DECOMPOSABILITY AND MINERALISATION PATTERN OF COIRPITH IN LATOSOLS

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1993

DECLARATION

I hereby declare that this thesis entitled **Decomposability and Mineralisation Pattern of Coirpith in Latosols** is a bonafide record of research work done by me during the course of research and this thesis has not previously formed the basis for award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

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ACKNOWLEDGEMENT

With immense pleasure, I take this opportunity to express my profuse and sincere gratitude to **Dr. P.K. Sushama,** Associate Professor, Department of Soil Science and Agricultural Chemistry and Chairperson of my Advisory Committee for suggesting the problem and ably guiding me throughout the course of the investigation. I remember with gratitude the keen interest shown by her in each and every bit of my attempt which has resulted in successful completion of the work.

I am deeply indebted to **Dr. A.I. Jose,** Professor and Head, Department of Soil Science and Agricultural Chemistry and a member of my Advisory Committee for the valuable suggestions and guidance throughout the course of the investigation and preparation of the manuscript.

I am greatly obliged to **Dr. C.K. Peethambaran,** Associate Professor, Department of Plant Pathology, College of Agriculture, Vellayani and my Advisory Committee Member for his critical appraisal of manuscript and constructive suggestions for its betterment.

I am thankful to **Sri. P. V. Prabhakaran,** Professor and Head, Department of Agricultural Statistics for the valuable help in the statistical analysis of the data.

The profound thanks are due to the Staff members of the Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara, especially to Prof.P.A. Khora and Dr. N.P. Chinnamma, Professors, for their kind and generous co-operation and constant encouragement.

My profound sense of gratitude is also due to Dr.(Miss) D. Prema for her valuable assistance and erudite guidance and perpetual support throughout the course of this investigation.

My heartfelt gratitude and moral obligation remain with Mr. P. Muraleedharan, Mr. A.P. Vijayan, Miss. K.S. Sapheena, Mr. C.Sivakumar, Mr. A. Ramesh, Mr. Visveswaran, Mr. M.P. Suresh Babu, Mr. S. Venugopal, Mr. K.K. Dineshkumar, Miss.G.Allirani, Miss. P. Babykala, Mr. Edwin Prem and Mr. K. Angaiah.

I would like to thank Dr. C.C. Abraham, Associate Dean, College of Horticulture, for the facilities provided for undergoing the M.Sc. (Ag.) Programme.

The award of Junior Fellowship by the Kerala Agricultural University is greatly acknowledged.

My hearty thanks are expressed to Mr. K. Venkatachalapathy, Mr. M. Athinarayanan, Mr. P. Jayaseelan and Miss Christy Nirmala Mary, for extending all possible help in the proper conduct of this programme.

Words fail to express my sincere gratitude towards my family and my friends without whom the thesis would not have attained this shape.

Finally I thank M/S BLAISE COMPUTER CONSULTANCY, MANNUTHY for neat and prompt execution of typing.

S. JOTHIMANI

Dedicated to
Those who inspire me

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Introduction

INTRODUCTION

India ranks third among the coconut producing countries of world, covering over 1.51 million hectares of area and producing approximately 9700 million nuts per annum. In the production scenario, Kerala tops with 4527 million nuts followed by Tamil Nadu (2358 million nuts), Karnataka (1202 million nuts) and Andhra Pradesh (730 million nuts) which indicates that more than 90 per cent of the production are from the southern states (Thampan, 1992). Coir factories for which the basic raw material is coconut husk, are emerging in these states in a big way (Ajithkumar, 1991). Coirpith is the major waste product of this industry and a total of 4.6 lakh tonnes of coirpith is being produced annually in our country. This material is now considered as an environmental hazard posing problems of disposal.

Coirpith constitutes about 70 per cent of the coconut husk. Based on the mode of extraction of coir fibre, there can be pith from retted as well as unretted husk. The former is obtained from husks subjected to retting in backwater whereas the later involves direct decortication or mechanical extraction. The major difference between the two is that retted pith has a lower lignin content when compared to the unretted one. The fibre to pith ratio in the husk is approximately 1:2. Based on the data on brown fibre and white fibre production, an estimated quantity of 2.65 lakh tonnes of pith from retted husk and 1.76 lakh tonnes of pith from unretted husk is available per annum (Thampan, 1992).

Decline of organic matter in tropical soils including latosols is very fast, the major reasons being high temperature and rainfall characteristics of the climate which are conducive for the rapid microbial decomposition. Regular and adequate organic manure application is the only way out to escape this crisis. But the non availability of enough farm yard manure, compost or green manure makes this option really difficult and thereby our agricultural fields are getting rapidly depleted. Further insufficiently low build up of organic carbon content is being reported from fields which even received regular doses of conventional organic manures presumably because of high rate of oxidation of organic materials under humid tropical situation in Kerala (Padmam, 1992).

Works so far conducted on coirpith confirmed the use of decomposed coirpith as a manure along with inorganic fertilizers for sustained crop production (Nagarajan et al., 1985, Boppaiah, 1991 and Perumal et al. 1991). But composting and enrichment techniques of this lignin rich material are still at its infant stage and therefore, to be refined to the specificities and contexualities of each situation and soil type.

Similarly, though the composted coirpith is identified as a soil conditioner its influence on nutrient release pattern is practically a less studied area. Further the role of microbes in the organic recycling of coirpith is to be tested in detail under contextual situations. This study was therefore, undertaken with the following objectives.

1. To determine the rate of decomposition and mineralisation pattern of coirpith incorporated with the laterite soil.

2. To study the influence of microbial inoculation on the decomposition of coirpith.

3. To estimate the fertility value of the resulting compost from coirpith as compared to green leaf manure.

Review of Literature

REVIEW OF LITERATURE

Coirpith has been recognised as an organic amendment and its potential in improving physical, chemical and biological characteristics of soil is under various stages of experimentation. Efforts are in progress for evolving rapid composting and enrichment techniques of coirpith as it contains an appreciable amount of lignin, pentosan and hexosan compounds which are resistant to degradation. All these efforts can be very well compared with organic recycling of other farm wastes.

1. Decomposition of organic materials and CO_2 evolution

Allison and Cover (1960) conducted laboratory studies to determine the rate of decomposition of short leaf pine saw dust in soil, by measuring the amount of CO_2 evolved. They reported that during a period of 160 days with adequate nitrogen supplied, 58 per cent of the wood carbon was released as CO_2, the corresponding value for wheat straw was 64 per cent. Chakraborty and Sen (1967) conducted a laboratory experiment using tender green leaves of *Phaseolus* sp with C:N ratio of 14:1 after mixing with the soil thoroughly. They found that initially the rate of evolution of CO_2 from soils was higher, gradually it decreased and after about 30 to 45 days, the rate of decomposition of organic matter was almost at the equilibrium point.

Debnath and Hajra (1972) recorded the rate of CO_2 evolution from soils that were incorporated with farm yard manure, dhaincha and paddy straw. The incubation was done for 120 days and the rate of CO_2 evolution was found to be the highest within 48 hours of incubation. FYM has been graded as the best organic matter builder, followed by dhaincha.

The organic matter degradation property of soil heterotrophs is commonly used to indicate the level of microbial activity. Measurement of CO_2 evolution has been developed as one of the methods to measure the decomposition rate (Alexander, 1978).

Banger and Patil (1980) stated that the addition of nitrogen to lower down the original C:N ratio (74:1) of wheat straw significantly resulted in liberating more amount of CO_2 than control. Further it was observed that if C:N ratio was 30:1, CO_2 evolution was significantly superior to that of 40:1. The incubation period had a significant role in CO_2 evolution. In the first week, maximum amount of CO_2 was evolved which was followed by the second week. The amount of CO_2 evolved during the weeks was inferior. According to Edwards (1982) the magnitude of carbon mineralisation was directly related to the release of CO_2 from the soil.

Murthy (1984) observed that the increased rate of decomposition due to microbial activity shot up as soon as the energy providing organic materials were supplied to soil. Patil et al. (1984) reported that the rate of CO_2 evolved from spent wash (a distillery waste) amended soil was nearly three times faster than that of FYM treatment. Minhoni and Cerri (1987) stated that the samples with organic residue and soil kept under drier condition showed initially greater CO_2 evolution. Jenzen and Kucey (1988) measured the mineralisation of carbon and nitrogen over a 12 week incubation period under controlled conditions. The rate of decomposition as measured by CO_2 evolution appeared to be controlled by nitrogen content of the residue.

According to Raina and Goswami (1990) about half of the carbon mineralised was evolved as CO_2 during the first 20 days when ^{14}C labelled wheat root and shoot were incorporated with soil under laboratory condition. Bopaiah (1991) found that the rate of decomposition of coirpith increased due to the enhanced activity of Pleurotus sp by fertilizer nitrogen. Due to the incorporation of inorganics along with fungus the C:N ratio of coirpith narrowed down from 112:1 to 24:1.

2. Role of mineral nitrogen for organic matter breakdown

Nitrogen is a key nutrient substance for microbial growth and hence for organic matter breakdown. If the nitrogen content of the substrate is poor, decomposition is slow and carbon mineralisation will be stimulated by supplemental nitrogen (Alexander, 1978). The addition of urea to muck soil accelerated the decomposition, but the long term effect was an inhibition of the same as indicated by Couture and Fortin (1983).

Knapp et al. (1983) showed that straw decomposition rate was strongly dependent on available carbon and nitrogen during initial decomposition. When N was limting, excess available carbon was apparently immobilized as polysaccharides.

Joshi et al. (1985) reported that blending urea with retted and unretted coirdust resulted in immobilisation of urea.

Fog (1988) summarised the various effects of added nitrogen on organic matter decomposition. According to him nitrogen added to decomposing organic matter had no effect or negative effect on microbial activity. A negative effect of nitrogen was found in organic matter with a higher C:N ratio but the reverse was true for easily degraded organic matter with low C:N ratio.

3. Mineralisation of organic materials with the addition of rockphosphate

Incorporation of rockphosphate increased the availability of phosphorus and the total nitrogen present in the compost (Prasad and Jha, 1974). Maurya and Dhar (1976) indicated that there was significant increase in the yield and also improvement in the quality of sweet potato with the application of green manures along with phosphatic fertilizers. Addition of organic manures with rockphosphate could be advantageous to crop with respect to yield in neutral soils (Rastogi et al., 1976).

According to Talashilkar and Patil (1979) there was a high amount of phosphorus in available form, when rockphosphate was applied with compost. Mathur et al. (1980) reported a higher release of phosphorus from rockphosphate, when it was applied with compost. Krishna and Ramulu (1983) observed that the coirwaste applied along with mussorie rockphosphate as an amendment had increased the fertilizer use efficiency of neutral soil. Singh and Yadav (1986) stated that the incubated mixed chopped rice straw with rockphosphate had a favourable effect on the mineralisation of nutrient.

Rasal et al. (1988) showed that carbon compound of the compost was reduced significantly due to mineral additive such as rockphosphate. Tiwari et al. (1988) found that composting with rockphosphate increased the citrate and water soluble phosphorus.

4. Enrichment of microbial inoculum with organic wastes in soil

4.1. Microbes alone

About 50.68 per cent of the lignin in the barley straw was removed by treating it with the culture filtrate of Pleurotus sajor caju grown on the substrata (Holankoya, 1987). Genterova and Lazorova (1987) reported that the Pleurotus ostreatus decomposed lignin and hemicellulose at higher rate than cellulose, only amorphous part of the cellulose seemed to be degraded. The degrading rate decreased in the following order - ligin > hemicellulose > cellulose. On testing the ability of forty five fungal strains on decomposition of lignin, Valmaseda et al. (1990) reported that Pleurotus sp was the best to degrade lignin.

Suitability of coirpith as a manure for different crops after converting it into decomposed form with Pleurotus sp. was reported by Sharma and Mitra (1990). Perumal et al. (1991) observed that the application of composted coirpith and coirpith plus inoculants in combination with inorganic nitrogen maintained high fertility status than the control.

.2. Microbes in combination with inorganics

The decomposition of sugarcane trash with different phosphate sources and microbial cultures took about 3 to 4 months, but phosphorus sources with microbial cultures took 5 months for decomposition. The compost without phosphorus or cultures were not ready even after 5 months (Shinde and Rote, 1983).

Nagarajan *et al*. (1985) observed that after 26th day of incubation with *Pleurotus* sp and urea, the C:N ratio of coirpith was reduced. Coirpith inoculated with *Pleurotus* sp plus inorganic NPK fertilizers applied at 12.5 t ha^{-1} level registered higher yield of groundnut and rice (Nagarajan *et al*., 1986).

Bopaiah (1991) recommended five spawn bottles of *Pleurotus sajor caju* fungus and five kg of urea for decomposing a tonne of coirpith. The inclusion of coirpith and inoculants with inorganic fertilizers further improved the nitrogen status of the soil as observed by Perumal *et al*.(1991).

5. **Transformation of organic matter in the soil**

Oden (1919) described humic acid as dark brown, almost black substance insoluble in alkali, and precipitated by acids. But the fulvic acid was soluble both in alkalies and in acids with light yellow to golden yellow in colour. Hurst and Burges (1969) held the view that lignin was the chief contributor towards humic acid. Felbeck (1971) observed that humic acid degrades to fulvic acid and Schnitzer and Khan (1972) stated that the fulvic acid was the resultant product from humic acid. Budihal and Rao (1978) reported that 12.4 per cent of organic matter was humic acid fraction in Karnataka soils. They also observed that neutral reaction and relatively higher base saturation favoured predominance of humic acids. The least degree of aromatisation of humic acid of the laterite soil appeared to be due to acidic reaction, higher base saturation and low exchange capacity. Humic acid was the first transformation products of soil organic matter whereas fulvic acid was formed by further transformation and destructive synthesis (Ram and Raman, 1981).

Usha and Jose (1984) characterised the soil organic matter in different soil types of Kerala and reported that on an average the percentages of humic acid and fulvic acid in the soil organic matter were 28.3 and 36.5 respectively. Hernando and Polo (1986) compared the humic acid obtained by the decomposition of wheat straw by fungi with the soil humic acid. Carbon, nitrogen and hydrogen contents were higher in straw humic acids than the soil humic acids. The manures applied with or without NP fertilizers to meadow black soil significantly increased the humus fractions in the soil (Qui and Ding, 1986).

The humic acid was higher during decomposition of wheat straw. The main constituent of the humic like fractions of compost was not of microbial origin, but is derived from the oxidative alteration of the straw lignin (Alemendros and Martinez, 1987). Prasad and Kumar (1988) pointed out that the fulvic acids of organic wastes changed considerably on their incorporation into soil. Singh and Amberger (1990) examined the production of humic substances and their retention capacity for phosphorus and calcium that was released during composting of wheat straw. They observed that the addition of mussorie and hyper-phos retarded humic acid production and enhanced fulvic acid production.

There is no reported work on the transformation of organic matter due to the addition of coirpith.

6. Manurial value of coirpith

Ramaswami (1977) reported that there was significant increase in grain yield of paddy due to the application of coirpith @ 10 t ha^{-1} along with 75 per cent NPK dose and that the straw yield of sorghum was increased @ 25 t ha^{-1} coirpith application. Lokanathan and Lakshminarasimhan (1979) observed that application of coirdust @ 5 t ha^{-1} gave higher yield of groundnut. Mayalagu et al. (1983) observed the highest yield of groundnut by the application of 20 t ha^{-1} of coir waste as compared to treatments with pressmud, FYM and sand. Santhi et al.(1991) concluded that the application of coirpith showed favourable effect on the uptake of major nutrients by the rice crop. Pushpanathan and Veerabadran (1991) noticed significant increase in available nutrient content of the soil with the application of composted coirpith.

7. Nutrient availability from coirpith as compared to other organic materials

The availability of nutrients is largely governed by the changes in pH,organic carbon, CEC, available N, P and K.

7.1. Effect on soil pH

Influence of organic matter on soil pH is widely established. Gidnavar et al. (1972) found that application of FYM along with 330 kg of sulphur decreased the pH of the soil. Amendments such as pressmud, paddy husk and gypsum, applied in non-saline alkali soil decreased the pH

(Paramasivam, 1979). The same trend was also observed by Raja and Raj (1980). Balasubramanian (1981) pointed out that half dose of gypsum plus 15 t ha^{-1} of pressmud plus 25 kg ha^{-1} of zinc sulphate markedly reduced the soil pH.

Clarson (1983) and Clarson et al.(1983) reported that the application of coirpith @ 10 t ha^{-1} decreased the soil pH from 9.20 to 8.35. The combined application of coirpith with inorganics was less effective than coirpith alone in reducing soil pH. Ramaswami et al. (1983) also supported these findings strongly. According to Sahu and Patnaik (1990) the increase in pH of the soil due to mineralisation of organic matter was brought about by the replacement of hydrogen ions by ammonium ions.

According to Nagarajan et al.(1991) the application of lignin rich coirpith did not have any effect on soil reaction as well as soluble salts contents. The soil pH reduced significantly by the addition of raw as well as composted coirpith (Pushpanathan and Veerabhadran, 1991). Santhi et al. (1991) showed that upon coirpith application its slight acidic nature would have reduced the soil pH which again leads to an increase in the availability of nutrients. Savithri et al. (1991) concluded that the incorporation of composted coirpith along with gypsum reduced the soil pH by 0.40 to 0.60 units. Application of pressmud @ 30 t ha^{-1} to a highly alkaline soil (pH 9.3) reduced the soil pH (Rajamannar and Ramulu, 1982).

7.2. Effect on organic carbon

Application of FYM to saline alkali soils had increased the orgaic carbon content of the soil (Gidnavar et al., 1972). Reddy (1973) had also showed that the application of gypsum plus green manure or pressumed in saline alkali soil increased organic carbon content. The same result was also observed by Raja and Raj (1979) with pressmud application. Ravikumar and Krishnamoorthy (1980) evaluated the effect of different soil amendments on chemical properties of the soil and observed that organic amendments were superior to inorganics in improving chemical properties of the soil and yield of finger millet. Shanmugam and Ravikumar (1980) stated that application of organic residues in alkali soils increased organic carbon content of the soil. Flaig (1984) reported that there was decrease in carbon content of the soil through the degradation of soil organic matter as a consequence of enhanced microbial activity.

Nagarajan et al. (1986) observed that the organic carbon content of inoculated coirpith decreased due to the reduction in volume of the ligno-cellulosic material. Application of coir waste with NPK fertilizers, in coastal sandy soil of Kerala, had decreased the organic carbon content (Nambiar et al., 1988). Application of composted coirpith recorded highest organic carbon content than other organic manures as pointed out by Pushpanathan and Veerabadran (1991). Santhi et al. (1991) observed that there has been increase in organic carbon content (0.61 per cent) due to coirpith application. According to Selvi et al. (1991) the organic carbon content was significantly more in composted coirpith treated plots than the FYM treated plots.

7.3. Effect on Cation Exchange Capacity (CEC)

Cation exchange capacity of the soil was found to be increased by application of gypsum plus green manure or pressmud (Reddy, 1973). According to Paramasivam (1979), Raja and Raj (1979) and Balasubramanian (1981) pressmud @ 10 t ha^{-1} increased the CEC considerably. Application of FYM to seirozem soil in the semi arid region of Haryana, increased the CEC (Singh et al., 1980).

Ravikumar and Krishnamoorthy (1980) evaluated the effect of different soil amendments on the chemical properties of the soil, the results indicated that application of organic amendments improved the CEC of the soil and it was positively correlated with the organic carbon content.

Clarson (1983) and Clarson et al. (1983) observed that the CEC of the soil was increased from 8.6 $cmol(+) kg^{-1}$ of soil to 9.25 $cmol(+) kg^{-1}$ of soil due to coirpith application @ 10 t ha^{-1}. Venkataraman (1984) stated that the addition of glyricidia leaves at the rate of 20 t ha^{-1} to soil generated higher concentration of water soluble ferrous and manganese and other cations than the control. In calcareous sandy soil the CEC was not greatly affected although there was a slight response in the silty clay loam soil as reported by Leboudi et al. (1988).

Savithri et al. (1991) showed an inverse relationship between exchangeable cations (calcium, potassium and sodium) and pH of the soil due to coirpith application.

7. fect on available nitrogen

Somani and Saxena (1975) observed a considerable increase in the available nitrogen status of the soil due to the application of slowly decompositing FYM. Singh and Lal (1976) identified that the magnitude of net effect of continuous mineralization and immobilisation of nitrogen was influenced by nature and quality of applied organic materials. According to Shi et al. (1978) the addition of materials rich in lignin decomposed slowly and so there was only slow release of nitrogen from the same. Pressmud application @ 10 t ha^{-1} increased available nitrogen in alkali soils (Raja and Raj, 1979). Ravikumar and Krishnamoorthy (1980) observed that the availability of nitrogen in alkali soil was improved by the application of FYM. Combined application of gypsum plus pressmud with zinc sulphate in alkali soil increased the available nitrogen (Balasubramanian, 1981). According to Rajamannar and Ramulu (1982) application of pressmud alone @ 30 t ha^{-1} to a highly alkali soil released considerable amount of nitrogen.

Ramaswami and Ramulu (1983) noticed that the nitrogen mineralisation was more when the coirpith @ 5 t ha^{-1} was applied along with 75 per cent of recommended NPK fertilizers. When the level of coirpith application was compared, there was no significant difference in the nitrogen mineralisation between low and higher doses releasing 189 and 188 kg ha^{-1} of nitrogen respectively with 5 and 10 t ha^{-1} coirpith. In general, Joshi et al. (1985) concluded that coirpith application increased the nitrogen status by 17 per cent.

Krishnan (1986) reported that the raw coirpith application did not cause much increase in available nitrogen, possibly due to the immobilisation of nitrogen and slow mineralisation because of the very wide C:N ratio of 112:1 of coirpith.

In inoculated coirpith with NPK fertilizers and gypsum the available nitrogen was highest (138 ppm) than the non inoculated coirpith (115 ppm) (Muthulakshmi, 1988). Nambiar et al. (1988) evaluated the effect of blending coirdust with fertilizer on the changes in carbon and nitrogen fractions in a coastal sandy soil of Kerala. The results indicated that the available nitrogen content decreased progressively with the time of incubation in all the treatments. There was no marked change in ammoniacal nitrogen during the period of incubation. The NPK fertilizers increased the nitrate nitrogen content of the soil, whereas in the NPK fertilizers plus coirdust treatment, the increase was marginal suggesting that the coirdust may inhibits nitrification.

Loganathan (1990) reported that application of composted coirpith alone and in combination with biofertilizers had improved the nitrogen status of the soil. The mean values of nitrogen levels revealed that the composted coirpith and coirpith plus biofertilizer registered higher values of 211.8 and 230.7 kg ha^{-1} respectively over inorganic nitrogen alone (201.9 kg ha^{-1}). But the application of raw coirpith @ 12.5 t ha^{-1} reduced the available nitrogen status of the soil, indicating the possibility of immobilisation of nitrogen present in soil due to the decomposition of raw coirpith (Savithri et al., 1991). Selvi et al. (1991) though identified significantly higher levels of available nitrogen with composted coirpith over the NPK fertilizers, it was comparatively lower than that of green leaf manure, mushroom-spent compost and FYM treatments. Pushpanathan and Veerabadran (1991) also reported that the available nitrogen status of the soil was improved by the addition of organic manures. Among the various organic manures, the order of increased N availability was: composted coirpith > biogas slurry > FYM > raw coirpith.

