.

11. The economic analysis showed that rice-rice-soybean system achieved higher net return and B-C ratio at Coimbatore and rice-groundnut system resulted in higher net returns at Pattukottai. Application of 50 per cent recommended dose of potassium to each crop of the system produced the higher B-C ratio at Coimbatore while 100 per cent recommended dose of potassium resulted in Pattukottai.

12. Among the soil fertility parameters, soil organic carbon content improved considerably in rice-rice-soybean system at Coimbatore and rice-soybean system at Pattukottai. Application of potassium to each component crop of the systems was significantly superior to the application of potassium to any one crop of the systems in improving soil organic carbon content. The post-harvest soil available N followed a similar trend as that of soil organic carbon content at Coimbatore. Irrespective of potassium levels, rice-soybean system at Pattukottai resulted in higher soil available N.

13. The post-harvest soil available P was considerably higher in rice-rice-finger millet system at Coimbatore and rice-groundnut system at Pattukottai. Application of 50 per cent and 100 per cent recommended dose of K resulted in similar soil available P at both the centres.

14. The post-harvest soil available K was not significantly different in cropping systems at Coimbatore. Rice-soybean system resulted in higher soil available K content at Pattukottai. Application of 50 per cent as well as 100 per cent recommended doses of potassium resulted in comparable soil available K at Coimbatore, whereas 100 per cent recommended dose of potassium produced higher available K content of post-harvest soil. At Coimbatore, the direct and cumulative effects were superior to the residual effects on post-harvest soil available K. At Pattukottai, the season of K application did not influence the post-harvest soil available K.

15. The post-harvest soil non-exchangeable K was higher in rice-rice-soybean system at Coimbatore and rice-soybean system at Pattukottai indicating the depletion of soil reserve K with the least amount. Application of either 50 per cent or 100 per cent recommended dose of K did not produce considerable variation in post-harvest soil non-exchangeable K.

16. The electro-ultrafiltration (EUF) K analysis revealed that rice-rice-finger millet system at Coimbatore and rice-groundnut system at Pattukottai resulted in higher total EUF-K.

17. Balance sheet of available K revealed the superiority of rice-rice-soybean at Coimbatore and rice-groundnut system at Pattukottai.

Summing up, potassium application at 50 per cent recommended dose to each one of the component crops of rice-rice-soybean system in K-rich soils of Coimbatore region is highly remunerative one. For low-K soils of Pattukottai representing the Cauvery Mettur Project area of Thanjavur district, application of 100 per cent recommended dose of potassium to each component crop of the rice-groundnut system is the most economical. For less water availability situation in Cauvery Mettur Project area, potassium application at 100 per cent recommended dose to each component crop of rice-sesame system is the most profitable practice.

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*Original not seen.