7.5. Effect on available phosphorus

Singh et al. (1968) observed relatively high available phosphorus when FYM was applied and compared to the application of poultry manure and goat manure. Increased rate of manure application resulted in a proportionately higher rate of available phosphorus. Mandal and Chatterjee (1972) reported that the application of coirpith reduced the formation of insoluble ferric phosphate. Mandal and Khan (1972) noticed increased phosphorus release in soil due to the application of rice straw or berseem hay. According to Mandal and Mandal (1973) application of both organic matter and lime significantly lowered the fixation of aluminium phosphate and iron phosphate in all the soil types except laterites. Desirable effects on available phosphorus content with the application of organic matter were also documented by Ramaswami (1977), Paramasivam (1979) and Raja and Raj (1979). Farm yard manure with inorganics also improved the availability of phosphorus in alkali soils (Ravikumar and Krishnamoorthy, 1980 and Singh et al., 1980).

Available phosphorus content of the soil increased from 30 kg ha^{-1} to 35 kg ha^{-1} due to incorporation of coirpith @ 10 t ha^{-1} with soil. When the coirpith @ 10 t ha^{-1} incorporated along with zinc sulphate @ 25 kg ha^{-1} in the soil, the available phosphorus was increased to 421 kg ha^{-1} (Clarson, 1983; Clarson et al., 1983). Muthulakshmi (1988) observed that application of inoculated coirpith with NPK fertilizers and gypsum recorded higher available phosphorus (9.7 ppm) followed by inoculated coirpith with NPK fertilizers alone.

Perumal et al. (1991) reported that increase in available P under coirpith addition was due to the solubilising nature of organic acids produced during decomposition. Results on this line were also reported by Loganathan (1990). Santhi et al. (1991) reported that the application of 75 per cent nitrogen along with coirpith recorded an increase in available phosphorus of 37 per cent over 75 per cent nitrogen alone. Inspite of low phosphorus content in coirpith, the coirpith applied treatments showed higher phosphorus status indicating the beneficial effect of applied coirpith on phosphorus transformation in the soil. The organic amendments influenced the available phosphorus content of the soil as the available phosphorus increased from 11.11 kg ha^{-1} to 11.62 kg ha^{-1} in coirpith treatment (Subbaraj, 1992). Tomar and Parchand (1992) found that the available phosphorus content of the soil increased with the increase in pH and decreases with organic carbon content of the soil.

7.6. Effect on available potassium

Kanwar and Prihar (1962) observed an increase in the exchangeable and water soluble potassium in the soil when FYM was applied. Greewal et al. (1981) recorded an increase in available potassium from 100 to 140 ppm, when FYM was applied in sandy loam soil. Rajamannar and Ramulu (1982) also showed an increase in available potassium content of the soil when pressmud was applied @ 30 t ha^{-1}. The release of available nutrients by the application of pressmud was due to the decomposed products of pressmud as pointed out by Balasubramanian and Ramaswami (1983).

Application of coirpith @ 10 t ha^{-1} increased the available potassium content from 190 kg ha^{-1} to 250 kg ha^{-1} in soil (Clarson, 1983; Clarson et al., 1983). Muthulakshmi (1988) found that the available potassium content was gradually decreased from 170 ppm to 130 ppm during the period of incubation. In treatments involving application of NPK fertilisers alone or in combination with coirpith and inoculated coirpith or with gypsum, the available potassium was higher than in treatments with free of NPK fertilisers. Nagarajan et al. (1990) recorded increased potassium contents in soil from 338 kg ha^{-1} to 508 kg ha^{-1} by the application of coirpith plus 75 per cent nitrogen. [illegible] et al. (1991) showed that there was marked increase in the amount of exchangeable potassium due to the application of organic manures till the 24th day after incubation and thereafter it markedly declined by the formation of salts with iron at low pH. Perumal et al. (1991) also observed that the incorporation of composted oirpith and coirpith plus bioinoculants registered higher alues of potassium availability (652 and 672 kg ha^{-1}, espectively) but were on par with each other and significantly superior to inorganic nitrogen alone (577 kg ha^{-1}). Savithri *et al.* (1991) pointed out that the composted coirpith application@ 12.5 t ha^{-1} increased the availability of potassium from 789 kg ha^{-1} to 904 kg ha^{-1}. The combined effect of composted coirpith along with NPK fertilisers recorded the highest available potassium of 951 kg ha^{-1}. Subbaraj (1992) proved that the application of organic amendments markedly influenced the available potassium as the composted coirpith increased available potassium content from 48 kg ha^{-1} to 89 kg ha^{-1}.

7.7. Effect on other nutrient elements

Application of inoculated coirpith with NPK fertilisers and gypsum resulted in highest available calcium and magnesium (Muthulakshmi, 1988). Selvi *et al.* (1991) have also reported that the composted coirpith enhanced the available calcium and magnesium which were compared with that of green leaf manure and FYM but was inferior to mushroom compost.

Incorporation of manures with the inorganics significantly enhanced the micronutrient availability (Selvi *et al.*, 1991). The availability of iron under composted coirpith enhanced progressively, whereas the availability of zinc and manganese was appreciably more under composed coirpith than under any other organics.

Materials and Methods

MATERIALS AND METHODS

An investigation on decomposability and mineralisation pattern of coirpith in latosols was undertaken at the College of Horticulture, Vellanikkara during September 1991 to August, 1992. In order to study the various aspects and to meet the specific objectives set out, two separate experiments, viz. an incubation study and a field experiment were conducted.

1. Incubation study

1.1. Materials

The following materials were used for this study.

1.1.1. Laterite soil

The laterite soil identified as a member of Vellanikkara I series available at the College campus was collected and used for this study. The soils were described as deep dark reddish brown laterite soils having clay loam surface texture, underlaid, by yellowish red silty clay sub soils. The principal associated soils are the Vellanikkara II and Vellanikkara III series, the former being very deep soils and the latter less deep.

Soil samples were analysed as per the standard methods for different attributes as furnished in Table 1. The preliminary analytical data are also provided in the same table.

1.1.2. Coirpith

Raw coirpith was collected from St. Joseph Fibre Works, Kandassankadavu where coir fibre is being extracted mechanically. Chemical composition of the coirpith was determined as per the standard methods (Jackson, 1958). The data are presented in Table 2. Its C:N ratio was 90:1.

1.1.3. Green leaf manure - Glyricidia maculata

The required green leaf manure of Glyricidia sp was collected from the campus of the College of Horticulture, Vellanikkara. This material was also subjected to chemical analysis as in the case of coirpith. The results are furnished in Table 2. The C:N ratio was found to be 13:1.

1.1.4. Fungus - Pleurotus sajor caju

The lignin degrading fungi of Pleurotus sp. was used for this study. Required fungal inoculum was collected from the Department of Soil Science and Agricultural Chemistry,

Table 1. Preliminary analytical data and the methodology adopted for soil analysis

Sl. No.	Determination	Mean value	Extractant used	Method of estimation	Instrument used	References
	Physical properties					
1.	Particle size distribution (%)		-	International pipette method	-	Piper, 1942
	i. Coarse sand	8.80				
	ii. Fine sand	50.20				
	iii. Silt	34.80				
	iv. Clay	6.20				
2.	Apparent specific gravity g cm^{-3}	1.48	-	-	-	Chopra and Kanwar (1991)
3.	Absolute specific gravity g cm^{-3}	2.40	-	-	-	,,
4.	Pore space (%)	42.83	-	-	-	,,
	Chemical properties					
5.	pH	5.30	-	Direct reading	pH meter	Jackson, 1958
6.	Organic carbon (%)	0.47	-	Walkley and Black method	Titrimetric	Piper, 1942
7.	Available N (kg ha^{-1})	250.12	-	Alkaline permanganate method	Macrokjeldahl digestion & distillation apparatus	Subbiah and Asija, 1956
8.	Available P (kg ha^{-1})	8.74	Bray-I	Ascorbic acid blue colour method	Spectrophotometer	Watanabe and Olsen, 1965.
9.	Available K (kg ha^{-1})	210.31	N Ammonium acetate (pH 7)	Direct reading after dilution	Flame Photometer	Jackson, 1958
10.	CEC [cmol(+) kg^{-1}]	10.40	N Potassium chloride	,,	,,	,,
11.	Humic acid (%)	0.32	-	-	-	Stevenson, 1965
12.	Fulvic acid (%)	0.51	-	-	-	Stevenson, 1965

Table 2. Chemical composition of organic materials

Sl. No.	Determination	Mean value		References
		Coirpith	Glyricidia	
1.	Moisture Content (%)	10.84	73.20	Jackson, 1958
2.	Carbon (%)	89.00	39.40	,,
3.	Nitrogen (%)	1.03	3.60	,,
4.	Phosphorus (%)	0.09	0.34	,,
5.	Potassium (%)	1.20	2.21	,,
6.	Cellulose (%)	32.00	22.00	Updegroff, 1969
7.	Lignin (%)	29.00	9.80	Thimmaiah, 1989
8.	C/N Ratio	90:1	13:1	Jackson, 1958

Agricultural College and Research Institute, Coimbatore and used at the rate of five spawn bottles/t of coirpith (Nagarajan, et al., 1990).

1.1.5. Inorganic fertilizers

Urea and rockphosphate were the fertilizers used. The nutrient concentrations were found to be 46% N and 27% P_2O_5, respectively (Chopra and Kanwar, 1991).

1.2. Methodology

1.2.1. Design : 2^3 + 1 Factorial experiment in completely randomised design

1.2.2. Factors and levels:

M : Microbe (*Pleurotus sajor caju*)	Zero and five spawn bottles per tonne of coirpith
R : Rockphosphate	Zero and 60 kg P_2O_5 ha^{-1}
U : Urea	Zero and 120 kg N ha^{-1}

1.2.3. Replication : 4

1.2.4. Treatments

There were nine treatments involving eight factorial combinations of the three factors viz rockphosphate and urea each at two levels and t

Notation	Treatments
Control	Soil + glyricidia (10:1)
$M_0R_0U_0$	Soil + coirpith (10:1)
$M_0R_0U_1$	Soil + coirpith + Urea
$M_0R_1U_0$	Soil + coirpith + rockphosphate
$M_0R_1U_1$	Soil + coirpith + urea + rockphosphate
$M_1R_0U_0$	Soil + coirpith + micobe
$M_1R_0U_1$	Soil + coirpith + microbe + urea
$M_1R_1U_0$	Soil + coirpith + microbe + rockphosphate
$M_1R_1U_1$	Soil + Coirpith + microbe + urea + rockphosphate

The incubation study was conducted to assess the rate of decomposition as influenced by various treatments (Gaur et al., 1971). The study was carried out for 6 months and the observations were recorded at weekly intervals. For the first week after incubation it was done at an interval of alternate days.

Sieved soil (1 kg) was taken in wide mouthed glass bottles. The treatments as given above were imposed in these bottles. In 50 ml test tubes, 25 ml of 0.5 N NaOH was taken. The tubes were suspended into each bottle with the help of thread. The mouth of the bottle was closed tightly to make it airtight using rubber cork and wax. The mouth was also covered with a plastic paper.

The CO_2 trapped in the alkali was determined by titrating the excess alkali against 0.5 N Hcl using 5 ml of saturated barium chloride solution to prevent the interference of sodium carbonate. The amount of carbon-dioxide evolved during decomposition was calculated as outlined by Edwards (1982) and the rate of CO_2 evolution was worked out as mg of CO_2/100 g of soil per day.

2. Field laboratory study

Materials and the design of the experiment were the same as that of incubation study as outlined in 1. Study was conducted for 12 months from September, 1991 to August, 1992.

2.1. Layout of the field

Pits of size 1 m^3 were dug in the experimental site for decomposition studies at 1 m space. They were lined with wooden planks and polythene sheets on all sides to prevent the entry of run off and soil into the pits. The pits were filled with the soil and coirpith (10:1) and treatments were incorporated as described in 1.2.4. The soil with glyricidia in the ratio of 10:1 was maintained as control. The layout of field is shown in Fig. 1.

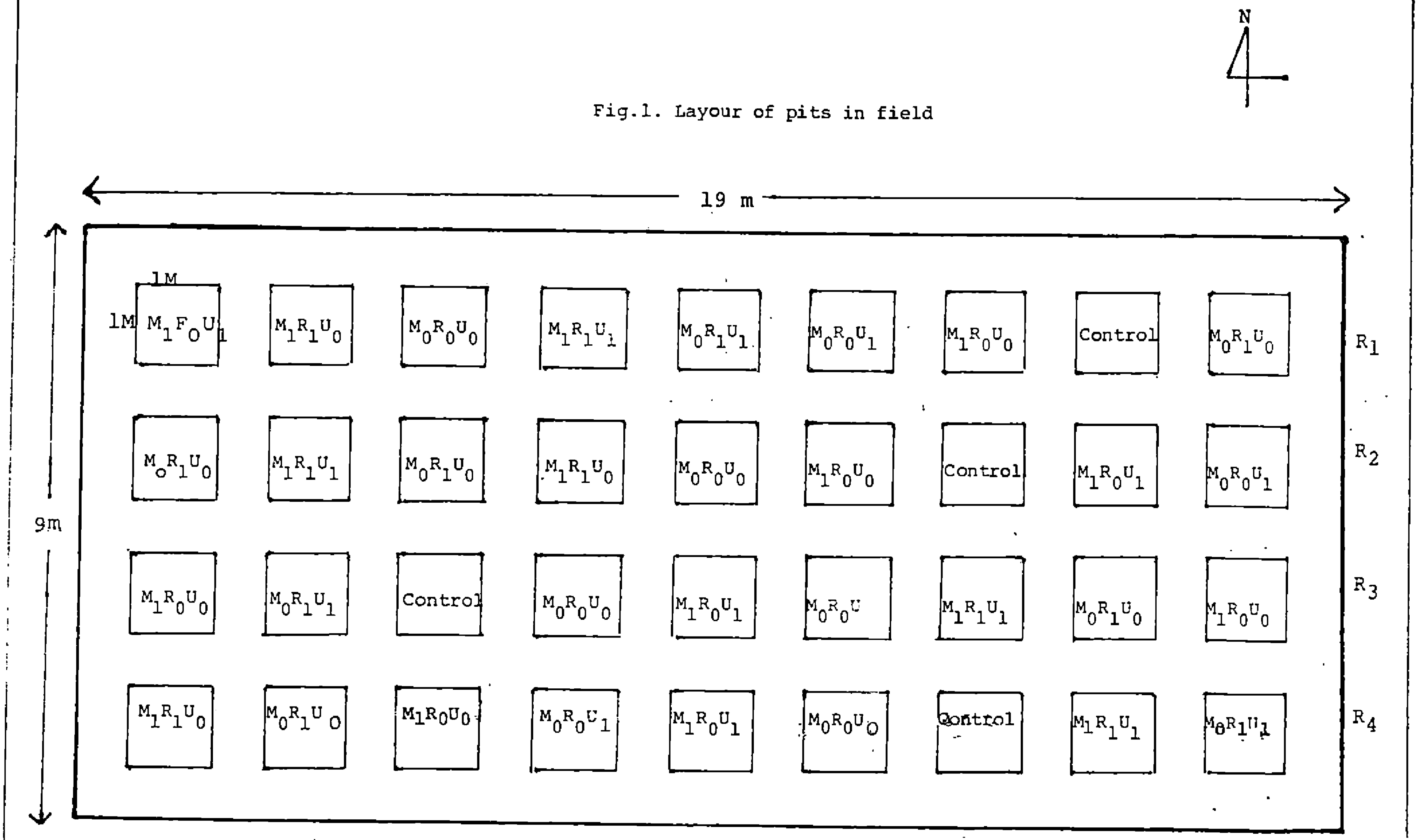
2.2. Method of soil sampling

Soil samples were collected at monthly intervals from the pits after initiating the treatments. Samples collected from three locations at a depth of 30 cm, 60 cm and 90 cm within the pits were pooled to get one composite sample for chemical analysis.

2.3. Analytical procedures

The soil samples collected were air dried, ground with a wooden mallet and passed through 2 mm sieves. The sieved samples were utilised for determining pH, organic carbon, CEC, available N, P and K at monthly intervals using the methods given in Table 1.

Fig.1. Layour of pits in field



2.4. Fractionation of soil organic matter

Fractionation of soil organic matter was carried out adopting the procedure suggested by Stevenson (1965) as indicated in the flow chart given in Appendix I.

2.4.1. Humid acid

Ten gram of the soil was refluxed with ethanol. Latter the soil was washed with the 0.1 N H_2SO_4 to remove $CaCO_3$ present in the soil. To this residue 50 ml of 0.5 N NaOH solution was added. The mixture was shaken for 12 hours on a mechanical shaker, the sides of the bottle were washed with distilled water and the mixture was centrifuged. Dark coloured supernatant liquid was filtered and the pH of the solution was adjusted to 1.0 with concentrated HCl. Additional 50 ml of 0.5N NaOH was added to soil, the content was shaken, centrifuged and filtered. The pH of the extract was adjusted to 1.0 with conc. HCl and the humic acid was allowed to settle. The supernatant liquid in the acidified extract represented the fulvic acid. This was siphoned off. The humic acid was separated by centrifuging. The purification procedure was repeated. The supernatant liquid in each case was transferred to the original acid filtrate. Humid acid was washed with distilled water until free of chloride. It was dried and ground to a fine powder. This was weighed and reported as percentage of humic acid on moisture free basis and also as percentage of organic matter.

2.4.2. Fulvic acid

The acid extract collected in the humic acid preparation was fulvic acid, a known aliquot was taken, evaporated and dried. The residue was weighed and reported as percentage of fulvic acid on moisture free basis and also as percentage of organic matter.

3. C & N determination of organic materials

The total nitrogen in the organic materials was determined by Microkjeldahl digestion and distillation method. The total carbon in the organic materials were determined by ignition method (Jackson, 1958).

4. Cellulose

The powdered plant samples were treated with acetic and nitric acid mixture to remove the easily soluble sugars. The cellulose in the residue was dehydrated to glucose in hot acidic medium and then dehydrated to hydroxy methyl furfurol, which produced green colour with the anthrone reagent. The intensity of the colour is directly proportional to cellulose content, which was measured at 630 nm by using spectrophotometer (Updegroff, 1969).

5. Lignin

The powdered plant samples were treated with 64 per cent sulphuric acid to remove the soluble sugars. The acid residue was washed with water and hot alcohol to remove resin and fats. Finally with 0.1 N KoH to make it free from cellulose.The acid free residue was weighed and expressed as percentage of lignin (Thimmaiah, 1989).

6. Statistical Analysis

Data generated on the various parameters of the experiment were analysed statistically by using the analysis of variance. In case the effects were found to be significant, critical difference was calculated for making logical comparisons between treatment means (Panse and Sukhatme, 1985).

Results and Discussion

RESULTS AND DISOUSSION

1. Incubation study

This part of the study was carried out to assess the rate of decomposition of lignin rich coirpith and glyricidia as influenced by various enrichment techniques. As described in Chapter 2, the rate of decomposition was studied at weekly intervals for six months. The cumulative evolution of CO_2 as well as the and rate of CO_2 evolution as influenced by the main, interaction and combined effects of microbe, rockphosphate and urea from the coirpith enriched soil and control at different periods of incubation is presented and discussed below.

1.1. Main effects on CO_2 evolution

The cumulative CO_2 evolution due to the effect of main factors such as microbe, rockphosphate and urea are presented in Table 3a and 3b. The analyses of variance of the data are given in Appendix II. The rate of CO_2 evolution is depicted in Fig. 2.

1.1.1. Effect of microbial incorporation on CO_2 evolution

The microbial inoculation significantly influenced the cumulative CO_2 evolution throughout the period of incubation. The microbially inoculated treatments (M_1)

Table 3a. Cumulative carbon dioxide evolution (mg/100 g of soil) as influenced by the main effects of microbe (M), rockphosphate (R) and urea (U) at different periods of incubation

Treatments	Period of incubation, days									
	2	4	6	8	16	24	32	40	48	Mean
M_0	9.98	15.51	21.23	26.00	39.63	53.09	64.35	74.03	83.36	43.03
M_1	27.76	45.70	61.30	77.81	100.78	122.71	141.79	157.50	171.56	100.77
R_0	18.87	30.10	41.06	51.68	69.91	87.64	103.48	116.72	127.72	71.80
R_1	18.88	31.12	41.48	52.14	70.49	88.15	102.64	115.01	126.40	71.81
U_0	17.02	27.52	37.35	47.41	65.71	83.54	99.02	112.60	125.40	68.40
U_1	20.73	33.70	45.19	56.41	74.69	92.25	107.11	118.89	129.43	75.38
Mean	18.87	30.61	41.27	51.91	70.20	87.90	103.07	115.75	127.45	
CD(0.05)	2.41	5.12	3.23	5.39	4.78	5.77	8.19	6.82	10.04	

M_0 - Without microbe R_0 - Without rockphosphate U_0 - Without urea

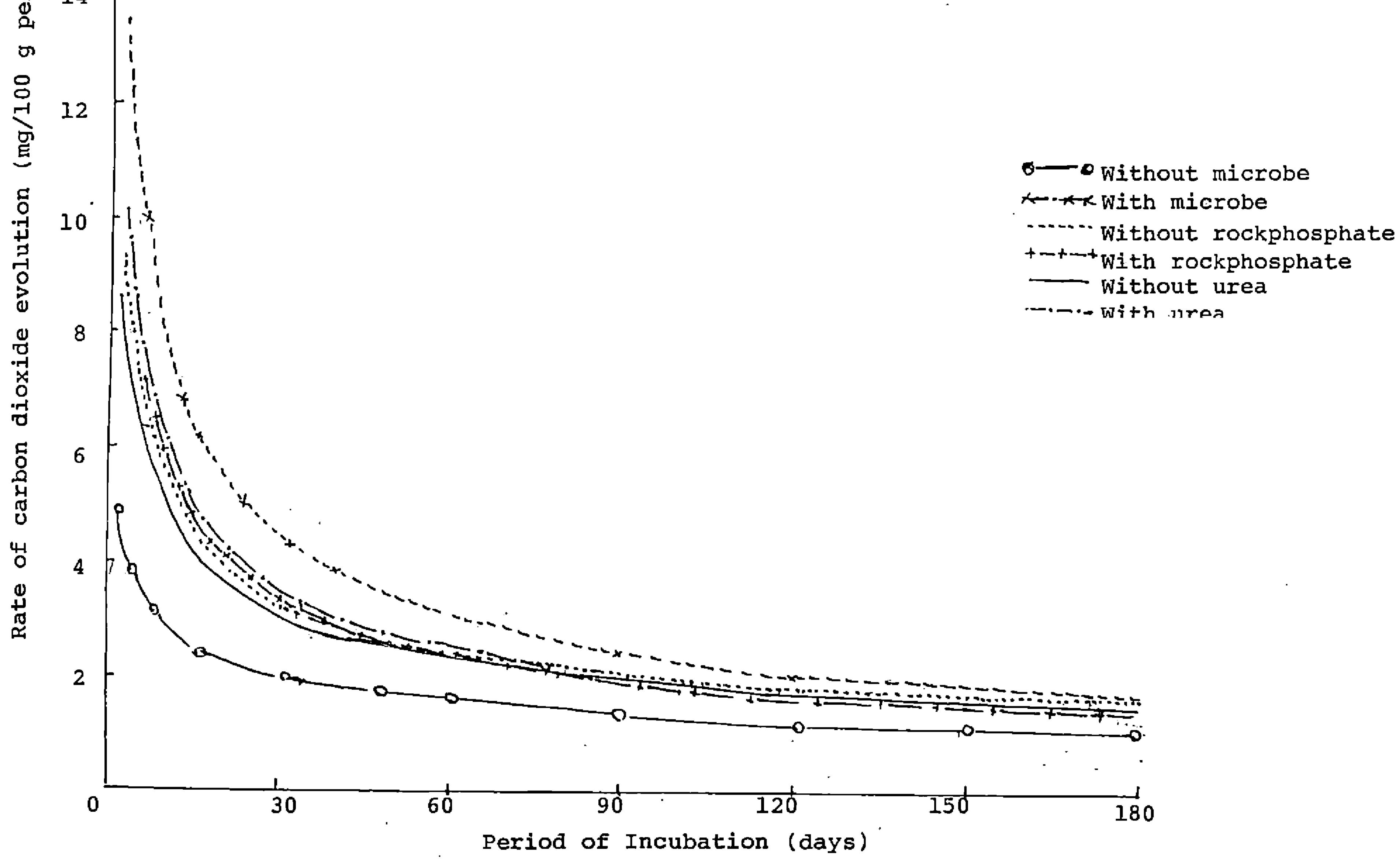
M_1 - With microbe R_1 - With rockphosphate U_1 - With urea

Table 3b. Cumulative CO_2 evolution (mg/100 g of soil) as influenced by the main effect of microbe, rock-phosphate and urea at different days of incubation

Treatments	Period of incubation, days					
	60	90	120	150	180	Mean
M_0	98.2	125.2	152.9	183.9	212.6	154.6
M_1	192.5	218.1	245.5	283.8	319.8	251.9
R_0	146.3	176.5	207.9	247.8	285.0	212.7
R_1	144.4	166.8	190.5	220.0	247.4	193.8
U_0	143.1	171.2	201.5	239.8	274.2	206.0
U_1	147.6	172.1	196.9	228.0	258.2	200.6
Mean	145.4	171.7	199.2	233.9	266.2	
CD(0.05)	12.7	15.1	11.4	31.0	40.0	

Not significant

Fig. 2. Effect of microbe, rockphosphate and urea on rate of carbon dioxide evolution



maintained significantly higher values of cumulative CO_2 evolution than the non-microbial treatments (M_0) throughout the period of incubation. The prominance of the M_1 treatment was evident even on the second day of inoculation with a value of 27.76 mg/100 g compared to 9.98 mg/100 g with M_0 (Table 3a). M_1 showed significant increase throughout the period. On 48th day it registered a value of 171.56 mg/100 g of soil as against to 83.36 mg/100 g of soil with M_0. There was only slight increase in CO_2 evolution during these periods. But M_1 was always found to be superior to M_0 (Table 3b). Initially high rate of decomposition in M_1 (13.88 mg/100 g per day) and its subsequent reduction nearing to an almost static value of around 1.70 mg/100 g per day towards the end of incubation as revealed from Fig. 2 further supported the above observed trend in cumulative CO_2 evolution.

1.1.2. Effect of rockphosphate on CO_2 evolution

The effect of rockphosphate was insignificant throughout the period of incubation on CO_2 evolution for the soil treated with coirpith except on 120th day. However, R_1 (with rockphosphate) in general showed slight superiority over R_0 (without rockphosphate) especially in the early stages of incubation. R_1 with an initial value of 18.88

attained 126.4 mg/100 g within 48th day of incubation and at the end of the experiment it showed 247.4 mg/100 g of soil. In the case of R_0 the corresponding values were 18.87, 127.72 and 285.0 mg/100 g of soil respectively (Table 3a, 3b).

Rate of CO_2 evolution was around 9.44 mg/100g per day initially and this narrowed down to about 2.6 mg/100 g per day on 48th day of incubation for both R_0 and R_1. Towards the end of the experiment the rate of CO_2 evolution was almost static and comparable with that of microbe treated plots (Fig. 2).

1.1.3. Effect of urea application on CO_2 evolution

Effect of urea on cumulative CO_2 evolution showed an almost the same trend as that of microbial inoculation. Addition of urea significantly influenced the cumulative CO_2 evolution from the soil throughout the period of incubation except on the 32nd, 40th and 48th day. The addition of urea (U_1) resulted in a cumulative CO_2 evolution of 20.73 mg/100 g on the 2nd day of incubation and 129.43 mg/100 g on 48th day. Corresponding values for U_0 were 17.02 and 125.40 mg/100 g respectively, for U_0.

The rate of CO_2 evolution was higher in U_1 during the initial stages whereas the reverse was true during the later stages. U_1 with an initial value of 10.37 mg/100 g per day positioned a static level around 2.70 mg/100 g per day on 48th day of incubation (Fig. 2). The corresponding values for U_0 were 8.51 and 2.61 mg/100 g per day respectively. (Fig.2)

1.2. Interaction effects on CO_2 evolution

The effect of two factor interaction such as microbe-rockphosphate, microbe-urea and rockphosphate-urea is presented in Table 4a and 4b. The cumulative CO_2 evolution as influenced by the three factor interaction is presented in Table 5a and 5b. The analyses of variance pertaining to the two factor and three factor effects are given in Appendix II. The rate of CO_2 evolution irrespective of period of sampling is depicted in Fig. 3 and 4.

1.2.1. Microbe-rockphosphate interaction

Microbe-rockphosphate interaction influenced the cumulative CO_2 evolution non-significantly at all the stages of incubation except on 90th, 120th, 150th and 180th day. This was revealed from the mean value of about 100 mg/100 g

Table 4a. Cumulative carbon dioxide evolution (mg/100 g of soil) as influenced by the interaction effects of microbe-rockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at different period of incubation

Treat-ments	Period of incubation, days									
	2	4	6	8	16	24	32	40	48	Mean
M_0R_0	9.96	15.20	20.82	25.40	39.50	53.32	64.88	73.93	82.14	42.79
M_0R_1	10.01	15.83	21.65	26.61	39.76	52.85	63.80	74.07	84.52	43.23
M_1R_0	27.78	45.00	61.29	77.95	100.31	121.95	142.07	159.01	174.81	100.80
M_1R_1	27.75	46.42	61.33	77.69	101.24	123.47	141.51	155.98	168.31	100.41
M_0U_0	6.83	11.42	16.65	20.77	33.95	46.90	57.72	67.43	76.69	37.26
M_0U_1	13.13	19.59	25.81	31.24	45.30	59.26	70.95	80.57	89.97	48.42
M_1U_0	27.20	43.60	58.04	74.06	97.48	120.20	140.34	157.81	174.16	99.21
M_1U_1	28.33	47.81	64.59	81.58	104.06	125.22	143.25	157.19	168.98	102.33
R_0U_0	17.10	27.62	38.88	49.22	67.90	86.26	102.79	117.24	130.18	70.80
R_0U_1	20.63	32.57	43.23	54.12	71.91	89.02	104.17	115.70	126.78	72.80
R_1U_0	16.93	27.41	35.81	45.60	63.52	80.83	95.25	107.98	120.65	65.99
R_1U_1	20.83	34.84	47.16	58.70	77.48	95.49	110.05	122.08	132.19	77.64
Mean	18.87	30.61	41.27	51.91	70.20	87.90	103.07	115.75	127.45	
CD(0.05)	3.41	NS	4.57	7.62	6.76	8.17	NS	9.64	NS	

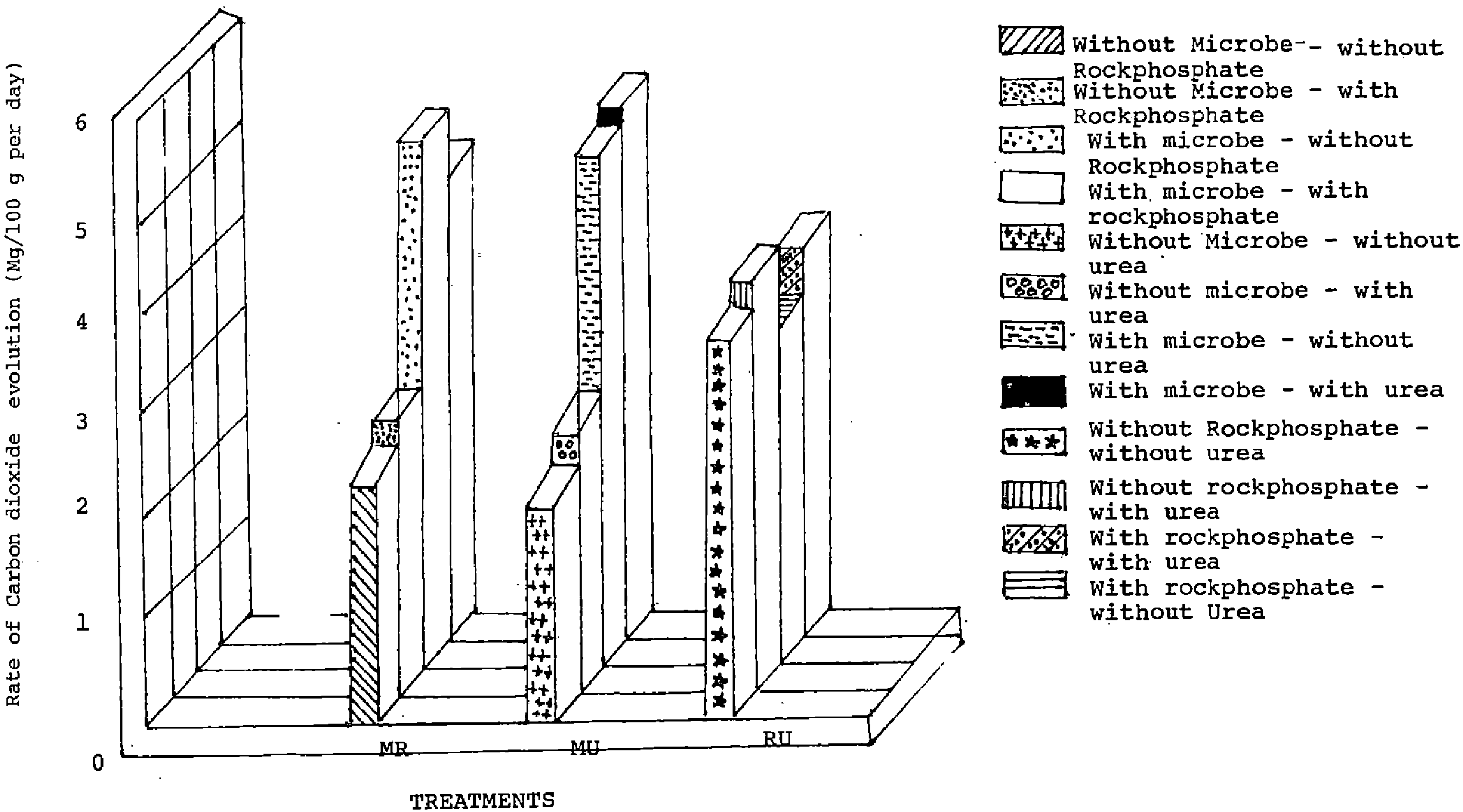
NS - Not significant

Table 4b. Cumulative CO_2 evolution (mg/100 g of soil) as influenced by the interaction effect of microbe - rockphosphate, microbe - urea and rockphosphate - urea at different days of incubation

Treatments	Period of incubation, days					
	60	90	120	150	180	Mean
M_0R_0	96.2	122.4	146.7	177.2	209.6	150.4
M_0R_1	100.3	128.0	159.2	190.0	215.6	158.8
M_1R_0	206.4	230.7	269.2	318.3	360.3	276.9
M_1R_1	188.5	205.6	222.9	249.3	279.3	229.1
M_0U_0	92.7	123.2	157.4	192.8	223.7	157.9
M_0U_1	103.8	127.2	148.5	175.1	201.5	151.2
M_1U_0	193.6	219.3	245.7	286.8	324.7	154.2
M_1U_1	191.4	216.9	246.4	280.8	314.9	250.1
R_0U_0	149.1	179.8	210.7	247.8	285.9	214.7
R_0U_1	143.6	173.2	205.1	247.7	284.1	210.7
R_1U_0	137.2	162.6	192.4	231.8	262.4	197.3
R_1U_1	151.6	170.9	188.7	208.2	232.4	190.4
Mean	145.4	171.7	199.2	233.9	266.2	
CD(0.05)	NS	21.3	16.1	43.8	56.6	

Not significant

Fig. 3. Interaction Effects of Microbe-Rockphosphate (MR), Microbe-Urea (MU) and Rockphosphate-Urea (RU) on the rate of CO_2 evolution



in microbial treatments (M_1R_0 and M_1R_1) as against to 43 mg/100 g in the non-microbial treatments (Table 4a). A sharp rise in CO_2 evolution in soil incubated with microbe was noticed from about 28 mg/100 g to around 170 mg/100 g within 48 day while in non-microbial plots these values were 10 and 80 mg/100 g respectively. This trend is also evident from the Table 4b which revealed values of 209.6 mg/100 g and 360.3 mg/100 g for M_0R_0 and M_1R_0 respectively, at the end of the experiment.

The interaction effect on rate of CO_2 evolution is shown in Fig. 3. Irrespective of the period of incubation nearly an almost three fold hike in CO_2 evolution with microbial inoculation as compared to non-inoculated ones.

1.2.2. Microbe-urea interaction

Microbe-urea interaction on cumulative CO_2 evolution was significant only on 2nd, 6th and 40th day of incubation. The treatment M_1U_1 was superior in CO_2 evolution throughout the period of incubation except on 40th and 48th day where M_1U_0 showed slight increase. However, these treatments were on par with each other during those periods. The non-microbial plots showed variation in mean values from 37.26 (M_0U_0) to 48.42 (M_0U_1) mg/100 g of soil during initial period of incubation up to 48 days (Table 4 a) whereas the variation was very high in microbial treated plots as revealed from 99.21 (M_1U_0) and 102.33 (M_1U_1) mg/100 g. At the end of the experiment also, the superiority of microbial treatment was maintained and this was about 1½ times high over the non-microbial treatments (Table 4b). The variations in the rate of CO_2 evolution (Fig. 3) were also supportive to this.

1.2.3. Rockphosphate-urea interaction

Rockphosphate-urea interaction was insignificant on CO_2 evolution throughout the period of incubation except on 8th, 16th, 24th and 40th day. The mean values of R_0U_0 varied between 70.80 mg/100 g to 214.70 mg/100 g at the end of incubation whereas these values were 77.64 and 190.40 mg/100 g respectively for R_1U_1 (Table 4a and 4b).

With regard to the rate of CO_2 evolution, the urea treatments (R_0U_1 and R_1U_1) were slightly superior to others (Fig. 3).

1.2.4. Microbe-urea-rockphosphate interaction

The mean values revealed that the three factor interaction effects were very much conspicous with the

Table 5a. Cumulative carbon dioxide evolution (mg/100 g of soil) as influenced by interaction effect of microbe-rockphosphate-urea at different periods of incubation

Treatments	Period of incubation, days									
	2	4	6	8	16	24	32	40	48	Mean
$M_0R_0U_0$	6.71	11.21	16.40	20.33	33.91	47.22	58.33	67.10	74.80	37.33
$M_0R_0U_1$	13.20	19.22	25.24	30.47	45.09	59.42	71.44	80.76	89.47	48.26
$M_0R_1U_0$	6.96	11.69	16.92	21.21	34.01	46.61	57.14	67.76	78.57	37.87
$M_0R_1U_1$	13.06	19.96	26.38	32.01	45.52	59.11	70.47	80.38	90.47	48.59
$M_1R_0U_0$	27.50	44.08	61.38	78.12	101.90	125.30	147.26	167.39	185.57	104.28
$M_1R_0U_1$	23.05	45.90	61.19	77.77	98.71	118.59	136.88	150.63	164.05	97.97
$M_1R_1U_0$	26.90	43.13	54.71	70.00	93.05	115.08	133.40	148.21	162.74	94.18
$M_1R_1U_1$	28.60	49.72	67.95	85.39	109.44	131.88	149.65	163.78	173.91	107.62
Mean	18.87	30.61	41.27	51.91	70.20	87.90	103.07	115.75	127.45	
CD (0.05)	NS	NS	NS	10.78	9.56	11.55	NS	13.64	20.08	

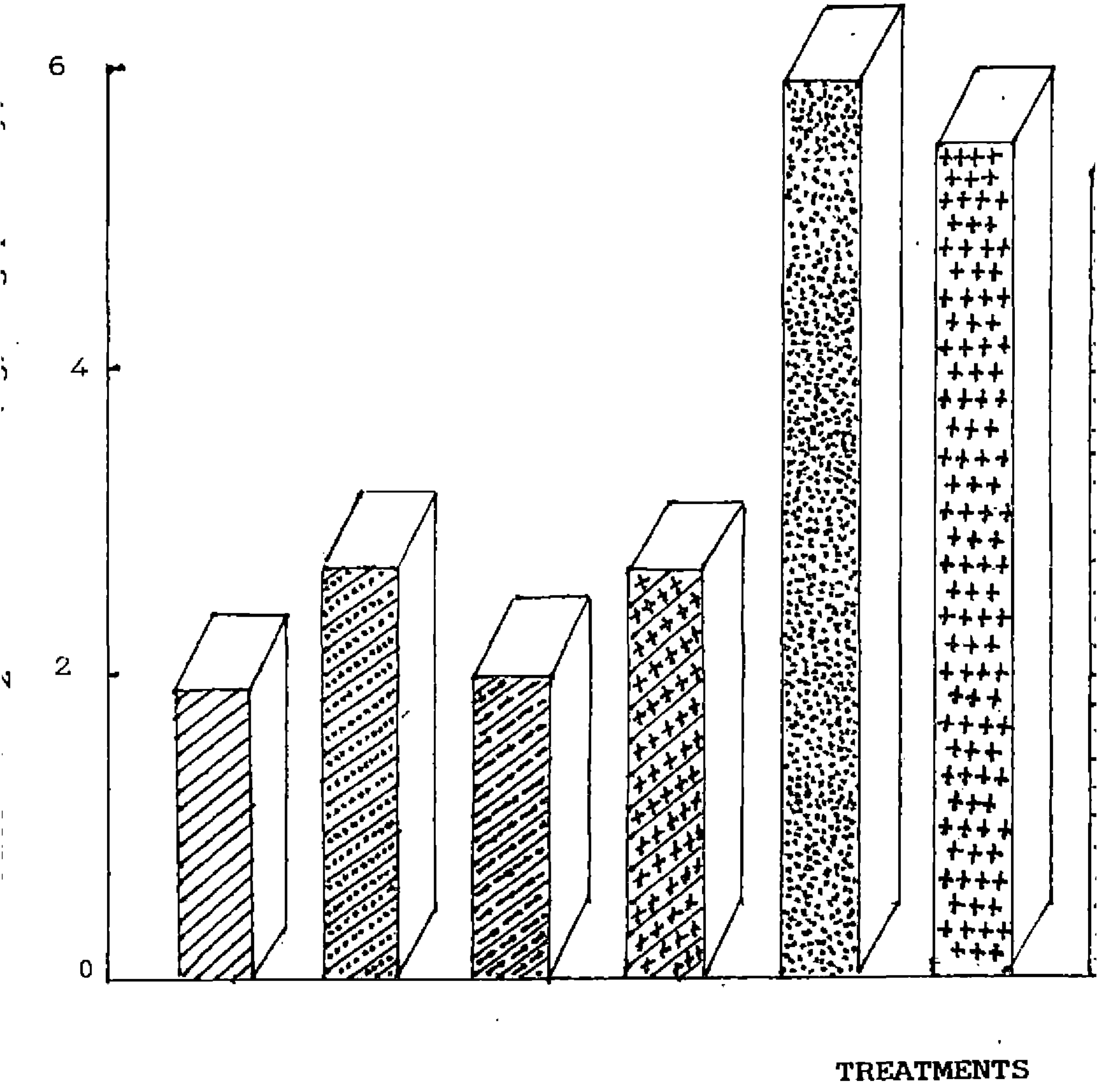
NS - Not significant

Table 5b. Cumulative CO_2 evolution (mg/100 g of soil) as influenced by the interaction effect of microbe - rockphosphate - urea at different days of incubation

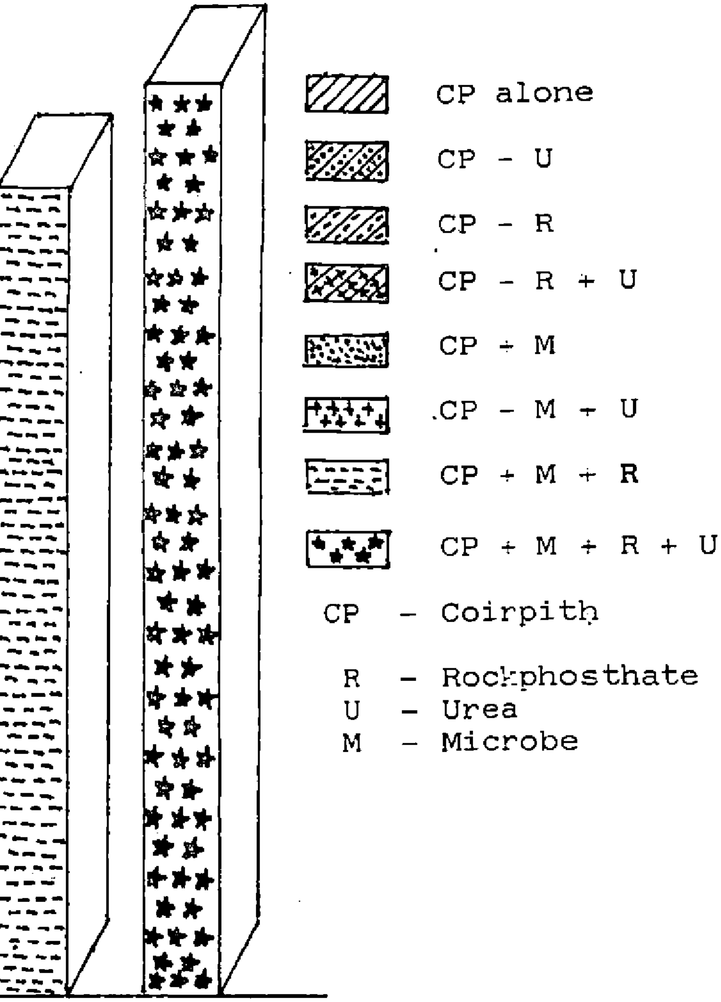
Treatments	Period of incubation, days					
	60	90	120	150	180	Mean
$M_0R_0U_0$	81.9	117.9	145.9	175.0	208.2	145.8
$M_0R_0U_1$	103.2	126.8	147.4	179.3	211.0	153.5
$M_0R_1U_0$	104.6	128.4	168.8	210.5	239.1	170.3
$M_0R_1U_1$	110.5	127.6	145.5	170.8	192.0	150.1
$M_1R_0U_0$	208.8	241.7	275.5	320.6	363.6	282.0
$M_1R_0U_1$	184.1	219.6	262.8	316.1	357.1	267.9
$M_1R_1U_0$	178.3	196.8	215.9	253.0	285.7	225.9
$M_1R_1U_1$	198.7	214.3	227.9	245.5	272.8	231.8
Mean	145.4	171.7	199.2	233.9	266.2	
CD (0.05)	NS	NS	NS	NS	NS	

Not significant

Fig.4. INTERACTION EFFECT OF MICROBE - ROCKPHOSPHATE



– UREA ON RATE OF CO_2– EVOLUTION.



presence of microbes. This was evident from the range of mean values from 37 mg/100 g to 49 mg/100 g in non-microbial treatments as compared to that of 94 mg/100 g to 108 mg/100 g with microbes during the initial phases of inoculation (Table 5a). Similarly the mean value ranged between 146 to 170 mg/100 g and 226 to 282 mg/100 g respectively, with and without microbial application at the end of the experiment (Table 5b). This superiority was detectable in a measurable way throughout the stages of the experiment also. Among the treatments $M_1R_1U_1$ was superior to others up to 48th day of incubation except on 40th and 48th day where $M_1R_0U_0$ was slightly superior. This trend was seen towards the end of incubation also as revealed from Table 5b.