APPENDICES

APPENDIX 1

Weather during the cropping period at Coimbatore

Standard Week	Period	Temperature (°C)		Relative humidity (%)		Rainfall		Bright sunshine hours	Evaporation (mm day ⁻¹)	Solar radiation (Cal cm ⁻² day ⁻¹) (Spherical surface)
		Maximum	Minimum	Relative humidity (%)		Amount	Rainy days			
				Morning	Evening					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1984										
20	May	14-20	35.7	22.9	88	40	21.4	3	9.1	238.4
21		21-27	35.6	23.4	80	37	-	-	19.1	264.9
22		28-3 Jun	33.7	24.0	74	46	-	-	4.9	230.1
23	June	4-10	32.0	23.0	71	45	-	-	4.4	222.0
24		11-17	30.8	23.3	73	58	23.9	3	2.0	188.4
25		18-24	29.3	22.0	79	56	15.4	2	3.7	190.7
26		25-1 Jul	30.4	23.3	71	59	2.2	-	9.3	204.4
27	July	2-8	31.2	23.2	72	47	0.5	-	6.3	239.5
28		9-15	30.3	22.2	86	63	33.8	5	3.8	180.8
29		16-22	28.6	22.3	82	61	7.9	1	1.9	175.4
30		23-29	30.8	22.2	82	49	1.8	-	5.8	215.8
31		30-5 Aug	31.2	21.9	77	50	1.3	-	6.3	172.2
32	Aug.	6-12	31.7	22.3	75	45	0.5	-	6.7	216.3
33		13-19	32.0	21.8	76	46	-	-	6.3	230.4
34		20-26	31.1	21.8	88	55	6.3	1	5.3	198.0
35		27-2 Sep	31.4	21.7	77	46	-	-	7.3	257.4
36	Sep.	3-9	32.3	21.1	86	45	-	-	8.4	246.9
37		10-16	31.9	21.7	77	41	-	-	9.0	254.6
38		17-23	32.3	22.3	89	57	12.0	2	6.0	202.7
39		24-30	30.7	21.6	93	63	79.6	4	4.4	161.8
40	Oct.	1-7	24.6	22.0	91	74	152.9	4	3.3	169.8
41		8-14	29.1	20.9	83	54	32.0	1	8.4	235.0
42		15-21	30.5	16.6	83	38	-	-	11.0	267.5
43		22-28	30.2	21.0	91	59	194.0	4	6.5	198.1
44		29-4 Nov	29.4	20.1	89	52	18.7	1	10.3	252.3
45	Nov.	5-11	29.3	20.5	93	53	51.0	2	8.0	227.5
46		12-18	29.8	20.3	89	57	17.5	2	6.7	185.5
47		19-25	28.7	20.1	84	53	-	-	5.7	176.9
48		26-2 Dec	28.3	17.5	87	59	36.5	1	5.0	159.5
49	Dec.	3-9	27.8	18.7	92	52	4.0	1	8.9	214.5
50		10-16	29.2	13.6	90	35	-	-	10.3	247.6
51		17-23	28.3	14.5	90	39	-	-	10.4	246.5
52		24-31	30.9	19.3	89	43	-	-	9.9	227.3

Appendix - 1a continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	Jan. 1-7	27.6	21.3	92	71	70.4	4	3.7	1.2	155.1
2	8-14	28.5	19.1	89	52	-	-	8.5	3.5	210.0
3	15-21	28.2	19.6	88	51	-	-	6.5	3.7	183.2
4	22-28	29.5	17.5	88	39	-	-	9.9	4.9	245.3
5	29-4 Feb.	31.3	18.8	88	38	-	-	7.9	5.1	240.9
6	Feb. 5-11	32.0	16.7	73	36	-	-	6.5	4.7	222.6
7	12-18	32.6	21.0	85	38	-	-	9.1	5.0	236.1
8	19-25	32.3	18.4	72	32	-	-	9.6	5.3	244.8
9	26-4 Mar.	34.8	18.7	80	22	-	-	10.9	6.8	266.0
10	Mar. 5-11	35.4	19.7	82	23	-	-	11.0	7.9	277.4
11	12-18	34.0	21.0	73	26	-	-	9.1	8.2	231.8
12	19-25	35.5	22.9	78	29	-	-	9.8	7.6	246.3
13	26-1 Apr.	36.2	23.3	83	34	34.8	1	9.4	8.1	227.5
14	Apr. 2-8	34.5	23.0	92	45	1.5	-	8.8	5.0	203.0
15	9-15	35.0	23.6	90	40	-	-	8.6	6.2	247.7
16	16-22	36.3	23.3	86	35	-	-	9.8	7.6	256.3
17	23-29	35.5	23.5	86	47	7.5	2	9.1	6.4	239.2
18	30-6 May	36.1	23.2	86	36	-	-	10.3	8.0	256.0
19	May 7-13	36.7	24.1	80	33	-	-	10.5	7.2	258.1
20	14-20	36.1	23.6	89	39	9.0	1	8.5	6.2	233.9
21	21-27	34.2	24.2	89	54	16.0	1	8.3	7.3	242.6