The rate of CO_2 evolution (Fig. 4) also revealed similar trend as that of cumulative CO_2 evolution. All the microbe incorporated treatments exhibited a value above 10 mg/100 g per day during the initial stages which got narrowed down to around 3.5 mg/100 g per day on 48th day of incubation and an almost stablized value of around 1.5 mg/100 g per day at the end of incubation. The corresponding values for the non-microbial treatments were 4.0, 1.6 and 1.0 mg/100 g per day respectively. However, among these treatments, urea treated ones showed conspicous increase over the non-urea treated at almost all stages of incubation.

1.3. Control vs coirpith treatments on CO_2 evolution

The comparative performance of control (Glyricidia sp.) over the coirpith treatments in terms of cumulative as well as rate of CO_2 evolution is provided in Table 6 a and 6 b.

Control was significantly superior to other treatments throughout the experiments. The mean cumulative CO_2 evolution with an initial value of 29 mg/100g attained a level of 211 mg/100 g on 48th day of incubation and a peak of 556 mg/100 g at the end of experiment with respect to the control. For the rest of the treatments, this was 19, 128 and 266 mg/100 g, respectively.

The rate of CO_2 evolution also found highly pronounced over the control throughout the period of investigation.

Measurement of CO_2 evolution has been considered as the important technique to determine the activity of soil heterotrophs which determines the decomposability of soil organic matter. The data on cumulative and rate of CO_2 evolution furnished in Table 3a, 3b, 4a, 4b and 5a, 5b and Fig. 2, 3, and 4 clearly suggest that microbial inoculation

Table 6a. Cumulative carbon dioxide evoluation (mg/100 g of soil) and rate of carbon dioxide evoluation (mg/100g of soil/day)as influenced by different treatments of coirpith over control at different period of incubation

Period of incubation, days	Cumulative CO_2 evolution		CD(0.05)	Rate of CO_2 evolution	
	Control	Coirpith treated		Control	Coirpith treated
2	29.15	18.87	3.62	14.58	9.13
4	51.18	30.61	7.68	12.80	7.65
6	69.33	41.27	4.85	11.56	6.67
8	86.93	51.91	8.09	10.87	6.49
16	111.92	70.20	7.12	7.00	4.39
24	136.80	87.90	8.66	5.70	3.66
32	161.64	103.07	12.28	5.05	3.22
40	189.19	115.75	10.23	4.73	2.89
48	210.64	127.45	15.06	4.39	2.68
Mean	116.31	71.89		8.52	5.20

Table 6b. Cumulative carbon dioxide evoluation (mg/100 g of soil) and rate of Carbon dioxide evoluation (mg/100g of soil/day) as influenced by different treatments of coirpith over control at different period of incubation

Period of incubation, days	Cumulative CO_2 evolution		CD(0.05)	Rate of CO_2 evolution	
	Control	Coirpith treated		Control	Coirpith treated
60	258.05	145.36	18.98	4.61	2.51
90	346.24	171.67	22.64	3.93	1.95
120	432.48	199.24	17.06	3.60	1.66
150	501.17	233.85	46.50	3.30	1.54
180	555.93	266.20	59.99	3.02	1.45
Mean	418.77	203.26		3.69	1.82

has significantly influenced the liberation of CO_2 from the coirpith treated soil. Critical analysis of the rate of evolution of CO_2 reveals that it attains peak values during the initial stages and thereafter decreases and tends to attain equilibrium value from 48th day of incubation. Rate of organic matter decomposition shoots up due to microbial activity as soon as the energy providing organic materials are supplied to the soil (Murthy, 1984 and Patil et al., 1984).

The CO_2 evolution is considered as the measure of heterotrophic microbial activity which determine the mineralisation of soil organic matter. It is widely established (Alexander, 1978) that as soon as organic matter is added to the soil, the microbial activity increases which result in corresponding CO_2 evolution. The observed high CO_2 evolution with glyricidia and coirpith treatments is attributable to this fact (Table 6 a and 6 b).

Persistently and significantly high CO_2 evolution was observed with Glyricidia treatment (Table 6 a and 6 b). Similar results were also reported by many workers (Chakraborty and Sen, 1967; Debnath and Hajra, 1972 and Murthy, 1984). It is understood that though certain universal biochemical phenomena are involved in microbial metabolism the rapidity with which a given substrate is oxidized will depend up on its chemical composition and physical and chemical condition of the surrounding environment. Under a given set of surrounding environmental conditions, the rate of decomposability is mainly influenced by the chemical composition of the substrate especially its C-N ratio, the succulence and the lignin content (Alexander, 1978). The observed high CO_2 evolution with glyricidia can therefore be justifiable by its high content of N (3.6 per cent), a key nutrient for microbial growth. Narrow C-N ratio (13:1), and fairly good moisture content (73.2 per cent) of glyricidia are yardsticks for its succulance, juvenility and low lignification. Similarly the observed low CO_2 evolution with coirpith treatments can satisfactorily be explained with the data in Table 2 which reveal that coirpith has a wide C-N ratio of 90:1 with a moisture content of 10.84 per cent. It is known that natural materials rich in lignin are less readily utilized by microbe than lignin poor products. Therefore, comparatively low rate of decomposition of coirpith may mainly be attributted to the resistance offered by the high lignin content to microbial decay.

But the lignin rich coirpith undergoes comparatively high rate of mineralization with microbial incorporation. As revealed from 3a, 3b and Fig. 2 and 3, both cumulative and rate of CO_2 evolution assume superior position at all stages of experimentation over the non-microbial treatment. The Pleurotus sp. used in the present investigation belong to the group of white-rotting fungi which attack both lignin and cellulosic constituents and was also known for its capacity (Genterova and Lazorova, 1987 and Valmaseda et al., 1990). The observed increase in the decomposition velocity in coirpith with fungal incorporation can therefore, be attributed to lignin and cellulose degrading capacity of the fungi which ultimately brings down the resistance to microbial decomposition.

Both main and interaction effects of nitrogen enrichment (Table 3a, 3b, 4a & 4b and Fig.2) revealed overall improvement in the rate and cumulative CO_2 evolution. Similar results of organic material decomposition under supplemental nitrogen are also reported by Couture and Fortin (1983) and Murthy (1984). Nitrogen is a key nutrient substance for microbial growth and hence for organic matter breakdown. If the nitrogen content of the substrate is high, the microflora satisfies its need from this source and additional quantities of nitrogen are not necessary for their proliferation. An almost two fold increase of CO_2 evolution in the case of control treatment (Glyricidia sp.) with inherent nitrogen content of 3.6 per cent (Table 2) is reflective of this. But if the substrate is poor in nitrogen, the amendment causes increase in CO_2 evolution and a greater loss of cellulose, hemicellulose and other polysacchrides. A material like coirpith with wide C-N ratio of 90:1 and low nitrogen content of 1.03 per cent can therefore, respond to supplemental nitrogen for rapid metabolization as observed in present investigation.

The effect of rockphosphate was not significant in mineralisation of coirpith as observed in Table 3a, 3b and Fig.2. Though phosphorus is knwon for increased mineralisation of organic compounds, it may not be as important as that of nitrogen. A C-N-P ratio of 100:10:1 is suggested for better mineralization of soil organic matter. Values ranging from 229:10:0.39 to 71:10:3.05 were also found suitable (Tisdale and Nelson, 1985). Coirpith with its inherent content of 0.09 per cent of phosphorus assumes a C-N-P ratio of 89:1.03:0.09 and this may be a comfortable ratio for the observed mineralisation. The insensitiveness to added phosphorus can therefore be attributed to its incapability in bringing out any desirable shift in the critical C:N:P ratio of coirpith for mineralisation. However, phosphorus treatments in combination with other adjunctants like urea and microbe were in general, showing desirable trends in organic matter mineralisation (Table 3a, 4b, 5a and 5b). The synergetic effect of microbe-urea and microbe-rockphosphate might have favourably affected the chemical composition of organic matter and surrounding environmental condition for the coirpith mineralisation of the substrate.

With all the treatments and treatment combinations, the rate of CO_2 evolution was found the highest in the 2nd day of incubation. Appreciable changes in general were also seen up to 48th day of incubation. Thereafter, it decreased and attained an almost equilibrium values at the end of 6th month of incubation (Fig. 2). As already established (Alexander, 1978), the rate of CO_2 evolution during mineralisation of organic matter is directly and positively linked with the build up of soil heterotrophs under optimal environmental conditions. During the initial stages of incorporation of fresh organic material, there is a rapid increase in the hetero-trophic organisms which is accompanied by the evolution of large amount of CO_2. As decay proceeds, the C-N ratio narrows and the energy reserve (carbon content) diminishes. At this stage a large portion of bacteria die for want of food supply and ultimately a new equilibrium is reached (Sabey, 1983). The attainment of this equilibrium is marked by an almost steady rate of CO_2 evolution and release of mineral nitrogen as revealed from the mineralization pattern of composed coirpith. The observed reduction of CO_2 evolution after 48th day of incubation and subsequent stabilization can therefore be well comprehended in the light of above observation. As reported by Murthy (1984) for glyricidia and other green leaf manures like water hyacinth, ipomea leaves etc., the energy reserves for coirpith might have also exhausted after 48th day of incubation resulting in significant reduction in the population of soil heterotrophs and consequent CO_2 evolution.

2. Field study

As described in Chapter 2, a field experiment was set up for one year with the same treatments as that of incubation study. At monthly intervals soil samples were collected and anlysed for pH, organic carbon, CEC, available N, available P, and available K and humic fractions at the final state. The data are presented and discussed below.

2.1 Soil pH

2.1.1. Main effects

Effect of main factors such as microbial inoculation, rockphosphate and urea on soil pH are provided in Table 7.

Table 7. Soil pH as influenced by the main effects of microbe (M), rockphosphate (R) and urea (U) at different periods of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0	5.25	5.12	4.97	4.87	4.98	4.83	5.44	5.29	4.98	5.42	4.85	5.10	5.09
M_1	5.24	5.11	5.13	5.08	4.98	5.05	5.38	5.33	5.04	5.47	4.99	5.00	5.15
R_0	5.31	5.21	5.12	4.96	5.05	4.99	5.43	5.39	5.01	5.43	5.01	5.11	5.17
R_1	5.18	5.01	4.98	4.99	4.92	4.88	5.38	5.23	5.01	5.46	4.83	5.04	5.08
U_0	5.38	5.25	5.22	5.24	5.17	5.15	5.65	5.52	5.20	5.41	4.98	5.13	5.28
U_1	5.11	4.97	4.88	4.71	4.80	4.72	5.17	5.11	4.82	5.48	4.86	5.02	4.97
Mean	5.24	5.11	5.05	4.98	4.98	4.94	5.41	5.31	5.01	5.44	4.92	5.12	-
CD(0.05)	0.25	0.15	0.11	0.18	0.07	0.13	0.16	0.11	0.13	NS	0.09	0.07	

M_0 - Without microbe R_0 - Without rockphosphate U_0 - Without urea

M_1 - With microbe R_1 - With rockphosphate U_1 - with urea

NS - Not significant

The analyses of variance of the data are given in Appendix III.

2.1.1.1. Effect of microbial inoculation

In general, there was a decrease in soil pH with (M_1) and without (M_0) microbial enrichment up to 6 months. Thereafter inconsistant variations were noticed in both cases. In the first month, M_0 recorded 5.25 and M_1 5.24. But at 7th month of sampling the values were 5.38 and 5.44 for M_1 and M_0 respectively. At the end of 12th month of sampling the value registered by M_0 was 5.10 and that of M_1 was 5.00. But these variations were found to be non-significant except at 3rd, 4th, 6th and 11th months of sampling. Though there was no definite trend, over the period, the M_1 treatment recorded higher values always except 1st, 2nd, 7th and 12th months. There was only slight increase in soil pH due to microbial incorporation with coirpith treated soil.

2.1.1.2 Effect of rockphosphate

The variations in soil pH were almost the same as that of microbial inoculation for the different periods of sampling. There was also no definite trend of rise or fall in pH values over the period. However, the addition of rockphosphate favoured a significant reduction of soil pH during 2nd, 3rd, 5th, 8th, 11th and 12th months of sampling.

2.1.1.3 Effect of urea

As observed in other two cases, the values ranged between pH 5.00 to 5.50. Throughout the period of sampling, there was reduction in soil pH due to the application of urea, it was found to be significant at all stages except at 10th month of sampling. The reduction in pH due to urea application was found to be 0.2 pH units in the first stage and 0.1 pH units in the last stage.

2.1.2. Interaction effects

The data pertaining to interaction effect of microbe-rockphosphate, microbe-urea and rockphosphate-urea are furnished in Table 8 and the effect of three factor interaction of microbe-rockphosphate-urea are presented in Table 9. Analyses of variance of the data are given in Appendix III.

Table 8. Soil pH as influenced by the interaction effects of microberockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at different period of sampling

Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0R_0	5.42	5.33	5.09	4.88	5.21	4.93	5.56	5.45	5.06	5.36	4.95	5.20	5.20
M_0R_1	5.07	4.91	4.85	4.86	4.74	4.72	5.33	5.13	4.91	5.47	4.75	5.00	4.98
M_1R_0	5.21	5.10	5.15	5.04	5.88	5.06	5.31	5.33	4.97	5.49	5.06	5.01	5.22
M_1R_1	5.27	5.10	5.10	5.13	5.09	5.04	5.44	5.34	5.11	5.45	4.92	5.08	5.17
M_0U_0	5.19	5.05	5.19	5.14	5.16	5.11	5.67	5.50	5.14	5.37	4.93	5.03	5.21
M_0U_1	5.30	5.19	4.76	4.95	4.80	4.54	5.22	5.08	4.82	5.46	4.78	5.18	5.01
M_1U_0	5.21	5.46	5.24	5.34	5.18	5.21	5.63	5.54	5.26	5.46	5.04	5.23	5.32
M_1U_1	4.91	4.74	5.01	4.83	4.79	4.89	5.12	5.13	4.81	5.49	4.94	4.86	4.96
R_0U_0	5.40	5.30	5.27	5.28	5.16	5.20	5.67	5.58	5.14	5.43	5.11	5.23	5.31
R_0U_1	5.22	5.13	4.98	4.64	4.94	4.79	5.20	5.20	4.88	5.43	4.90	4.99	5.03
R_1U_0	5.35	5.21	5.16	5.21	5.18	5.12	5.63	5.46	5.26	5.39	4.85	5.03	5.24
R_1U_1	4.99	4.81	4.79	4.78	4.66	4.64	5.14	5.01	4.75	5.53	4.82	5.05	4.91
Mean	5.24	5.11	5.05	4.98	4.98	4.94	5.41	5.31	5.01	5.44	4.92	5.12	
CD(0.05)	NS	0.21	NS	NS	0.10	0.18	0.23	0.16	0.19	NS	NS	0.09	

NS - Not significant

2.1.2.1. Microbe-rockphosphate interaction

In general, the combined application of microbe-rockphosphate decreased the pH values of the soil. This was very clear at the first month of sampling where M_1R_1 recorded only 5.27 as compared to 5.42 with M_0R_0. The same trend was noticed at all sampling intervals except 3rd, 4th, 6th, 9th and 10th months where the effects were found to be non-significant, except at 9th month of sampling. At the 12th month of sampling the treatment M_0R_0 was superior to others with a pH value of 5.2. The other treatments were on par with each other.

2.1.2.2. Microbe-urea interaction

The microbial enrichment with urea also tended to decreased the pH values of the soil at almost all the periods of sampling. This effect was significant only for 2nd, 6th and 12th months of sampling where the highest values were recorded by M_1U_0 with a mean value of 5.32 and this was closely followed by M_0U_0 (5.21). The mean values registered by M_1U_1 and M_0U_1 were centered around pH 5.00.

2.1.2.3. Rockphosphate-urea interaction

With the addition of inorganics to coirpith treated soil, there was a reduction in soil pH throughout the period of sampling except on 10th month. However, the effect was found to be significant only at 5th, 9th and 12th month of sampling. The highest mean value was recorded by R_0U_0 (5.31) and the least by R_1U_1 (4.91). However, the mean value registered by R_1U_0 (5.24) was found to be higher than that of R_0U_1 with 5.03.

2.1.2.4. Effect of microbe-rockphosphate-urea interaction

The treatment effect was found to be significant only for 5th, 8th, 11th and 12th months of sampling. At the 5th month of sampling the highest value was registered by $M_1R_1U_0$ (5.25) and the least by $M_0R_1U_1$ (4.39). The same trend was not evident in other three stages where $M_1R_0U_0$ recorded the highest value. Regarding the lowest value, $M_0R_1U_1$ recorded the same for 8th and 11th and $M_1R_0U_1$ for the 12th month, respectively. However, the highest mean value was registered by $M_1R_0U_0$ (5.35) and the least by $M_0R_1U_1$ (4.82).

2.1.3. Control vs coirpith treatment

The data presented in Table 10 indicate that the effect of coirpith treatments over control were not significantly influenced the soil pH except on 3rd, 4th, 5th, 10th, 11th and 12th months of sampling. At all these stages of

Table 9. Soil pH as influenced by interaction effect of microbe-rockphosphate-urea at different periods of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
$M_0R_0U_0$	5.27	5.18	5.24	5.19	5.21	5.21	5.71	5.56	5.18	5.30	5.03	5.23	5.28
$M_0R_0U_1$	5.56	5.48	5.95	4.56	5.21	4.65	5.41	5.34	4.94	5.43	4.88	5.16	5.21
$M_0R_1U_0$	5.10	4.93	5.14	5.09	5.10	5.01	5.63	5.44	5.11	5.44	4.83	4.83	5.14
$M_0R_1U_1$	5.04	4.90	4.56	4.63	4.39	4.43	5.03	4.83	4.70	5.50	4.68	5.18	4.82
$M_1R_0U_0$	5.53	5.43	5.30	5.36	5.10	5.19	5.63	5.60	5.11	5.56	5.20	5.23	5.35
$M_1R_0U_1$	4.89	4.78	5.00	4.73	4.66	4.93	4.99	5.06	4.83	5.43	4.93	4.80	4.92
$M_1R_1U_0$	5.60	5.49	5.19	5.33	5.25	5.23	5.64	5.48	5.41	5.35	4.86	5.23	5.34
$M_1R_1U_1$	4.94	4.71	5.01	4.93	4.93	4.86	5.25	5.20	4.80	5.55	4.96	4.93	5.01
Mean	5.24	5.11	5.05	4.98	4.98	4.94	5.41	5.31	5.01	5.44	4.92	5.12	
CD(0.05)	NS	NS	NS	NS	0.15	NS	NS	0.23	NS	NS	0.17	0.13	

NS - Not significant

Table 10. Soil pH as influenced by different treatments of coirpith over control at different period of sampling

Period of sampling, months	Control	Coirpith treated	CD(0.05)
1	5.10	5.24	NS
2	4.95	5.11	NS
3	4.78	5.05	0.17
4	4.68	4.98	0.27
5	4.68	4.98	0.15
6	4.88	4.94	NS
7	5.24	5.41	NS
8	5.18	5.31	NS
9	4.95	5.01	NS
10	5.13	5.44	0.21
11	4.55	4.92	0.13
12	4.88	5.12	0.10
Mean	4.92	5.13	

Not significant

sampling, the control were found inferior in raising the values of soil pH. There was also a gradual reduction in soil pH with the advancement of period of sampling up to 6th months. Afterwards no definite trend was noticed.

The initial pH of the soil was 5.30. There was no appreciable change in pH due to the application of coirpith either with or without other adjunctants such as microbe, rockphosphate and urea. On the contrary, the addition of inorganics to coirpith in the presence or absence of microbes tended to reduce the values of soil pH as indicated in Table 8 and 9. It is also evident from Table 10 that application of glyricidia always recorded the lower values as compared to coirpith treatments. The variation in pH under the above mentioned soil adjunctants can be attributed to the microbiological decomposition of organic matter. The humus materials which possess several types of functional groups determining the intensity and quantity of soil reaction vary in composition from one situation to another. Changes in these functional groups can be possibly be compared with that of the difference in rate of decomposition of coirpith with and without inorganic and microbial adjunctants and with that of glyricidia as outlined in section 1.

High value of pH as indicated by the treatment $M_1R_0U_0$ as compared to $M_0R_0U_0$ clearly suggests that the microbial enrichment favoured a rise in pH. But this influence is only to a limited extent. The rise in pH may be accounted to the release of exchangeable cations due to the mineralisation of organic matter. But the release may be only gradual and so a major change in soil reaction cannot be expected. Mean while it may be noted that the effect of microbes on the increase of soil pH values was mostly pronounced in the absence of both urea and rockphosphate. These findings are supported by Clarson (1983), Clarson et al. (1983) and Ramaswamy and Ramulu (1983). The application of inorganic fertilizers may modify the abundance of microbe, but such alterations are frequently more on the result of acidification than the nutrient addition. According to Alexander (1978), the treatment with fertilizer containing ammmonium salts increases fungal growth because of microbial oxidation of the nitrogen leading to the formation of nitric acid. Increasing rate of fertilizer application, magnifies the stimulation and so the addition of ammonium fertilizers favours the acidic nature of soil reaction. This may be the reason for the decrease in pH of the coirpith treated soil by the application of urea. Das et al. (1991) also reported similar findings.

The foregoing discussion tends to conclude that application of lignin rich coirpith did not have any effect on soil reaction. Addition of coirpith in presence of various adjunctants favoured only slight reduction of soil pH from its original level. But a steady state of acid reaction was maintained throughout the period of sampling.

2.2. Organic carbon

2.2.1. Main effects

The effect of main factors on organic carbon content of the soil is presented in Table 11. Organic carbon content of soil as influenced by microbe, rockphosphate and urea irrespective of periods of sampling is given in Fig. 5. The statistical analyses of the data are furnished in Appendix IV.

2.2.1.1. Effect of microbial culture

With the addition of microbial culture (M_1) into coirpith; the organic carbon content of the soil was reduced throughout the period of study. Although the treatments with and without the addition of microbial culture were found to be non-significant during 4th, 6th, 8th, 9th and 12th months of sampling, there was significant variation between the same during the other periods of sampling. At

Table 11. Organic carbon (per cent) of soil as influenced by the main effects of microbe (M), rockphosphate (R) and urea (U) at different periods of sampling

Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0	0.914	0.921	0.596	0.781	0.816	0.557	0.532	0.486	0.604	0.808	0.831	0.671	0.710
M_1	0.736	0.672	0.461	0.671	0.566	0.547	0.478	0.452	0.572	0.739	0.647	0.667	0.601
R_0	0.781	0.752	0.450	0.713	0.613	0.560	0.491	0.437	0.561	0.722	0.729	0.613	0.619
R_1	0.869	0.841	0.607	0.739	0.769	0.545	0.519	0.501	0.615	0.825	0.748	0.726	0.692
U_0	0.921	0.892	0.566	0.776	0.647	0.561	0.523	0.480	0.623	0.784	0.754	0.682	0.684
U_1	0.729	0.701	0.491	0.676	0.735	0.544	0.487	0.457	0.553	0.763	0.724	0.657	0.626
Mean	0.825	0.797	0.529	0.726	0.691	0.552	0.505	0.469	0.588	0.774	0.739	0.669	
CD(0.05)	0.110	0.140	0.069	NS	0.090	NS	0.040	0.037	0.056	0.040	0.040	0.051	

M_0 - Without microbe

M_1 - With microbe

NS - Not significant

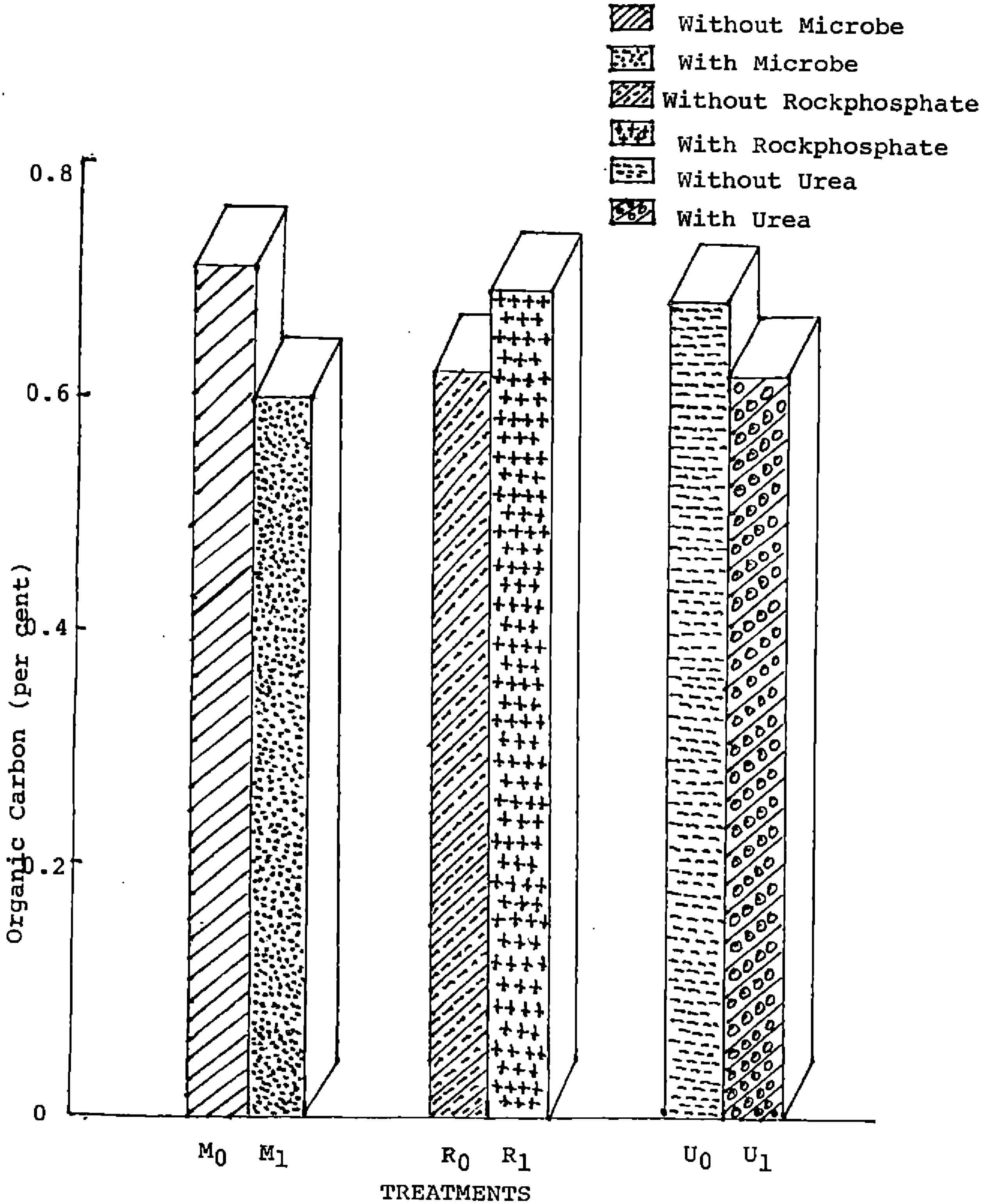
R_0 - Without rockphosphate

R_1 - With rockphosphate

U_0 - Without urea

U_1 - with urea

Fig. 5. Effect of microbe (M), Rockphosphate (R) and Urea (U) on organic carbon content of soil.



the first month of sampling the highest organic carbon content of the soil was registered by M_0 (without microbe) 0.914 per cent which was reduced to 0.736 per cent by M_1 (with microbe). The organic carbon content released under M_1 (0.461 per cent) was the least during 3rd month of sampling whereas it was 0.596 per cent under M_0.

2.2.1.2. Effect of rockphosphate addition

Addition of rockphosphate along with the coirpith increased the organic carbon content of the soil throughout the period of sampling except on 6th month. The treatments with and without the addition of rockphosphate (R_1 and R_0) were differed significantly during 3rd, 5th, 8th, 10th and 12th months of sampling. There was no significant variation between these (R_0 & R_1) treatments during the rest of months. The highest organic carbon of 0.869 per cent was observed at the first month of sampling in R_1 treatment (with rockphosphate) whereas the treatment R_0 recorded 0.781 per cent. The lowest value of 0.437 per cent organic carbon was recorded in R_0 (without rockphosphate) treatment during the 8th month of sampling and this was 0.501 per cent in R_1 due to rockphosphate application. The difference was significant.

2.2.1.3. Effect of urea application

The addition of urea did not favour the increase of organic carbon in soil. This is clearly evident from Table 11 where the U_0 treatments (without addition of urea) recorded significantly higher values of organic carbon during the 1st, 2nd, 3rd and 9th months of sampling. The organic carbon content due to the addition of urea decreased throughout the period of sampling. Though there was a slight increase in organic carbon content at 5th month of sampling, the effect was found to be non-significant. The highest value of 0.921 per cent of organic carbon recorded under U_0 treatment was reduced to 0.729 per cent under U_1 at the 1st month of sampling. The lowest value of 0.457 per cent recorded by U_1 treatment at 8th month of sampling was not significantly different from U_0 with a value of 0.480 per cent.

2.2.2. Interaction effects

The effects of two factor interaction such as microbe-rockphosphate, microbe-urea and rockphosphate-urea are presented in Table 12. The organic carbon content of the soil as influenced by the three factor interaction are presented in Table 13. The analyses of variance pertaining

Table 12. Organic carbon content(per cent) of the soil as influenced by the interaction effects of microbe-rockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at different period of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0R_0	0.872	0.905	0.502	0.706	0.840	0.550	0.502	0.435	0.533	0.784	0.904	0.626	0.680
M_0R_1	0.956	0.936	0.690	0.855	0.792	0.565	0.562	0.536	0.675	0.832	0.758	0.716	0.739
M_1R_0	0.690	0.600	0.397	0.720	0.386	0.570	0.480	0.439	0.589	0.660	0.555	0.600	0.557
M_1R_1	0.783	0.745	0.525	0.623	0.745	0.525	0.476	0.465	0.555	0.817	0.739	0.735	0.641
M_0U_0	1.111	1.159	0.679	0.843	0.756	0.584	0.577	0.503	0.660	0.817	0.900	0.680	0.772
M_0U_1	0.718	0.682	0.514	0.719	0.876	0.531	0.487	0.469	0.548	0.799	0.761	0.663	0.647
M_1U_0	0.731	0.626	0.454	0.710	0.538	0.537	0.469	0.457	0.585	0.750	0.608	0.684	0.596
M_1U_1	0.741	0.719	0.469	0.633	0.594	0.557	0.487	0.446	0.559	0.727	0.686	0.651	0.606
R_0U_0	0.875	0.809	0.476	0.795	0.546	0.574	0.521	0.461	0.593	0.720	0.742	0.580	0.641
R_0U_1	0.688	0.696	0.424	0.631	0.680	0.546	0.461	0.412	0.529	0.724	0.716	0.646	0.596
R_1U_0	0.968	0.976	0.656	0.758	0.748	0.547	0.525	0.499	0.653	0.847	0.765	0.784	0.727
R_1U_1	0.771	0.705	0.559	0.720	0.790	0.542	0.514	0.503	0.578	0.802	0.731	0.668	0.657
Mean	0.825	0.797	0.529	0.726	0.691	0.552	0.505	0.469	0.588	0.774	0.739	0.669	
CD(0.05)	0.152	0.194	0.097	NS	0.130	NS	0.056	0.046	0.079	0.056	0.056	0.073	

NS - Not significant

to the two factor and three factor interaction effects are given in Appendix IV.

2.2.2.1. Microbe-rockphosphate interaction

The interaction due to microbe-rockphosphate had no direct effect in increasing organic carbon content of the soil. Even without the addition of microbe, the treatment M_0R_1 showed significantly better performance as compared to other treatments during 8th, 9th and 10th months of sampling whereas, M_0R_0 was good in maintaining higher organic carbon status of the soil during 5th and 11th months of sampling with respective values of 0.840 and 0.904 per cent. The combined effect of microbe and rockphosphate (M_1R_1) was on par with M_0R_0 and M_0R_1 at 5th month of sampling. This trend was observed at the 10th month of sampling also. The highest organic carbon content of 0.956 per cent was recorded in M_0R_1 treatment during first month of sampling and the least organic carbon content of 0.386 per cent was observed in M_1R_0 treatment in the 5th month of sampling.

2.2.2.2. Microbe-urea interaction

There was not much benefit in improving the organic carbon status of the soil by these treatment combinations.

Similarly the high degrees of variations were noticed at 1st, 2nd, 3rd, 7th and 11th months of sampling. During all these stages M_0U_0 faired better as compared to other treatments. The highest value for organic carbon content (1.159 per cent) was found in M_0U_0 treatment at second month of sampling and the least (0.446 per cent) was noticed in M_1U_1 treatment during 8th month of sampling.

2.2.2.3. Rockphosphate-urea interaction

Only at 12th month of sampling, the interaction effect between rockphosphate and urea was found statistically significant. The treatment R_1U_0 significantly differed from others in the order $R_1U_1 > R_0U_0 > R_0U_1$ at this stage. Almost the same trend was followed at other stages of sampling with R_1U_0 maintaining the superiority in the release of organic carbon. The highest value of 0.976 per cent was recorded by R_1U_0 during 2nd month of sampling and the lowest value of 0.412 per cent at 8th month of sampling by R_0U_1.

2.2.2.4. Microbe-rockphosphate-urea interaction

The combined effect of microbe, urea and rockphosphate had no significant influence on organic carbon content of the soil at 1st month of sampling. Later during 2nd and 3rd

Table 13. Organic carbon (per cent) of soil as influenced by interaction effect of microbe-rockphosphate-urea at different periods of sampling

Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
$M_0R_0U_0$	1.060	1.027	0.532	0.732	0.688	0.575	0.555	0.450	0.563	0.735	0.903	0.567	0.701
$M_0R_0U_1$	0.685	0.782	0.472	0.680	0.992	0.525	0.450	0.420	0.503	0.832	0.877	0.685	0.659
$M_0R_1U_0$	1.162	1.290	0.825	0.953	0.825	0.593	0.600	0.555	0.758	0.900	0.870	0.792	0.844
$M_0R_1U_1$	0.750	0.582	0.555	0.757	0.760	0.538	0.525	0.518	0.593	0.765	0.645	0.640	0.636
$M_1R_0U_0$	0.690	0.590	0.420	0.857	0.405	0.572	0.487	0.472	0.623	0.705	0.555	0.593	0.581
$M_1R_0U_1$	0.690	0.610	0.375	0.582	0.367	0.567	0.472	0.405	0.555	0.615	0.555	0.607	0.533
$M_1R_1U_0$	0.773	0.662	0.487	0.563	0.670	0.502	0.450	0.442	0.548	0.795	0.660	0.775	0.606
$M_1R_1U_1$	0.793	0.828	0.563	0.683	0.820	0.547	0.502	0.487	0.563	0.840	0.817	0.695	0.678
Mean	0.825	0.797	0.529	0.726	0.691	0.552	0.505	0.469	0.588	0.774	0.739	0.669	
CD(0.05)	NS	0.280	0.138	NS	0.180	NS	NS	NS	NS	0.079	0.079	NS	

NS - Not significant

month of sampling, there was more release of organic carbon from $M_0R_1U_0$ as compared to other treatments. The same treatment was found to be on par with $M_0R_0U_1$ and $M_1R_1U_1$ at 5th, 10th and 11th months of sampling. The highest value of organic carbon of 1.290 per cent was registered by $M_0R_1U_0$ treatment during second month of sampling and the lowest value of 0.367 per cent was observed in $M_1R_0U_1$ at 5th month of sampling. The results indicated that the organic carbon content of the soil decreased progressively with the advancement of sampling periods in all the treatments.

2.2.3. Control vs coirpith treatments

The effects of coirpith treatments over control are furnished in Table 14. This effect did not show any significant difference on organic carbon content of the soil throughout the period of sampling. However, the control treatments maintained non significantly higher values of organic carbon for the 5th, 8th, 9th, 11th and 12th months of sampling. The highest organic carbon content of 0.885 per cent was recorded by coirpith treatments at the 1st month of sampling which lowered to 0.669 at the final stage of sampling. In the case of control, the content of organic carbon was 0.748 per cent and 0.730 per cent at the first and last months of sampling, respectively.

Table 14. Organic carbon content (per cent) as influenced by different treatments of coirpith over control at different period of sampling

Period of sampling, months	Control	Coirpith treated	CD(0.05)
1	0.748	0.825	NS
2	0.650	0.797	NS
3	0.525	0.529	NS
4	0.695	0.726	NS
5	0.788	0.691	NS
6	0.520	0.552	NS
7	0.472	0.505	NS
8	0.472	0.469	NS
9	0.630	0.588	NS
10	0.737	0.744	NS
11	0.762	0.739	NS
12	0.730	0.669	NS
Mean	0.644	0.653	

Not significant

In general, the organic carbon content of the soil was reduced with the advancement of period of sampling both for the control and coirpith treatments (Table 14). This might be due to the faster decomposition and mineralisation of organic matter. Similar observations were reported by Muthulakshmi (1988). As observed in Section 1 a continued slow release of CO_2 occurs soon after the disappearance of the organic residues (Glyricidia and coirpith). The decomposition of organic materials in soil leads to the synthesis of microbial tissue. But quantity of carbon in microbial tissue is usually insignificant in comparison to the amount tied up as stable humus (Stevenson 1985). In section 2.2.3, it is already observed that there is not much variation between the two sources of organic matter in the maintenance of organic carbon. This is mainly due to the fact that part of the carbon of the more easily decomposible constituents is resynthesized into microbial components that are more resistant to decomposition than the initial plant material. Nagarajan et al. (1987) also observed a slight decrease in organic carbon content of inoculated coirpith due to the reduction in volume of the ligno-cellulose material.

As revealed from section 2.2.1.1 there was reduction in organic carbon in microbial treatments (M_1) as compared to non-microbial onces (M_0). This might be due to the degradation of soil organic matter as a consequence of enhanced microbial activity (Flaig, 1984). From Fig. 5 it can be noticed that the rise and fall of organic carbon status of soil over different periods of sampling is almost the same. The increased microbial synthesis of carbon both by the native and introduced microbes may be the reason to this phenomenon. The effect of microbial inoculation is found to be very clear from the recorded lower values of organic carbon under M_1 as compared to M_0 (Table 11). Several stages can be observed in the decay of coirpith in soil. The initial phase of microbial attack is characterised by rapid loss of readily decomposable organic substances. Depending on the nature of the soil microflora and quantity of synthesized microbial cells, the amount of substrate carbon utilised for cell synthesis will vary. Since there is presence of lignin degrading fungi <u>Pleurotus</u> sp. in M_1 treatments, the decomposition of lignin to simple phenolic compounds takes places in a faster way (Alexander, 1978).

The organic carbon status of the soil is found to be slightly improved by the addition of mussorie rockphosphate (Table 11). Soil organic matter due to the added acidic coirpith might have enhanced the dissolution of rockphosphate. Mussouri rockphosphate contains calcium and so moderately reactive in laterite soil (Hammond *et al.*, 1986). So the rapid hydrolysis of organic matter by the reactive rockphosphate might have increased the organic carbon status of coirpith treated soil. There was no similar trend of improvement in the status of soil organic carbon due to the treatments, microbe-rockphosphate and rockphosphate-urea.

As described in section 2.2.1.3 the urea application to coirpith reduced the soil organic carbon status. The reason is attributed to rapid decomposition of coirpith in the presence of inorganic nitrogen as observed in section 1. So the more locking up of carbon in microbial tissue also takes place in presence of applied nitrogen (Alexander, 1978). Nambiar *et al.*(1988) also reported similar findings for a coastal sandy soil.

2.3. Cation Exchange Capacity (CEC)

2.3.1. Main effects

The effect of main factors such as microbe, rockphosphate and urea that are incorporated with coirpith are provided in Table 15. The mean effect of these factors

Table 15. Cation exchange capacity [cmol(+) kg^{-1}] of soil as influenced by the main effects of microbe (M), rockphosphate (R) and urea (U) at different periods of sampling

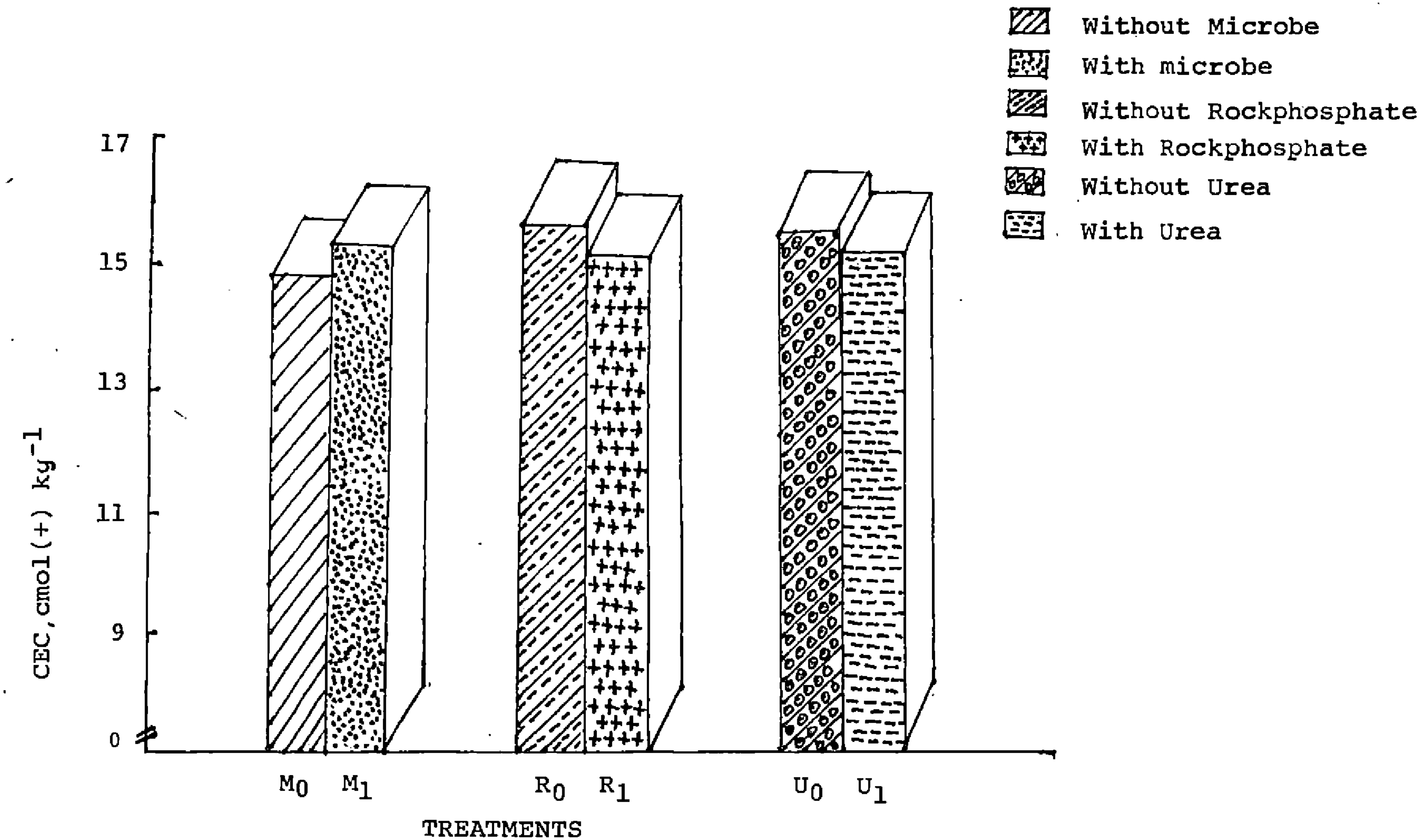
Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0	17.90	18.84	19.75	17.86	15.12	15.02	15.31	14.53	12.68	12.22	8.59	9.15	14.75
M_1	18.55	19.55	19.51	16.71	14.13	15.40	15.15	16.18	14.97	11.18	8.23	8.71	14.86
R_0	19.51	20.29	19.59	17.12	14.64	15.77	15.24	14.67	13.02	13.42	8.27	8.21	14.98
R_1	16.94	18.10	19.67	17.45	14.62	14.65	15.23	16.03	14.63	9.98	8.55	9.74	14.63
U_0	18.06	18.91	20.53	17.92	14.04	14.80	15.47	15.57	13.50	10.94	8.87	9.95	14.88
U_1	18.39	19.49	18.73	16.65	15.22	15.62	14.99	15.13	14.19	12.47	7.95	7.91	14.73
Mean	18.22	19.20	19.63	17.29	14.63	15.21	15.23	15.35	13.82	11.70	8.41	8.93	
CD(0.05)	2.40	1.90	NS	NS	NS	0.72	0.46	0.78	0.57	1.22	0.79	0.79	

M_0 - Without microbe R_0 - Without rockphosphate U_0 - Without urea

M_1 - With microbe R_1 - With rockphosphate U_1 - with urea

NS - Not significant

Fig. 6. Effect of microbe (M), Rockphosphate (R) and Urea (U) on cation exchange capacity of soil



on CEC of the soil is depicted in Fig. 6. The analyses of variance of the data are given in Appendix VI.