APPENDIX 1b

Weather during the cropping period at Pattukottai

Standard week	Period	Temperature (°C)		Relative humidity (%)		Rainfall		Evapora (mm da
		Maximum	Minimum	Morning	Evening	Amount (mm)	Rainy days	
1986								
42	Oct. 15-21	30.2	25.9	89	66	8.5	2	5.9
43	22-28	28.9	25.3	93	70	3.1	1	6.0
44	29-4 Nov.	28.0	23.7	94	69	50.0	5	4.7
45	5-11	26.7	23.6	89	65	70.0	2	4.3
46	12-18	25.9	22.8	84	70	8.5	1	5.8
47	19-25	26.7	21.5	87	65	4.5	1	5.3
48	26-2 Dec.	25.2	20.4	92	74	130.5	7	2.2
49	3-9	24.9	21.8	90	63	22.5	2	3.6
50	10-16	26.7	21.2	85	69	1.0	-	3.6
51	17-23	26.0	20.0	90	71	23.0	2	2.5
52	24-31	26.7	21.2	91	62	34.5	3	2.9
1987								
1	Jan. 1-7	26.7	21.0	79	54	-	-	3.4
2	8-14	27.6	22.7	86	68	22.0	1	3.4
3	15-21	27.1	21.6	84	64	-	-	4.5
4	22-28	27.2	21.8	82	50	-	-	4.5
5	29-4 Feb.	27.6	21.6	84	53	-	-	4.8
6	5-11	29.2	23.7	80	48	-	-	5.3
7	12-18	29.9	23.6	83	41	-	-	5.7
8	19-25	31.1	25.5	84	45	-	-	5.8
9	26-4 Mar.	31.8	25.6	73	52	-	-	5.2
10	5-11	30.2	27.4	81	59	-	-	6.0
11	12-18	33.5	28.0	85	64	6.5	1	5.9
12	19-25	31.6	27.2	90	55	-	-	6.3
13	26-1 Apr.	32.0	25.6	83	44	-	-	6.4
14	2-8	29.9	24.0	74	57	-	-	7.1
15	9-15	29.8	26.2	61	40	-	-	7.4
16	16-22	32.6	26.9	72	50	-	-	7.2
17	23-29	34.6	26.2	78	54	1.5	-	7.1
18	30-6 May	35.0	28.9	79	57	-	-	8.1
19	7-13	35.2	29.0	82	53	-	-	7.9
20	14-20	34.5	27.9	87	61	35.5	2	6.9
21	21-27	34.0	28.1	89	64	9.0	1	7.4

APPENDIX II

EQUIVALENTS FOR DIRECT AND INDIRECT SOURCES OF ENERGY

Particulars	Unit	Equivalent energy/MJ	Remarks
(1)	(2)	(3)	(4)
A. INPUTS			
1) <u>Human labour</u>			
a) Adult Man	Man hour	1.96	
b) Woman	Woman hour	1.57	1 Adult woman = 0.8 Adult man
c) Child	Child hour	0.98	1 Child = 0.5 Adult man
2) <u>Animals</u>			
a) Bullocks			
i) Large	Pair hour	14.05	Body wt. above 450 kg
ii) Medium	-do-	10.10	Body wt. 352-450 kg
iii) Small	-do-	8.07	Body wt. less than 350 kg
3) Diesel	Litre	56.31	Includes the cost of lubricants
4) Petrol	-do-	48.23	-do-
5) Electricity	KW	11.93	
	1 HP Hr.	8.90	
6) <u>Machinery</u>			
a) Electric Motor	kg	64.80	Distribute the weight of the machinery equally over the total life span of the machinery (in hours). Find the use of machinery (hours) for the particular operation or crop.
b) Prime movers other than electric (including self-propelled machines)	kg	64.80	