2.3.1.1. Microbial inoculation

The monthly variation over CEC of the soil due to microbial incorporation is presented in Table 15. Statistically significant influence of microbial inoculation on CEC of the soil was observed during 8th and 9th months of sampling. The CEC of the soil significantly increased from 14.53 and 12.68 in non-microbe treated (M_0) to 16.18 and 14.97 cmol(+) kg^{-1} in microbe treated (M_1) at 8th and 9th months of sampling respectively. In general, the values decreased with the advancement of periods of sampling from 3rd month onwards. During the initial stages of 1st, 2nd and 3rd months of sampling, the CEC values of 18.55, 19.55 and 19.51 cmol(+) kg^{-1} were recorded respectively by M_1 (microbe enriched) treatment. For the same treatment the values decreased as 8.23 and 8.71 at 11th and 12th months of sampling, respectively.

2.3.1.2. Effect of rockphosphate

As in the previous case of microbial, effect on the CEC of the soil was reduced with sampling time (Fig. 9). The effect of rockphosphate was found to be significant for almost all the periods under sampling except on the 3rd, 4th, 5th, 7th and 11th months. The CEC of the soil increased with the addition of rockphosphate at the later stages of sampling (11th and 12th months of sampling). In the initial stages of first and second month of sampling the values of CEC decreased from 19.51 (R_0) to 16.94 (R_1) and from 20.29 (R_0) to 18.10 (R_1) respectively. Anyway there was no definite trend in the changes of CEC with and without the addition of rockphosphate.

2.3.1.3. Effect of urea application

Soon after the addition of urea there was increase in CEC of the soil as the U_1 treatment recorded a value of 18.39 cmol(+) kg^{-1} as compared to 18.06 by U_0. At the final stages the corresponding values for U_1 and U_0 were 9.95 and 7.91 respectively. There is no definite trend of increase of CEC due to the addition of urea. There was a significant increase in the CEC of the soil by the addition of urea during 6th, 9th and 10th months of sampling. The CEC value reduced from 8.87 and 9.95 in U_0 treatment to 7.95 and 7.91 in U_1 treatment during 11th and 12th months of sampling, respectively. In general, the CEC values of the soil showed a decrease as the stages of sampling advanced.

2.3.2. Interaction effects

The data presented in Table 16 represent the interaction effects of microbe-rockphosphate, microbe-urea and rockphosphate-urea on CEC of the soil as influenced by coirpith treatments at different periods of sampling and the combined effect of these factors is provided in Table 17. The analyses of variance of data are provided in Appendix VI.

2.3.2.1. Microbe-rockphosphate interaction

In general, the CEC of the soil decreased with the advancement of sampling periods. The highest CEC of 21.63 cmol(+) kg^{-1} was recorded in M_1R_0 during second month while the same treatment reported the least value of 7.87 cmol(+) kg^{-1} at the 12th month of sampling. Combined application of microbe and rockphosphate (M_1R_1) was inferior to other treatments up to second month of sampling and after that it steadily increased and during 5th month of sampling, it was found to be on par with M_0R_0 and M_0R_1. At 8th and 9th month of sampling, these treatments registered higher values of 16.36 and 16.28 cmol(+) kg^{-1} respectively. They were highly superior to the other treatments.

Table 16. Cation exchange capacity [cmol(+) kg^{-1}] of the soil as influenced by the interaction effects of microbe-rockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at different period of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0R_0	18.11	18.95	18.67	19.09	15.90	15.26	15.49	13.36	12.38	14.26	8.33	8.37	14.88
M_0R_1	17.68	18.73	19.83	16.63	14.36	14.77	15.13	15.71	12.98	10.18	8.85	9.93	14.67
M_1R_0	20.91	21.63	19.50	15.15	13.39	16.27	15.00	15.99	13.66	12.58	8.21	7.87	15.01
M_1R_1	16.19	17.47	19.51	18.27	14.87	14.54	15.31	16.36	16.28	9.79	8.25	9.55	14.70
M_0U_0	17.80	18.61	21.35	18.17	14.13	14.98	15.76	14.40	12.72	11.38	8.69	10.21	14.85
M_0U_1	17.99	19.07	18.15	17.56	16.14	15.06	14.86	14.66	12.64	13.06	8.49	8.09	14.65
M_1U_0	18.31	19.20	19.70	17.67	13.96	14.62	15.17	16.75	14.28	10.50	9.06	9.70	14.91
M_1U_1	18.79	19.90	19.31	15.74	14.30	16.19	15.14	15.60	15.67	11.87	7.41	7.73	14.80
R_0U_0	18.60	19.28	20.94	17.37	14.19	15.26	16.26	14.12	12.38	13.30	8.33	8.85	14.91
R_0U_1	20.42	21.31	18.23	16.88	15.10	16.27	14.23	15.22	13.66	13.54	8.21	7.39	15.04
R_1U_0	17.51	18.53	20.11	18.47	13.90	14.33	14.67	17.03	14.61	8.57	9.41	11.05	14.85
R_1U_1	16.36	16.67	19.23	16.43	15.34	14.98	15.76	14.04	14.64	11.39	7.69	8.43	14.25
Mean	18.22	19.20	19.63	17.29	14.63	15.21	15.23	15.35	13.82	11.70	8.41	8.93	
CD(0.05)	NS	2.64	NS	2.06	1.98	NS	0.66	1.11	0.80	1.72	NS	NS	

NS - Not significant

2.3.2.2. Microbe-urea interaction

The interaction was found to be significant only during 9th month of sampling. At this stage the combined effect of microbe and urea (M_1U_1) maintained a good CEC of 15.67 cmol(+) kg^{-1} of soil as compared to other treatments in the order M_1U_0, M_0U_0, and M_0U_1, with respective values of 14.28, 12.72 and 12.64 cmol(+) kg^{-1}.

2.3.2.3. Rockphosphate-urea interaction

In the initial stages, the combined application of rockphosphate and urea (R_1U_1) slightly influenced the CEC of the soil. Significant variation between the treatments was noticed consequently for the periods of 7th, 8th, 9th and 10th months of sampling. Among these periods, only at 9th month of sampling R_1U_1 superseded the other treatments. The highest CEC value of 21.31 cmol(+) kg^{-1} was recorded by R_0U_1 treatment at second month of sampling and the same treatment registered the lowest value of 7.39 cmol(+) kg^{-1} at 12th month of sampling.

2.3.2.4. Microbe-rockphosphate-urea interaction

The data clearly indicated that the values of CEC of the soil were steady up to 10th month of sampling. There was

Table 17 Cation exchange capacity [cmol(+) kg^{-1}] of soil as influenced by interaction effect of microbe-rockphosphate-urea at different periods of sampling

Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
$M_0R_0U_0$	16.45	17.35	22.75	19.11	15.35	14.10	16.80	12.46	12.26	13.30	7.53	9.05	14.71
$M_0R_0U_1$	19.77	20.55	16.59	19.08	16.45	16.43	14.18	14.26	12.50	15.22	9.13	7.69	15.15
$M_0R_1U_0$	19.15	19.87	19.95	17.23	12.90	15.86	14.72	16.35	13.18	9.46	9.84	11.38	14.99
$M_0R_1U_1$	16.21	17.60	19.71	16.04	15.83	13.69	15.53	15.06	20.78	10.90	7.85	8.49	14.81
$M_1R_0U_0$	20.75	21.21	19.13	15.64	13.03	16.43	15.72	15.79	12.50	13.30	9.13	8.65	15.11
$M_1R_0U_1$	21.07	22.06	19.87	14.66	13.75	16.12	14.28	16.19	14.82	11.86	7.29	7.09	14.92
$M_1R_1U_0$	15.87	17.20	20.27	19.71	14.90	12.81	14.62	17.71	16.05	7.69	8.98	10.74	14.72
$M_1R_1U_1$	16.51	17.74	18.75	16.83	14.85	16.27	15.99	15.02	16.51	11.88	7.53	8.36	14.69
Mean	18.22	19.20	19.63	17.29	14.63	15.21	15.23	15.35	13.82	11.70	8.41	8.93	
CD(0.05)	NS	NS	NS	NS	NS	1.43	NS	NS	NS	2.43	1.58	NS	

NS - Not significant

sudden decrease after this period. The treatments were significant during the periods of 6th, 10th and 11th months of sampling. With regard to combined effect, the treatment $M_1R_1U_1$ registered a CEC value of 16.27 cmol(+) kg^{-1} at 6th month of sampling. For the same treatment the values of CEC reduced to 11.88 and 7.53 cmol(+) kg^{-1} during 10th and 11th months of sampling respectively.

2.3.3. Control vs coirpith treatments

The data provided in Table 18 showed that the effect of coirpith treatments over control did not differ significantly during all the sampling periods except 2nd, 6th, 7th 10th and 12th months. Except for 7th and 10th months, coirpith treatments performed better with high CEC value of the soil. For both the treatments, the highest values of CEC were registered during initial stages. The values were narrowed down at the end of sampling. For the first month of sampling the control recorded a value of 15.47 cmol(+) kg^{-1} whereas coirpith treatments, 18.22 cmol(+) kg^{-1}. But at the 12th month of sampling, the values were reduced to 7.47 and 8.93 cmol(+) kg^{-1} for control and coirpith treatments respectively.

From the results described in section 2.3.3 it is revealed that the decomposition of both glyricidia and

Table 18. Cation exchange capacity (cmol kg^{-1}) of soil as influenced by different treatments of coirpith over control at different period of sampling

Period of sampling, months	Control	Coirpith treated	CD(0.05)
1	15.47	18.22	NS
2	15.82	19.20	2.80
3	16.93	19.63	NS
4	16.10	17.29	NS
5	15.46	14.63	NS
6	11.54	15.21	1.07
7	20.67	15.23	0.70
8	16.19	15.35	NS
9	13.30	13.82	NS
10	13.76	11.70	1.82
11	7.37	8.41	NS
12	7.47	8.93	1.18
Mean	14.17	14.80	

Not significant

coirpith improves the cation exchange capacity of soil. This may be due to colloidal humic substances that may be formed during the decay of organic matter. The another possibility is that the reduction in soil pH as described in .2.1 and consequent release of cations from the soil. Organic acids produced by colonizing microorganisms may act as solubilizers of mineral matter in soil.

Biochemical compounds having chelating characteristics such as simple aliphatic acids, aminoacids and polyphenols are continuously produced in soil through the activities of microorganisms. These constituents normally have only a transitory existence as the amounts present in the soil solution at any one time will represent a balance between synthesis and destruction by micro-organisms (Stevenson, 1985). When the cations are released into the soil by the mineralisation of coirpith they may, subsequently be adsorbed by clay minerals and humic substances. As the predominant clay mineral is the kaolinite with low exchange capacity (Table 17), the cations may migrate to still lower horizons (Bear, 1976) beyond the sampling depth of soil under study. These aspects also help explain the decreased values of CEC at the end of sampling period (Table 15).

As evident from the Fig. 6 the application of inoculated coirpith resulted in the highest available calcium and magnisum which might have resulted in the increased CEC values of the soil. In the case of coirpith the content of calcium is reported as 0.84 per cent (Ravindranath, 1991). The decomposition of the coirpith will also result in the release of calcium ions into the soil. As described in section 2.3.1.1. microbial enrichment of coirpith treated soil, improved the CEC of the soil to a considerable extent. This may be due to formation of biochemical compounds having chelating characteristics which is facilitated by the introduced Pleurotus sp. (Muthulakshmi, 1988).

There is no appreciable increase in CEC of the soil due to rockphosphate addition along with coirpith (Table 15). As explained in section 1, the rate of decomposition of coirpith was less and the release of cations might have decreased due to the rockphosphate applications.

In general, with the addition of urea, there was a reduction in CEC values of the soil (Table 15). Neither the microorganisms can multiply nor the organic matter can be decomposed unless nitrogen is assimilated into microbial protoplasm. According to Romacle (1981), the fungal colonization is promoted by urea application, since the ammonium ions are the most readily assimilated nitrogen sources for most of the micro-organisms. By the urea application, the ammonium salts released in to the soil. The released NH_4^+N undergo immediate nitrification. The process of nitrification excerts a major influence on soil acidification and the leaching of calcium. So due to the application of ammoniacal fertilizer like urea, the level of calcium ions in soil will be reduced (Russell, 1973).

2.4. Available nitrogen

2.4.1. Main effects

The effects of main factors such as microbe, rockphosphate and urea on mineralization of available N content of the soil as influenced by coirpith treatments are presented in Table 19. The mean effect of these factors is shown in Fig. 7. The analyses of variance of the data are given in Appendix VI.

2.4.1.1. Microbial inoculation

In general the available nitrogen content of the soil decreased, as the sampling intervals advanced. A mean value of 244.6 and 151.3 kg ha^{-1} was recorded at 1st and 12th months of sampling, respectively. With regard to microbial

Table 19. Available nitrogen (kg ha^{-1}) content of soil as influenced by the main effects of microbe (M), rockphosphate (R) and urea (U) at different periods of sampling

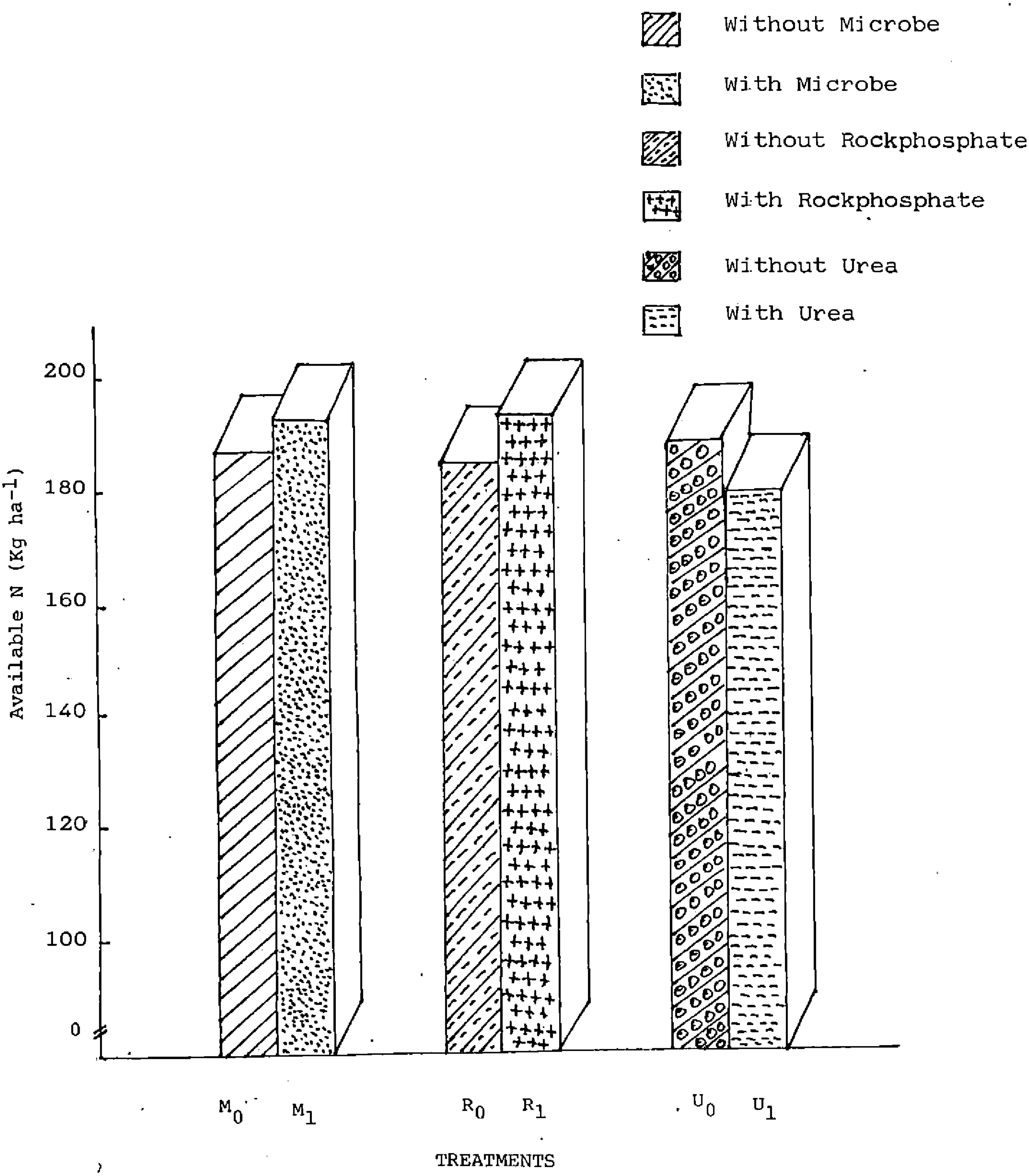
Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0	246.6	241.8	241.0	211.5	144.5	162.1	178.1	160.9	172.9	167.8	154.1	143.0	185.4
M_1	242.7	238.1	229.3	203.9	138.2	136.2	141.2	180.9	223.1	217.6	184.4	159.5	191.2
R_0	261.5	258.3	251.5	191.9	146.2	151.9	167.5	170.5	169.7	164.6	142.5	131.4	184.1
R_1	227.8	221.5	218.8	223.4	136.4	145.4	151.8	171.3	226.2	220.8	196.1	171.1	192.6
U_0	252.9	249.4	248.4	200.7	141.3	143.7	137.0	196.4	219.1	214.0	189.8	168.2	188.4
U_1	236.4	230.4	221.9	214.6	141.3	151.6	182.3	145.4	176.8	171.3	148.7	134.3	179.9
Mean	244.6	239.9	235.2	207.7	141.3	149.8	159.7	170.9	198.0	192.6	169.3	151.3	
CD(0.05)	16.1	15.2	22.8	30.6	NS	6.4	15.0	30.4	32.0	32.0	35.2	30.6	

M_0 - Without microbe
M_1 - With microbe
NS - Not significant

R_0 - Without rockphosphate
R_1 - With rockphosphate

U_0 - Without urea
U_1 - with urea

MINERALISATION OF AVAILABLE N AS INFLUENCED BY COIRPITH



addition to coirpith incorporated soil it was revealed that available N content decreased from M_0 to M_1 up to 7th months of sampling. Afterwards, a slight increase of available N in M_1 treatment was noticed as compared to M_0. On an average M_0 registered a value of 185.4 kg N ha^{-1} and M_1 191.2 kg N ha^{-1}. The decrease in available N content from M_0 to M_1 was found to be significant only in 6th and 7th months of sampling. However, the increase in available N content showed a significant variation between the treatments (M_0 and M_1) for the 9th and 10th months of sampling.

2.4.1.2. Rockphosphate addition

With the addition of rockphosphate to the soil treated with coirpith, there was no regular pattern in the increase of available N content throughout the period of study. At the onset of application the available nitrogen content decreased from 261.5(R_0) to 227.8 kg ha^{-1}(R_1). In contrast to this the available nitrogen content increased from 131.4 (R_0) to 171.1(R_1) at 12th month of sampling. However, the variations were not statistically significant on 5th and 8th months of sampling. Irrespective of the period of sampling R_0 recorded a mean value of 184.1 kg ha^{-1} and R_1 192.6 kg ha^{-1}. The maximum available nitrogen of 261.5 kg ha^{-1} and minimum of 131.4 kg ha^{-1} recorded by M_0 treatment at 1st and 12th months of sampling, respectively.

2.4.1.3. Urea application

With regards to urea application, there was no regular pattern of increase or decrease in available N content between the two treatments of U_0 and U_1 over the different periods of sampling. The variation was found to be significant for almost all the periods of sampling except 4th and 5th months of sampling. Immediately after the imposition of the treatment there was a sudden decrease in available N content of the soil from 252.9 (U_0) to 236.4 (U_1) kg ha^{-1}. The variation between U_0 and U_1 however decreased for subsequent periods of sampling. Slowly the content under U_1 increased as compared to U_0 from 4th month to 7th month of sampling onwards. But this trend was significant only for 6th and 7th months of sampling. The decrease in N content of the soil due to urea application was found to be highly significant for all the periods from 8th to 12th months of sampling. The highest available nitrogen content of 252.9 kg ha^{-1} at 1st month of sampling and the lowest of 134.3 kg ha^{-1} on 12th month of sampling were recorded.

2.4.2. Interaction effects

The interaction effects of microbe-rockphosphate, microbe-urea and rockphosphate-urea on available N content of the soil are presented in Table 20 and the interaction effects of microbe-rockphosphate-urea on available nitrogen content are provided in Table 21. The analyses of the varaince of the data are given in Appendix VI.

2.4.2.1. Microbe-rockphosphate interaction

Even without addition of microbial culture and rockphosphate (M_0R_0) the treatment maintained high values in releasing the available N content of the soil over other treatments up to 4th month of sampling. At the 4th month M_0R_1 was found to be superior by giving 248.1 kg ha^{-1} of available nitrogen. Later from 9th to 12th month of sampling M_1R_1 (microbe-rockphosphate) faired better. All these effects were found to be significant. The data revealed that with the addition of microbe and rockphosphate (M_1R_1) to the coirpith treated soil resulted in the highest available N content of 294.4 kg ha^{-1} at 9th month of sampling. The least value for N content was recorded by the same treatment at 7th month of sampling (104.7 kg ha^{-1}). However, the mean value of 202.9 kg N ha^{-1} was found to be the highest for M_1R_1 which was closely followed by M_0R_0 (188.5 kg N ha^{-1}), M_0R_1 (182.2 kg N ha^{-1}) and M_1R_0 (179.6 kg N ha^{-1}).

Table 20. Availabble nitrogen content (kg ha^{-1}) of the soil as influenced by the interaction effects of microbe-rockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at different period of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0R_0	280.5	277.1	270.6	174.9	138.8	149.0	157.3	121.9	187.8	182.6	166.2	155.8	188.5
M_0R_1	212.6	206.5	211.5	248.1	215.2	175.3	198.9	199.9	157.9	152.9	142.1	130.1	182.2
M_1R_0	242.5	239.5	232.5	208.9	153.7	156.8	177.7	219.1	151.7	146.5	118.7	106.9	179.6
M_1R_1	242.9	236.6	226.2	198.8	122.7	115.5	104.7	142.7	294.4	288.7	250.1	212.1	202.9
M_0U_0	262.9	263.1	268.3	203.5	134.1	165.1	159.7	208.2	211.3	206.2	189.4	171.1	203.6
M_0U_1	230.2	220.4	213.8	219.5	154.9	159.2	196.5	113.7	134.5	129.4	118.9	114.9	167.2
M_1U_0	242.9	235.7	228.5	198.0	148.6	122.3	114.2	184.6	227.0	221.9	190.2	165.3	189.9
M_1U_1	242.6	240.5	230.1	209.7	127.8	150.1	168.1	177.2	219.1	213.3	178.6	153.8	192.6
R_0U_0	281.2	281.4	274.0	194.1	165.0	154.9	135.4	206.6	175.2	170.1	137.7	121.9	191.5
R_0U_1	241.8	235.2	229.0	189.7	127.4	151.0	199.7	134.5	164.2	159.1	147.2	140.8	176.6
R_1U_0	124.5	217.4	222.8	207.4	117.6	132.5	138.5	186.2	263.0	257.9	241.8	241.4	202.0
R_1U_1	231.0	225.7	214.8	239.5	156.2	158.3	165.0	156.4	189.4	183.6	150.3	127.9	183.1
Mean	244.6	239.9	235.2	207.7	141.3	149.8	159.7	170.9	198.0	192.6	169.3	151.3	
CD(0.05)	22.8	21.6	32.2	42.2	NS	14.1	21.3	43.0	45.4	45.3	49.8	43.3	

NS - Not significant

2.4.2.2. Microbe-urea interaction

The interaction effects were found to be significant in all the months except 1st, 4th, 5th, 7th, 11th and 12th months of sampling. At the 1st, 2nd and 3rd months of sampling the combined effect of microbe and urea (M_1U_1) was found to be inferior to M_0U_0 treatment (without microbe and without urea). For 9th and 10th months of sampling microbial inoculation without urea (M_1U_0) showed significantly better performance compared to other treatments. However, this treatment was found to be on par with M_0U_0 and M_1U_1. The mean values recorded under M_0U_0 was highest (203.6 kg N ha^{-1}) as compared to M_1U_1 (192.6 kg N ha^{-1}), M_1U_0 (189.9 kg N ha^{-1}) and M_0U_1 (167.2 kg N ha^{-1}).

2.4.2.3. Rockphosphate-urea interaction

Interaction effect for the release of available N in soil showed that the significantly highest value was recorded by R_0U_0 treatment (281.2 kg ha^{-1}) at the first months of sampling and it was found to be superior as compared to other treatments. The same trend was noticed at the second month of sampling. Though the effects were not significant at 5th month of sampling, the treatment M_0R_0 was found to be in the first position with the highest available nitrogen content of 165.0 kg ha^{-1}. Later at 7th month of sampling, R_0U_0 was observed to be an inferior to other treatments (R_1U_0 and R_1U_1 and R_0U_1). At later stages of sampling (from 9th month of onwards) the R_1U_0 was superior to others in available N content of the soil. The least value of 117.6 kg ha^{-1} was recorded by R_1U_0 at 5th month of sampling and the highest value of 281.4 kg ha^{-1} by R_0U_0 at the second month of sampling. In general, the mean values of available nitrogen followed the order $R_1U_0 > R_0U_0 > R_1U_1 > R_0U_1$.

2.4.2.4. Microbe-rockphosphate-urea interaction

Statistically significant influence of microbe-rockphosphate-urea enrichment on available N content of the soil was observed during all the stages of sampling except 4th and 5th month of sampling. A high value of available N (333.6 kg ha^{-1}) was recorded by $M_0R_0U_0$ treatment at the second month of sampling whereas the lowest value of 42.3 kg ha^{-1} was recorded by $M_0R_1U_1$ treatment at 12th month of sampling. The combined effect of microbe, rockphosphate and urea ($M_1R_1U_1$) was found to be significantly superior in maintaining available N content of soil at 9th, 10th and 11th months of sampling, whereas the treatment $M_0R_0U_0$ was found to be significantly superior at the 1st, 2nd and 3rd months of sampling. However, the mean value recorded by

Table 21. Available nitrogen (kg ha^{-1}) of soil as influenced by interaction effect of microbe-rockphosphate-urea at different periods of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
$M_0R_0U_0$	329.7	333.6	325.4	177.2	141.9	158.8	117.4	164.6	160.7	155.5	140.5	124.1	194.1
$M_0R_0U_1$	231.4	220.5	215.8	172.5	135.6	139.2	197.3	179.2	214.8	209.7	191.9	187.5	182.9
$M_0R_1U_0$	196.2	192.6	211.3	229.7	126.2	171.4	202.0	251.7	261.9	256.8	238.3	218.0	213.0
$M_0R_1U_1$	229.1	220.3	211.7	266.6	174.1	179.2	195.8	148.2	54.1	49.1	45.9	42.3	151.4
$M_1R_0U_0$	232.8	229.2	222.7	210.9	188.2	151.0	153.4	248.5	189.7	184.6	135.0	119.7	188.8
$M_1R_0U_1$	152.2	249.9	242.3	207.0	119.2	162.7	202.0	189.7	113.7	108.4	102.5	94.1	170.3
$M_1R_1U_0$	252.9	242.2	234.4	185.0	109.0	93.6	75.1	120.7	264.2	259.2	245.4	210.3	191.0
$M_1R_1U_1$	232.9	231.0	218.0	212.5	136.4	137.4	134.3	164.6	324.6	318.1	254.7	213.5	214.8
Mean	244.6	239.9	235.2	207.7	141.3	149.8	159.7	170.9	198.0	192.6	169.3	151.3	
CD(0.05)	32.2	30.5	45.6	NS	NS	19.9	30.1	60.8	64.1	64.1	70.5	61.3	

NS - Not significant

the treatment $M_1R_1U_1$ was found to be highest and the lowest by $M_0R_1U_1$.

2.4.3. Control Vs coirpith treatments

There was statistically significant variation between the control and coirpith treatments during initial stages of sampling (1st, 2nd and 3rd months). On the later stages of sampling (from 4th month onwards) the effect of coirpith treatments did not differ significantly from control on available N content of soil. Throughout the periods of sampling the glyricidia (control) was superior in maintaining high available N content of soil with a mean value of 233.4 kg ha^{-1} as compared to 188.3 kg ha^{-1} for coirpith treatments.

Only a small fraction of the nitrogen in soil, exists in available mineral compounds at any time as NO_3^- and exchangeable NH_4^+. These mineral forms of nitrogen represent a balance between mineralization and immobilization and are affected by the activity of soil micro-organisms and C-N ratio of plant residues.

As described in section 2.4.3., the net release of available nitrogen was more under the control with the green

Table 22. Available nitrogen content (kg ha^{-1}) of soil as influenced by different treatments of coirpith over control at different period of sampling

Period of sampling, months	Control	Coirpith treated	CD(0.05)
1	311.4	244.7	24.2
2	308.3	239.9	22.9
3	302.1	235.2	34.2
4	285.0	207.7	NS
5	202.3	141.3	NS
6	179.2	149.8	NS
7	178.5	159.7	NS
8	161.6	170.9	NS
9	237.6	198.0	NS
10	232.6	192.6	NS
11	207.2	169.3	NS
12	194.7	151.3	NS
Mean	233.4	188.3	

Not significant

leaf manure, glyricidia as compared to coirpith treatments. This is mainly due to high content of nitrogen and low content of lignin in glyricidia, a just reverse condition of these constituents in coirpith (Table 2) making it C-N ratio as wide as 90:1. So there was a slow pace in the liberation of nitrogen from the coirpith.

Among the main effects, the microbial inoculation to coirpith improved the available nitrogen status of the soil. But the available nitrogen release was found to be very slow and the microbial effect was evident only from 8th month of sampling (Table 19). This progressive increase in the available nitrogen content may be due to the mineralisation of coirpith and native organic matter in the soil. Similar experiments on the release of available nitrogen by using raw as well as uninoculated coirpith conducted by Muthulakshmi (1988), Loganathan (1990) and Savithri et al. (1991) are in agreement with the present findings.

The application of rockphosphate also increased the available nitrogen content of coirpith treated soil probably due to high rate of decomposition as revealed in section 1. In this case also availability of nitrogen shot up from 8th month of sampling onwards. The immobilisation-mineralization process of nitrogen by coirpith is the main reason for this phenomenon.

With the urea application to coirpith enriched soil, the available nitrogen release was found to be gradual. Irrespective of the period of sampling, the overall release of available nitrogen due to this treatment indicated that urea addition inhibited the mineralisation. Joshi et al. (1985) also observed that blending of urea with, coirdust incorporated with coastal sandy soils of Kerala, resulted in immobilisation of nitrogen.

Regarding the interaction effects (Table 20 and 21), the combination of NP fertilizers with coirpith increased the nitrogen content to a marginal level. With the use of inoculated coirpith with NP fertilizers, there is only slight increase in available nitrogen content of soil. The results, as indicated by the mean value of available nitrogen content of soil, revealed that available nitrogen content decreased progressively during the period of incubation. The values recorded by the interaction effect of microbe-rockphosphate-urea was less than the initial status of available nitrogen in soil (250.1 kg ha^{-1}). Similar results were reported by Nambiar et al. (1988)

2.5. Available phosphorus

2.5.1. Main effects

The data pertaining to the effect of main factors such as microbe, rockphosphate and urea on available P content of the soil are presented in Table 23. The mean effect of these factors on available P is depicted in Fig. 8. The analyses of variance of data are given in Appendix VII.

2.5.1.1. Microbial incorporation

There was a general trend in increasing available P content of the soil up to 5th month of sampling and then decreased slowly from 5th month onwards. The decrease was more pronounced at the later stages of sampling. The effect of microbial inoculation was significant throughout the periods of sampling, except at 1st, 3rd and 4th months of sampling. At all other periods, there were significant variations between the two treatments (M_0 & M_1). The treatment M_0 released more amount of P than the M_1 throughout the period of sampling except at 4th month. But at the same stage the effects were found to be non-significant. The magnitude of increase from M_0 to M_1 varied between the treatments from 6.35 to 40.58 per cent. A highest value of availabe P (10.95 kg ha^{-1}) was observed in

Table 23. Available phosphorus (kg ha^{-1}) content of soil as influenced by the main effects of microbe (M), rockphosphate (R) and urea (U) at different periods of sampling

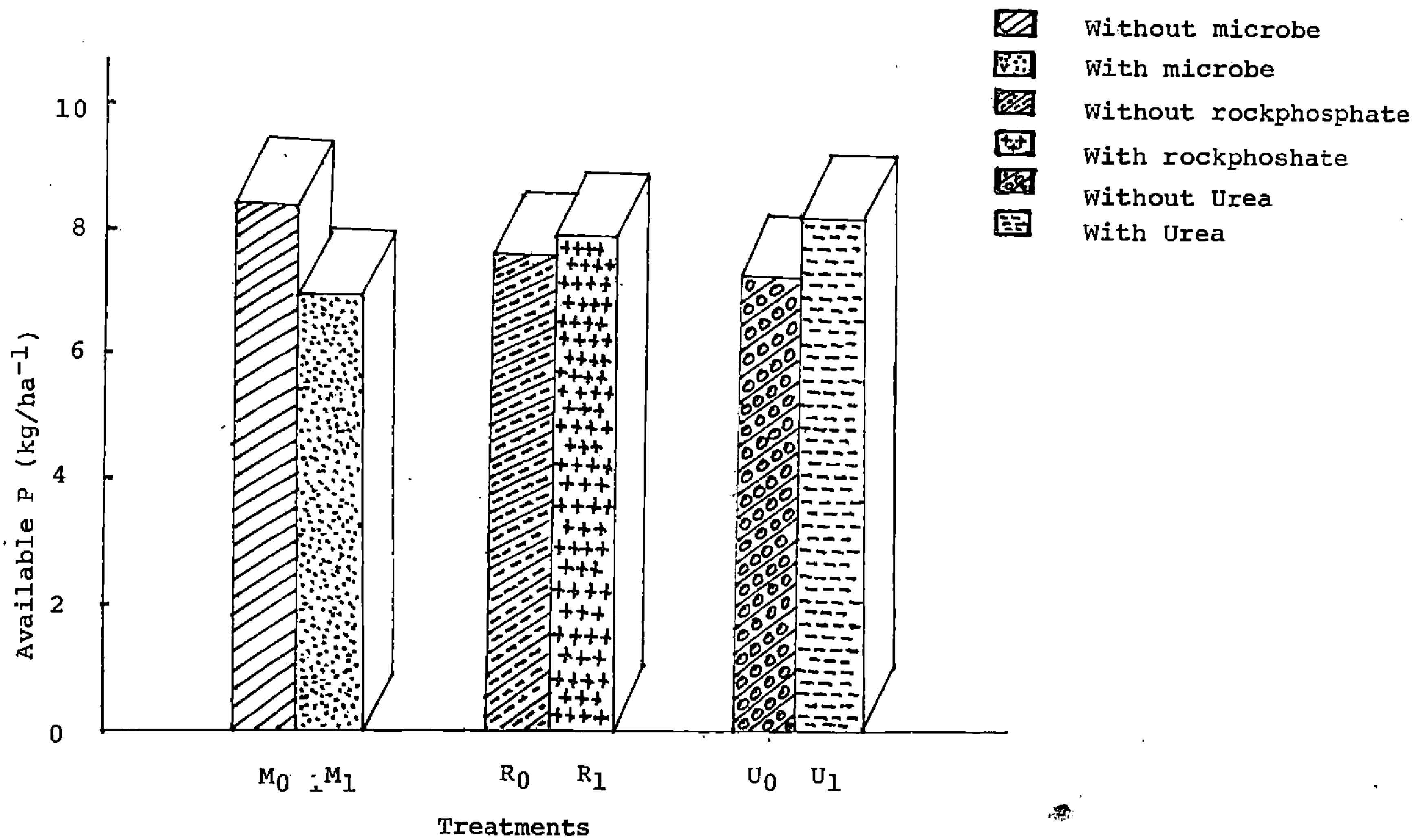
Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0	5.926	7.183	8.848	10.322	10.210	10.631	9.722	9.524	8.821	7.056	6.170	5.597	8.374
M_1	5.572	5.209	8.315	10.950	9.073	7.562	7.613	7.298	7.140	6.090	4.903	3.506	6.936
R_0	5.924	6.034	8.467	10.483	8.842	9.485	7.853	8.264	8.537	6.363	5.496	4.573	7.527
R_1	5.574	6.359	8.696	10.789	10.441	8.807	9.482	8.557	7.424	6.783	6.037	4.530	7.790
U_0	4.997	4.653	7.682	10.522	9.575	9.222	8.337	7.675	7.140	6.332	5.449	4.574	7.180
U_1	6.501	7.740	9.482	10.749	9.708	8.970	8.998	9.146	8.821	6.815	6.084	4.528	8.129
Mean	5.749	6.196	8.582	10.636	9.642	9.097	8.668	8.411	7.981	6.573	5.767	4.552	
CD(0.05)	NS	1.632	0.897	NS	0.982	0.889	0.817	1.037	1.215	0.781	0.646	0.843	

M_0 - Without microbe R_0 - Without rockphosphate U_0 - Without urea

M_1 - With microbe R_1 - With rockphosphate U_1 - with urea

NS - Not significant

Fig. 8. Effect of microbe (M), Rockphosphate (R) and Urea (U) on mineralisation of available P content of soil.



M_1 treatment at 4th month of sampling and the least value of 3.506 kg ha^{-1} was recorded by the same treatment at 12th month of sampling.

2.5.1.2. Rockphosphate application

The data presented in Table 23 indicated that there was not much improvement on the available P status of the soil due to the addition of rockphosphate. The effect of rockphosphate addition was significnat at 5th and 7th month of sampling. At 7th month of sampling R_1 treatment recorded a value of 9.482 kg ha^{-1} and R_0, 7.853 kg ha^{-1}. The highest value of 10.789 kg ha^{-1} of available P was observed in R_1 treatment at 4th month of sampling and the least value of 4.530 kg ha^{-1} was also recorded by the same treatment at 12th month of sampling.

2.5.1.3. Urea application

Addition of urea benefited the available P content of the soil. The treatment U_1 registered a higher value of available phosphorus as compared to U_0 throughout the period of sampling except 6th month. But these variations were found to be significant for 2nd, 3rd, 8th and 9th months of sampling only. The available P content of the soil under U_0

was 4.653 kg ha^{-1} which significantly increased to 7.740 under U_1 at the second month of sampling. The same trend of increase in available P content of soil was noticed at other stages also. The maximum P content was recorded at 4th month of sampling with a mean value of 10.636 kg ha^{-1} and the minimum at 12th month with a mean value of 4.552 kg ha^{-1}.

2.5.2. Interaction effects

The data provided in Table 24 shows the effect of interaction of microbe-rockphosphate, microbe-urea and rockphosphate-urea on the release of available P in soil. The effect of microbe-rockphosphate-urea iteraction on available P content of soil provided in Table 25. The analyses of variance of the data are presented in Appendix VII.

2.5.2.1. Microbe-rockphosphate interaction

The effect of microbe-rockphosphate on the available P content of the soil was significant during all except at 1st, 4th, 5th, 6th and 9th months of sampling. At the other stages of sampling, the treatment M_0R_0 maintained significantly higher values of availabe P. Both M_0R_0 and

Table 24. Available phosphorus content (kg ha^{-1}) of the soil as influenced by the interaction effects of microbe-rockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at different period of sampling

Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0R_0	7.130	7.901	10.231	10.155	9.585	10.532	9.448	10.501	9.934	8.190	7.400	6.489	8.957
M_0R_1	4.722	6.466	7.484	10.488	10.834	10.731	9.997	8.546	7.707	5.922	5.859	4.704	7.788
M_1R_0	4.718	4.168	6.722	10.810	8.099	8.239	6.258	6.027	7.139	4.536	3.591	2.656	6.080
M_1R_1	6.426	6.251	9.909	11.089	10.048	6.884	8.968	8.568	7.140	7.644	6.216	4.355	7.792
M_0U_0	4.954	5.959	7.994	9.055	9.909	10.383	9.640	8.567	7.308	7.035	6.363	6.090	7.770
M_0U_1	6.899	8.408	9.703	11.589	10.510	10.879	9.805	10.480	10.333	7.077	6.896	5.124	8.976
M_1U_0	5.040	3.346	7.369	11.990	9.241	8.062	7.035	6.783	6.972	5.628	4.536	3.079	6.590
M_1U_1	6.104	7.073	9.262	9.910	8.906	7.061	8.191	7.813	7.308	6.552	5.271	3.933	7.282
R_0U_0	4.584	4.723	8.618	11.295	8.847	10.232	6.930	7.119	6.972	5.607	4.767	4.190	6.990
R_0U_1	7.264	7.345	8.317	9.670	8.837	8.539	8.776	9.409	10.102	7.119	6.224	4.956	8.047
R_1U_0	5.410	4.583	6.745	9.749	10.303	8.212	9.745	8.231	7.308	7.056	6.132	4.959	7.369
R_1U_1	5.739	8.135	10.648	11.828	10.579	9.402	9.220	8.883	7.539	6.510	5.943	4.101	8.211
Mean	5.749	6.196	8.582	10.636	9.642	9.097	8.668	8.411	7.981	6.573	5.767	4.552	
CD(0.05)	NS	2.309	1.268	2.765	NS	1.257	1.155	1.466	1.718	1.105	0.871	1.193	

NS - Not significant

M_1R_1 were on par with the M_0R_1 at 2nd, 3rd, 7th and 10th months of sampling. Though not significant, the combined effect of microbe-rockphosphate (M_1R_1) registered highest values of available P of 11.089 kg ha^{-1} during 4th month of sampling. The treatment (M_1R_0) recorded significantly lower values of available P during almost all the periods of smapling. The least value of 2.656 kg ha^{-1} was recorded in M_1R_0 treatment during 12th month of sampling.

2.5.2.2. Microbe-urea interaction

The interaction effect of microbe-urea was significant only during 4th, 9th and 12th month of sampling. The treatment M_0U_1 was superior to others during all the periods of sampling except at 4th and 12th month of sampling. However, this treatment was on par with the M_1U_0 and M_1U_1 treatments during 4th and 12th months of sampling respectively. The treatment M_1U_0 recorded the lowest values during all the sampling months except in 4th, 5th and 6th months. A significantly higher available P content of 11.990 kg ha^{-1} was recorded in M_1U_0 treatment during 4th month of sampling. The least vlues of 3.079 kg ha^{-1} as available P was registered by the same treatment at 12th month of smapling.

2.5.2.3. Rockphosphate-urea interaction

Significant influence of rockphosphate-urea on available P content of the soil was noticed during 3rd, 6th, 7th, 9th 10th and 11th months of sampling. No specific trend was observed in the release of available P from the soil during the initial stages of sampling. However, from the 9th month to 12th months of sampling the treatment R_0U_1 was significantly superior to the other treatments. The combined application of the fertilizers (R_1U_1) released more available P in the soil from 2nd month to 6th month of sampling and the supremacy of the treatment over other treatments was found to be statistically significant at the 3rd month. The highest and the lowest values of 11.828 and 4.101 kg ha^{-1} as available P recorded in R_1U_1 treatment during the 4th and 12th months of sampling respectively.

2.5.2.4. Microbe-rockphosphate-urea interaction

The effects of microbe-rockphosphate-urea interaction on mineralisation of available P are presented in Table 25. The influence of microbe-rockphosphate-urea was significnt on the release of availabe P content of the soil mostly from 6th month onwards. The treatment $M_0R_0U_1$ was observed as a significantly superior treatment during 8th, 10th and 12th months of sampling. But it was found to be statistically on

Table 25. Available phosphorus (kg ha^{-1}) of soil as influenced by interaction effect of microbe-rockphosphate-urea at different periods of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
$M_0R_0U_0$	6.015	6.469	9.613	9.101	8.962	10.208	7.938	8.484	7.308	6.930	6.426	5.922	7.781
$M_0R_0U_1$	8.245	9.333	10.813	11.210	10.208	10.855	10.957	12.518	12.561	9.450	8.375	7.056	10.132
$M_0R_1U_0$	3.892	5.450	6.375	9.008	10.855	10.557	11.341	8.651	7.308	7.140	6.300	6.216	7.758
$M_0R_1U_1$	5.553	7.483	8.593	11.968	10.812	10.904	8.652	8.442	8.106	4.704	5.418	3.192	7.819
$M_1R_0U_0$	3.153	2.978	7.623	13.490	8.732	10.256	5.922	5.754	6.636	4.284	3.108	2.457	6.199
$M_1R_0U_1$	6.283	5.358	5.821	8.130	7.466	6.222	6.594	6.300	7.643	4.788	4.074	2.856	5.961
$M_1R_1U_0$	6.928	3.715	7.115	10.490	9.750	5.868	8.148	7.812	7.308	6.972	5.964	3.701	6.981
$M_1R_1U_1$	5.925	8.788	12.702	11.689	10.346	7.900	9.787	9.325	6.972	8.316	6.468	5.009	8.602
Mean	5.749	6.196	8.582	10.636	9.642	9.097	8.668	8.411	7.981	6.573	5.767	4.552	
CD(0.05)	NS	NS	1.793	NS	NS	1.778	1.634	2.074	NS	1.562	NS	1.687	

NS - Not significant

par with most of the other treatments at the 6th month of sampling. The treatment $M_0R_1U_1$ was superior at this stage. At the 7th month of sampling, $M_1R_1U_1$ was fouund to be on par with the $M_0R_1U_0$ and $M_0R_0U_1$ and the same trend was noticed at 10th month of sampling. From 7th month onwards the treatment $M_0R_1U_1$ did not differ from $M_1R_0U_1$. The highest available P of 13.49 kg ha^{-1} was observed in $M_1R_0U_0$ treatment at 4th month of sampling and the least availabe P of 2.475 kg ha^{-1} was recorded in $M_1R_0U_0$ treatment at 12th month of sampling period.

2.5.3. Control vs coirpith treatments

The effect of coirpith treatments over control on the available P status of the soil is provided in Table 26. The effect of availabe P was statistically significant at 3rd, 4th, 5th, 7th, 10th and 11th months of sampling. At the 3rd, 4th and 5th months of sampling the coirpith treatments was superior in maintaining higher available P status of the soil as compared to control. But at the stages of 7th, 10th and 11th months, glyricidia application was found to be good in maintaining the available P status.