Appendix II continued

(1)	(2)	(3)	(4)
c) Farm machinery excluding self- propelled machines	kg	62.70	
7) <u>Commercial fertiliser</u>			
i) N	kg	60.6	Estimate the quantity of nitrogen, P_2O_5 and K_2O in the chemical. Then compute the amount of energy input from chemical fertilisers.
ii) P_2O_5	kg	11.1	
iii) K_2O	kg	6.7	
8) Farm yard Manure	kg	0.3	Dry matter
9) <u>Chemicals</u>			
i) Superior chemicals	kg	120	Chemicals requiring dilution at the time of application
ii) Zinc sulphate	kg	20.9	
iii) Inferior chemicals	kg	10.0	D.D.T., Gypsum or any other chemical not requiring dilution.
10) <u>Seed</u>			
a) Output of crop production system and is not processed			Same as that of output of crop production system.
b) Output of crop production system and is processed before using it for seed (eg. <i>Potato, Groundnut, Cotton etc.</i>)			Add 2.5, 1.0 and 0.5 M.J./ha ⁻¹ for Potato, Groundnut and other seed respectively to the equivalent energy of the product of crop production system.

Appendix II continued

(1)	(2)	(3)	(4)
B. <u>OUTPUTS</u>			
1. Cereal crops such as Wheat, Maize, Sorghum Bajra, Barley, Oats, Paddy (not shelled rice)	kg	14.7	The main output is grain
2. Pulses, such as Mash, Moong, Lentil, Arhar, Soybean, Peas, Beans etc.	kg	14.7	The main output is grain
3. Oilseeds such as Cotton seed, Groundnut pods (not shelled), Sesamum, Rapeseed, Mustard, Linseed, Sun- flower seeds etc.	kg	25.0	The main output is seed except for groundnut, where it is pod
4. <u>Fibre crops</u> :			
Cotton, Sunnhemp, Sunflex, Jute etc.	kg Dry mass	11.8	Main product of fibre
II. <u>By-product</u>			
1. Straw, Vines	kg	12.5	
	Dry mass		
2. Stalks, cobs, fuel- wood, fruits, vines, Plant wood.	kg	18.0	
3. Cotton Seed	kg	10.0	

APPENDIX IIIa
Cost structure (Rs ha⁻¹) in the cropping systems - Coimbatore

Cropping system	C O S T										Interest on the working capital	T.V.C.
	Human labour	Bullock labour	Seeds	N	P ₂ O ₅	K ₂ O	Irrigation	Pesticides	Petrol			
Rice-Rice-Rice												
K151	9858	253	630	1361	751	46	2679	1173	564		1710	1887.5
K152	9858	253	630	1361	751	46	2679	1173	544		1710	1885.5
K153	9858	253	630	1361	751	46	2679	1173	544		1710	1885.5
K154	9869	253	630	1361	751	138	2679	1173	544		1720	1891.8
K251	9858	253	630	1361	751	91	2679	1173	564		1714	1885.4
K252	9858	253	630	1361	751	91	2679	1173	564		1714	1885.4
K253	9858	253	630	1361	751	91	2679	1173	564		1714	1885.4
K254	9869	253	630	1361	751	274	2679	1173	564		1733	1966.7
K ₀	9847	253	630	1361	751	-	2679	1173	564		1754	1874.2
Rice-Rice-Soybean												
K151	8423	220	570	998	901	46	1667	1144	490		1446	1595.3
K152	8423	220	570	998	901	46	1667	1144	490		1446	1595.3
K153	8423	220	570	998	901	37	1667	1144	490		1445	1589.5
K154	8433	220	570	998	901	129	1667	1144	490		1455	1602.7
K251	8423	220	570	998	901	91	1667	1144	490		1450	1595.4
K252	8423	220	570	998	901	91	1667	1144	490		1450	1595.4
K253	8423	220	570	998	901	74	1667	1144	490		1449	1592.6
K254	8434	220	570	998	901	236	1667	1144	490		1468	1614.8
K ₀	8412	220	570	998	901	-	1667	1144	490		1440	1584.2
Rice-Rice-Finger Millet												
K151	9955	227	433	727	651	46	1051	1056	435		1457	1602.8
K152	9955	227	433	727	651	46	1051	1056	435		1457	1602.8
K153	9955	227	433	727	651	28	1051	1056	435		1455	1602.8
K154	9960	227	433	727	651	120	1051	1056	435		1465	1611.5
K251	9960	227	433	727	651	91	1051	1056	435		1462	1605.3
K252	9960	227	433	727	651	91	1051	1056	435		1462	1605.3
K253	9960	227	433	727	651	45	1051	1056	435		1459	1604.4
K254	9967	227	433	727	651	238	1051	1056	435		1478	1625.3
K ₀	9938	227	433	727	651	-	1051	1056	435		1451	1595.9
Rice-Rice-Cotton												
K151	8912	231	465	727	651	46	1781	1198	682		1469	1616.2
K152	8912	231	465	727	651	46	1781	1198	682		1469	1616.2
K153	8912	231	465	727	651	28	1781	1198	682		1468	1615.3
K154	8916	231	465	727	651	120	1781	1198	682		1477	1624.8
K251	8912	231	465	727	651	91	1781	1198	682		1474	1621.2
K252	8912	231	465	727	651	91	1781	1198	682		1474	1621.2
K253	8912	231	465	727	651	55	1781	1198	682		1470	1618.0
K254	8922	231	465	727	651	238	1781	1198	682		1493	1658.5
K ₀	8894	231	465	727	651	-	1781	1198	682		1463	1609.2

T.V.C.
 S₁ - Total variable cost
 S₂ - K applied during SWM Season, 1984
 S₃ - K applied during NEM season, 1984
 S₄ - K applied during Summer, 1985
 S₀ - K applied during all the three seasons
 K₀ - No net recommended dose of K

APPENDIX IIIb
Cost structure (Rs ha⁻¹) in the cropping systems - Pattukottai

Cropping system	C O S T O F										Interest on the working capital	T.V.C.
	Human labour	Bullock labour	Seeds	N	P ₂ O ₅	K ₂ O	Irrigation	Pesticides	Petrol			
Rice-Rice-Rice	K ₁ S ₁	5169	183	1469	534	425	46	1285	691	452	1025	11279
	K ₁ S ₂	5169	183	1469	534	425	48	1285	691	452	1026	11282
	K ₁ S ₃	5169	183	1469	534	425	94	1285	691	452	1035	11332
	K ₂ S ₁	5169	183	1469	534	425	92	1285	691	452	1030	11330
	K ₂ S ₂	5169	183	1469	534	425	96	1285	691	452	1030	11334
	K ₂ S ₃	5169	183	1469	534	425	188	1285	691	452	1040	11436
Rice-Rice-Soybean	K ₀	5169	183	1469	534	425	-	1285	691	452	1021	11229
	K ₁ S ₁	4910	176	339	544	650	46	1007	565	340	862	9179
	K ₁ S ₂	4910	176	339	544	650	37	1007	565	340	861	9169
	K ₁ S ₃	4910	176	339	544	650	83	1007	565	340	865	9319
	K ₂ S ₁	4910	176	339	544	650	92	1007	565	340	866	9329
	K ₂ S ₂	4910	176	339	544	650	71	1007	565	340	863	9310
Rice-Rice-Finger Millet	K ₂ S ₃	4910	176	339	544	650	166	1007	565	340	874	9611
	K ₀	4910	176	339	544	650	-	1007	565	340	857	9428
	K ₁ S ₁	5293	189	279	1025	563	46	1348	596	431	977	10747
	K ₁ S ₂	5293	189	279	1025	563	46	1348	596	431	977	10747
	K ₁ S ₃	5293	189	279	1025	563	92	1348	596	431	982	10798
	K ₂ S ₁	5293	189	279	1025	563	92	1348	596	431	982	10798
Rice-Rice-Cotton	K ₂ S ₂	5293	189	279	1025	563	154	1348	596	431	991	10899
	K ₂ S ₃	5293	189	279	1025	563	-	1348	596	431	972	10696
	K ₀	5080	171	274	528	365	46	985	563	394	841	9250
	K ₁ S ₁	5080	171	274	528	365	46	985	563	394	839	9234
	K ₁ S ₂	5080	171	274	528	365	65	985	563	394	843	9274
	K ₁ S ₃	5080	171	274	528	365	92	985	563	394	846	9314
Rice-Rice-Cotton	K ₂ S ₁	5080	171	274	528	365	92	985	563	394	846	9314
	K ₂ S ₂	5080	171	274	528	365	136	985	563	394	850	9349
	K ₂ S ₃	5080	171	274	528	365	-	985	563	394	846	9314
	K ₀	5080	171	274	528	365	-	985	563	394	836	9199

T.V.C. - Total variable cost
 S₁ - K applied during NEM season, 1986
 S₂ - K applied during Summer, 1987
 S₃ - K applied during both the seasons
 K₁ - 50 per cent recommended dose of K
 K₂ - 100 per cent recommended dose of K

APPENDIX IV

COST OF PRODUCE

Produce	Unit	Value (Rs.)
Paddy grain	Kg	2.20
Paddy straw	t	150.00
Soybean seed	Kg	4.00
Finger millet grain	Kg	2.00
Finger millet straw	t	100.00
Cotton kapos	q	700.00
Groundnut pod	Kg	4.50
Groundnut haulms	t	250.00
Maize grain	Kg	2.00
Maize straw	t	100.00
Sesame seed	Kg	9.00

APPENDIX V

EUF-K fractions in soil (ppm)

		C O I M B A T O R E							
EU _F fraction	Initial	Rice-Rice-Rice (C ₁)		Rice-Rice-Soybean (C ₂)		Rice-Rice-Finger millet (C ₃)		Rice-Rice-Cotton (C ₄)	
		50%	100%	50%	100%	50%	100%	50%	100%
1	15	15	19	13	16	19	22	15	18
2	35	36	38	30	37	46	65	30	38
3	37	47	50	38	45	55	75	37	44
4	32	47	50	39	44	50	70	39	44
5	28	43	49	35	38	45	59	36	36
6	24	36	42	32	33	34	48	33	39
7	62	94	102	96	98	70	92	82	100
Total	233	318	350	283	311	323	431	272	315
EU _F 10	50	51	57	43	53	65	87	45	56
EU _F 30	171	188	248	187	213	249	339	190	215
EU _F 30-35	62	94	102	96	98	74	92	82	100
EU _F 35	233	318	350	283	311	323	431	272	315
EU _F 30-35	0.016	0.500	0.411	0.513	0.460	0.297	0.271	0.432	0.465
P A T T U K O T T A I									
		Rice-Groundnut (C ₁)		Rice-Soybean (C ₂)		Rice-Maize (C ₃)		Rice-Sesame (C ₄)	
		50%	100%	50%	100%	50%	100%	50%	100%
1	13	8	4	8	6	9	6	9	7
2	21	11	12	11	9	10	9	9	12
3	15	9	7	8	5	6	6	5	9
4	10	6	4	5	3	2	3	2	4
5	7	4	3	4	1	1	2	1	2
6	5	4	3	3	1	1	1	1	1
7	18	10	8	10	8	4	4	6	6
Total	89	2	41	49	33	33	31	33	41
EU _F 10	34	19	16	19	15	19	15	18	19
EU _F 30	71	42	33	39	25	29	27	27	35
EU _F 30-35	18	10	8	10	8	4	4	6	6
EU _F 35	89	52	41	49	33	33	31	33	41
EU _F 30-35	0.254	0.238	0.242	0.256	0.320	0.138	0.148	0.222	0.171