The P content of decomposing organic residues has a key :ole in regulating the quantity of soluble P in the soil at

Table 26. Available phosphorus content (kg ha^{-1}) of soil as influenced by different treatments of coirpith over control at different period of sampling

Period of sampling, months	Control	Coirpith treated	CD(0.05)
1	4.354	5.749	NS
2	5.915	6.196	NS
3	7.465	8.582	1.345
4	8.686	10.636	2.933
5	6.870	9.642	1.473
6	8.500	6.097	NS
7	10.027	8.666	1.225
8	9.324	8.411	NS
9	7.098	7.981	NS
10	10.655	6.578	1.172
11	7.266	5.767	0.924
12	5.124	4.552	NS
Mean	7.607	7.405	

Not significant

any one time. In terms of P content of crop residues, net mineralization is considered to occur when the decomposing material contains more than 0.2 to 0.3 per cent P (Stevenson, 1985). As per the Table 2, the percetange of P varies from 0.34 per cent in glyricidia to 0.09 per cent in coirpith. As outlined in Section 2.5.3, at almost all the stages of sampling, there is less release of inorganic P from coirpith treatments as compared to control. Soil conditions that favour rapid decay of plant residues increase the rate of mineralization of phosphorus from added organic matter such as glyricidia and coirpith.

In general, the available phosphorus decreased due to microbial inoculation mainly by the immobilization of P for cell synthesis. The results described in section 2.5.1. and 2.5.2. indicated that the release of P tended to increase up to 5th month of sampling by the mineralisation of organic residues. The reduction in soil pH and the formation of organic acids also favoured the solubilization of fixed form of P. The production of chelating agents also enhances the P availability in soil. The further decrease in available P content of the soil (Table 23,24) may be accounted to removal of P from soil solution by adsorption to colloidal surfaces or by precipitation as in-soluble phosphates of Fe or Al.

But the application of rockphosphate favoured the release of available P in the coirpith treated soil (Table 23). The fertilizer P being an apatite form of phosphorus reduces the formation of insoluble ferric phosphate and thereby increases the available P in latosol (Mandal and Chatterjee, 1972).

The urea application also increased the available P content of the coirpith enriched soil (Table 23). This is mainly due to the increased mineralization of coirpith in the presence of urea which also generated more available P from the soil. These findings are in line with the reported works of Santhi et al. (1991).

Significant effect of microbe-rockphosphate and microbe-urea interactions (Table 24) may be due to the solubilizing nature of organic acids produced during organic matter decomposition (Loganathan, 1990 and Perumal et al. 1991). The combined application of fertilizers (R_1U_1) also released more available P in the soil (Table 24). As there are heterotrophs in soil, the addition of carbonaceous organic manures influenced their growth and activity especially when urea was blended with rockphosphate.

2.6. Available K

2.6.1. Main effects

The data furnished in Table 27 show the content of availabe K at different periods of sampling due to the influence of main factors such as microbial inoculation (M_1), rockphosphate addition(R_1) and urea enrichment (U_1). The mean effect of these factors is shown in Fig. 9. The analyses of variance of data are given in appendix VIII.

2.6.1.1. Microbial inoculation

Significant variation on the available K content of the soil was found at 6th, 10th and 12th months of sampling. At the 10th and 12th month of sampling the M_1 treatment faired better in the release of available K from the soil as compared to M_0. A reverse situation was found at the 6th month of sampling. The contents of exchangeable K decreased from 288.8 kg ha^{-1} (M_0) to 287.4 (M_1) kg ha^{-1} at the first month of sampling. In general, there was increase in available K content of the soil with a mean value of 251.3 kg ha^{-1} due to the addition of microbe (M_1) as compared to M_0 (245.6 kg ha^{-1}). The highest value was registered by M_0 at the first month of sampling as 288.8 kg ha^{-1} and the least of 160.7 kg ha^{-1} by the same treatment at 12th month

Table 27. Available potassium (kg ha^{-1}) of soil as influenced by the main effects of microbe (M), rockphosphate (R) and urea (U) at different periods of sampling

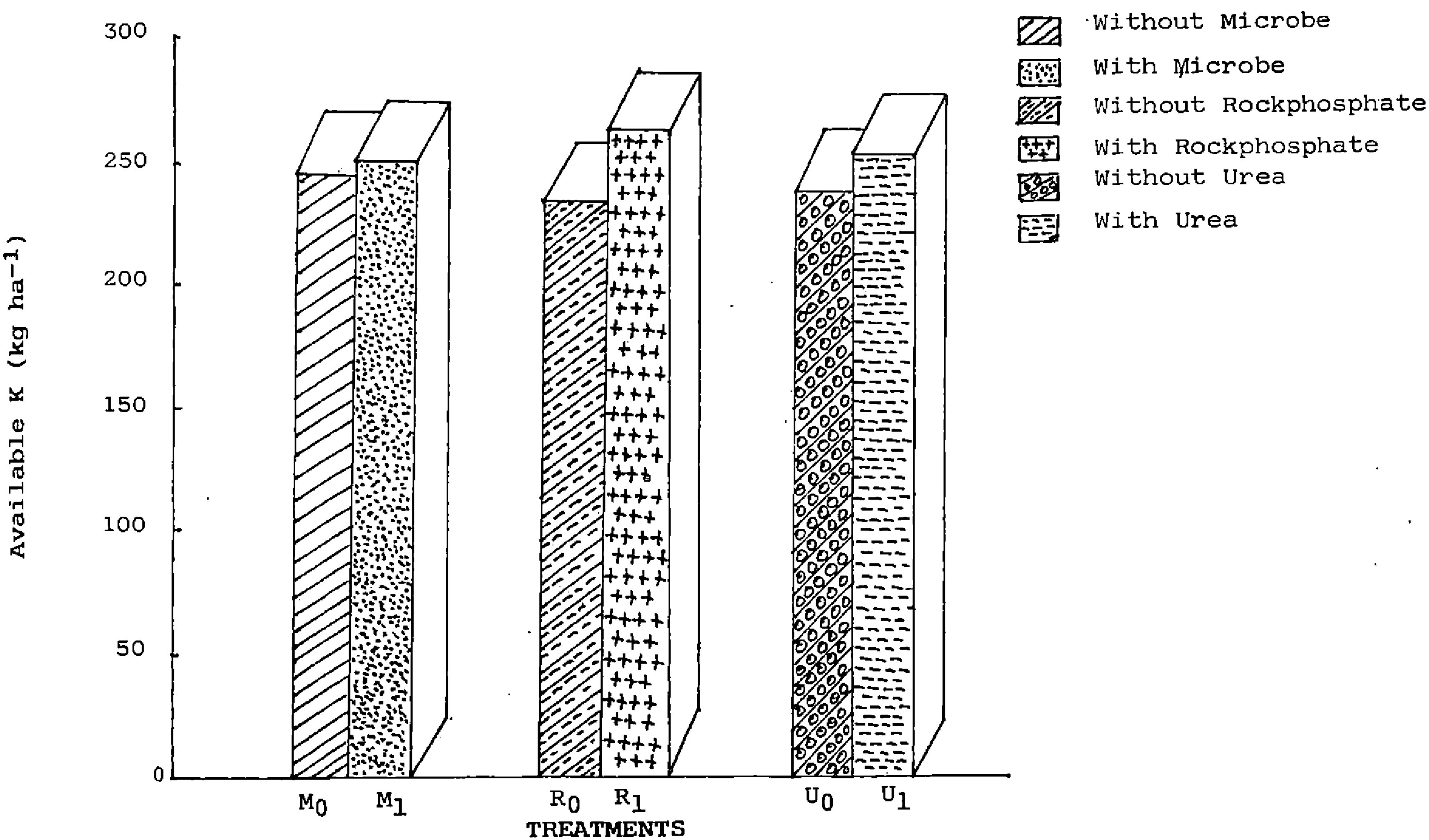
Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0	288.8	251.7	250.6	270.6	274.1	277.2	261.8	248.5	235.7	214.4	213.7	160.7	245.6
M_1	287.4	226.8	240.1	270.5	272.7	252.4	259.0	239.1	244.7	259.9	250.1	207.4	251.3
R_0	279.4	223.7	240.5	257.6	250.6	252.0	234.5	221.6	236.3	210.6	220.0	163.0	232.5
R_1	296.8	254.8	250.3	289.5	296.1	277.6	286.3	266.0	244.0	263.8	243.8	205.2	264.5
U_0	280.8	235.6	236.6	256.9	265.0	259.0	259.0	227.2	237.0	237.9	232.6	208.0	244.6
U_1	295.4	242.9	254.1	290.2	281.8	270.6	261.8	260.4	243.3	236.5	231.2	160.2	252.4
Mean	288.1	239.2	245.4	273.5	273.4	264.8	260.4	243.8	240.2	237.2	231.9	184.1	
CD(0.05)	NS	NS	NS	NS	31.8	21.5	20.0	28.4	NS	19.6	NS	22.4	

M_0 - Without microbe R_0 - Without rockphosphate U_0 - Without urea

M_1 - With microbe R_1 - With rockphosphate U_1 - with urea

NS - Not significant

Fig.9 EFFECT OF MICROBE(M), ROCKPHOSPHATE(R), & UREA (U) ON MINERALISATION OF AVAILABLE K AS INFLUENCED BY COIRPITH.



2.6.1.2. Effect of rockphosphate addition

At all the stages of sampling, the application of rockphosphate increased K content of the soil. As the period advanced, the content of mean exchangeable K in the soil was found to be decreased. Due to rockphosphate addition to coirpith, the values were increased from 250.6 to 296.1, 252.0 to 277.6, 234.5 to 286.3, 221.6 to 266.0, 210.6 to 263.8 and 163.0 to 205.2 kg ha^{-1} at the 5th, 6th, 7th, 8th, 10th and 12th months of sampling, respectively. However with the addition of rockphosphate, the available K content increased from the mean value of 232.5 kg ha^{-1} to 264.5 kg ha^{-1}. The highest available K content was recorded by R_1 at the first month of sampling as 296.8 kg ha^{-1}. The least value was recorded by R_0 at the 12th month of sampling (163.0 kg ha^{-1}).

2.6.1.3. Effect of urea enrichment

With the addition of urea, the release of available K from the soil increased up to 10th month of sampling. But the variations were found to be significant only for 8th and 12th month of sampling. A significant reduction of available K from 208.0 to 160.2 kg ha^{-1} was noticed at 12th month of sampling. The same trend was noticed at the 10th month also. The initial exchangeable K in experimental soil was only 210.3 kg ha^{-1}. In general, with the addition of urea the available K content of the soil was increased from the mean value of 244.6 (U_0) to 252.4 kg ha^{-1} (U_1). However, the highest value of 295.4 kg ha^{-1} was registered by U_1 at the first month of sampling and the least value of 160.2 kg ha^{-1} was recorded by the same treatment at the 12th month of sampling.

2.6.2. Interaction effects

The interaction effects of two factors such as microbe-rockphosphate, microbe-urea and rockphosphate-urea are presented in Table 28 and the three factor interaction of microbe-rockphosphate-urea is presented in Table 29. The analyses of variance of date are presented in Appendix VIII.

2.6.2.1. Microbe-rockphosphate interaction

The interaction effects were significant only at the 12th month of sampling. At this stage the treatment M_0R_0 recorded the least value of 120.6 kg ha^{-1} and all other treatments were on par with each other. The same treatment invariably registered comparatively lower values of available K in the soil throughout the period of sampling. However, the highest value of 306.6 kg ha^{-1} of

Table 28. Available potassium content (kg ha^{-1}) of soil as influenced by the interaction effects of microbe-rockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at different period of sampling

Treatments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
M_0R_0	273.0	243.6	251.3	245.7	262.5	266.7	237.3	228.2	227.7	195.5	203.2	120.6	229.6
M_0R_1	304.5	259.7	249.9	295.4	285.6	287.7	286.3	268.8	243.8	233.3	224.2	200.9	289.0
M_1R_0	285.7	203.7	229.6	269.5	238.7	237.3	231.7	214.9	245.0	225.6	236.8	205.3	235.3
M_1R_1	289.1	249.9	250.6	283.5	306.6	267.4	286.3	263.2	244.3	294.4	263.4	209.5	267.3
M_0U_0	267.4	235.2	232.4	249.2	249.2	274.4	259.1	229.6	224.2	233.7	189.2	179.2	235.2
M_0U_1	310.1	268.1	268.8	291.9	298.9	280.0	263.9	267.4	247.3	222.1	238.2	142.3	266.6
M_1U_0	294.1	235.9	240.8	264.6	280.7	243.6	258.3	224.7	249.9	269.0	276.0	236.8	256.2
M_1U_1	280.7	217.7	239.4	288.4	264.6	261.1	259.7	253.4	239.4	250.0	224.2	178.0	246.4
R_0U_0	285.0	214.2	224.0	228.9	244.3	235.9	214.2	196.7	239.4	185.7	186.4	164.7	215.0
R_0U_1	273.7	233.1	255.9	286.3	256.9	268.1	254.8	246.4	234.3	235.4	253.6	161.2	246.6
R_1U_0	276.5	256.9	249.2	284.9	285.6	282.1	303.8	257.6	234.7	290.0	278.8	251.3	270.9
R_1U_1	317.1	252.7	251.3	294.3	306.6	273.0	268.8	274.4	253.4	237.5	208.8	254.1	266.4
Mean	288.1	239.2	245.4	273.5	273.4	264.8	260.4	243.8	240.2	237.2	231.9	284.1	
CD(0.05)	NS	NS	NS	NS	NS	NS	28.3	NS	NS	27.7	63.2	31.7	

NS - Not significant

available K was recorded by M_1R_1 and the least value of 120.60 kg ha^{-1} by M_0R_0 at 5th and 12th month of sampling respectively. Irrespctive of the period of sampling M_0R_1 recorded the mean value of 289.0 kg ha^{-1} of available K in the soil followed by M_1R_1 (267.3 kg ha^{-1}), M_1R_0 (235.3 kg ha^{-1}) and M_0R_0 (229.6 kg ha^{-1}).

2.6.2.2. Microbe-urea interaction

Only at the 11th month of sampling, the effect of this interaction was found significant. Treatment M_1U_0 recorded the highest value of 276.0 kg ha^{-1} available K and the least of 189.2 kg ha^{-1} by M_0U_0 at this stage of sampling. The other treatments M_1U_1 and M_0U_1 were on par with each other. Among the different stages of sampling, the highest available K content in the soil was registered by M_0U_1 at the first month of sampling (310.1 kg ha^{-1}) and the least of 142.3 kg ha^{-1} by the same treatment at the 12th month of sampling.

2.6.2.3. Urea-rockphosphate interaction

At the 7th, 10th, 11th and 12th months of sampling, the interaction between urea and rockphosphate was found to be significant. Except at 12 month, the treatments followed the same trend with R_1U_0 registering the highest value and

R_0U_0 the lowest. The other treatments R_1U_1 and R_0U_1 were on par with each other. The maximum mean value was also recorded by R_1U_0 and the minimum by R_0U_0. However, the highest value of 317.1 kg ha^{-1} recorded at the first month by R_1U_1 treatment and the least value of 161.2 kg ha^{-1} by R_0U_1.

2.6.2.4. Microbe-rockphosphate-urea interaction

The effects were found to be significant at 6th, 7th, 10th, 11th and 12th months of sampling. Among the coirpith treated plots $M_1R_1U_0$ recorded the highest K status with the maximum of 362.8 kg ha^{-1} at 10th month of sampling. The lowest value of 96.8 kg ha^{-1} was recorded by $M_0R_0U_1$ treatment at 12th month of sampling. However, the maximum mean value was recorded by $M_1R_1U_0$ (299.4 kg ha^{-1}) and the minimum by $M_1R_0U_0$ (213.0 kg ha^{-1}). In the release of available K, the treatment $M_1R_1U_0$ maintained the supremacy over the other treatments at the 7th, 10th, 11th and 12th months of sampling.

2.6.3. Control vs coirpith treatments

The data provided in Table 30 showed th

coirpith treatments over control. The effect was

Table 29. Available potassium (kg ha^{-1}) of soil as influenced by interaction effect of microbe-rockphosphate-urea at different periods of sampling

Treat-ments	Period of sampling, months												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
$M_0R_0U_0$	268.8	238.0	239.4	228.2	246.4	273.0	231.0	212.8	229.6	196.2	175.2	144.4	233.6
$M_0R_0U_1$	277.2	249.2	263.2	263.2	278.6	260.4	243.7	243.6	225.7	194.8	231.2	96.8	235.6
$M_0R_1U_0$	266.0	232.4	225.4	270.2	252.0	275.8	288.4	246.4	218.7	217.2	203.2	213.9	242.5
$M_0R_1U_1$	343.0	287.0	274.4	320.6	319.2	299.6	284.2	291.2	268.8	249.4	245.2	187.8	280.9
$M_1R_0U_0$	301.3	190.4	208.6	229.6	242.2	198.8	197.4	180.60	249.2	175.2	197.6	185.0	213.0
$M_1R_0U_1$	270.2	217.0	250.6	309.4	235.2	275.8	266.0	249.2	240.8	276.0	276.0	225.6	257.7
$M_1R_1U_0$	287.0	281.4	273.0	299.6	319.2	288.4	319.2	268.8	250.6	362.8	354.4	288.6	299.4
$M_1R_1U_1$	291.2	218.4	228.2	267.4	294.0	246.4	253.4	257.6	238.0	225.6	172.4	130.4	235.3
Mean	288.1	239.2	245.4	273.5	273.4	264.8	260.4	243.8	240.2	237.2	231.9	184.1	
CD(0.05)	NS	NS	NS	NS	NS	53.0	40.0	NS	NS	39.2	89.3	44.8	

NS - Not significant

Table 30. Available pota ssium content (kg ha^{-1}) of soil as influenced by different treatments of coirpith over control at different period of sampling

Period of sampling, months	Control	Coirpith treated	CD(0.05)
1	327.6	288.1	NS
2	348.6	239.2	66.2
3	397.6	245.4	53.8
4	288.4	273.5	NS
5	253.4	273.4	NS
6	359.8	264.8	39.3
7	277.2	260.4	NS
8	291.2	243.8	42.7
9	296.0	240.2	47.7
10	298.4	237.2	29.4
11	269.0	231.9	NS
12	259.8	184.1	NS
Mean	305.6	248.5	

Not significant

significant at 2nd, 3rd, 6th, 8th, 9th and 10th months of sampling. At these stages the control was superior to coirpith treated. The effects were found to be on par with each other in the other stages of sampling. However, throughout the period of sampling, the control treatment was superior to coirpith treatments. The maximum value was recorded by the control at the third month of sampling (397.6 kg ha^{-1}) and the minimum of 184.1 kg ha^{-1} by the coirpith treatments at the 12th month of sampling.

The results presented in the preceding section 2.6.3. showed that there was more available K contents of the soil in glyricidia treated plots as comparated to coirpith treatments at all the stages of sampling. This is mainly due to the fact that the K content in glyricidia and coirpith are 2.2 and 1.2 per cent respectively (Table 2). The increased mineralisation of organic residues as described in section 1. might have increased the K availability in the soil with periods of sampling. The initial available K status was only 210.3 kg ha^{-1} (Table 1). As compared to this, the available K status of the soil was high during almost all the sampling periods. A rise in K status of soil was also noticed at the initial stages of sampling especially in the glyricidia treated plots due to increase in the mineralisation. The subsequent reduction in the available K content of the soil may be due to the formation of sparingly soluble salts with Fe at low pH as pointed out by Das et al. (1991). As discussed in Section 2.1.3, the pH of the soil was less in both the treatments when organic materials were incorporated (Table 10).

As outlined in section 2.6.1 all the main effects such as microbe, rockphosphate and urea improved the available K status of the coirpith treated soil (Table 27 and Fig. 9). The effect due to the rockphosphate addition was comparatively more than that due to microbial inoculation and urea addition. All these techniques favoured the mineralisation of coirpith as discussed in section 1.1. The high rate of mineralisation at the initial stages of sampling also substantiate these findings.

Section 2.6.1.1 reflected that the microbial effect influenced the increase in K status of the soil only slightly. This may be due to the microbial immobilisation of K as noticed by Muthulakshmi et al. (1988).

Due to rockphosphate addition, the available K status of the soil was much improved as shown in Fig. 9. This can also be attributed to the increased mineralisation of coirpith. These findings are in conformity with the results of Clarson (1983) and Clarson et al. (1983).

Urea addition also offered the same effect on available K contents of the soil mainly because of the increased mineralisation rate of coirpith. As indicated in Table 2, the K status of raw coirpith was 1.2 per cent. Nagarajan *et al.* (1990) observed increased potassium content in the soil by the application of coirpith with nitrogen.

2.7. Humic and Fulvic acid content

2.7.1. Main effects

Data on the distribution of humic and fulvic acid fractions of soil influenced by main factor such as microbe, rockphosphate and urea expressed as percentage on moisture free basis are presented in Table 31. The analyses of variance of the data is given in Appendix IX.

Among the effects of microbe, rockphosphate and urea on humic acid content of the soil treated with coirpith, urea only had significant influence on the humic acid content which showed 0.352 per cent to 0.395 per cent. Though the effects of microbe and rockphosphate were not significant, rockphosphate increased the humic acid content from 0.362 (R_0) to 0. 385 (R_1) per cent and the microbe decreased it from 0.389 (M_0) to 0.358 (M_1) per cent.

Table 31. Humic and fulvic acid contents (per cent) of soil influenced by main effect of microbe (M), rockphosphate (R) and urea (U) at final stage of sampling

Treatment	Humic acid (%)	Fulvic acid (%)
M_0	0.389	0.675
M_1	0.358	0.513
R_0	0.362	0.551
R_1	0.385	0.637
U_0	0.352	0.628
U_1	0.395	0.560
Mean	0.373	0.594
CD(0.05)	0.039	0.110

The influence of of microbe on fulvic acid content of the soil was found to be significant. It decreased from 0.675 (M_1) to 0.513 (M_0) per cent. The influence of other factors such as rockphosphate and urea was found to be non-signficant on fulvic acid content of the soil. However, the rockphosphate non significantly increased the fulvic acid content from 0.551 to 0.637 per cent. The addition of urea also reduced the fulvic acid content from 0.628 to 0.560 per cent which was found to be non-significant.

2.7.2. Interaction effects

The effect of microbe-rockphosphate, microbe-urea and urea-rockphosphate on humic and fulvic acid content of soil is presented in Table 32 and the interaction of effect of microbe-rockphosphate-urea is presented in Table 33. The analyses of variance of the data are given in Appendix IX.

2.7.2.1. Microbe-rockphosphate interaction

The variations were found to be non-significant with respect to both fractions. The treatment M_0R_1 recorded the maximum value for humic acid as 0.396 per cent and for fulvic acid as 0.685 per cent. The minimum values were registered by M_1R_0 with 0.342 per cent and 0.436 per cent for humic and fulvic acid content of the soil, respectively.

Table 32. Humic and fulvic acid contents (per cent) of soil influenced by the interaction effect of microbe-rockphosphate (MR), microbe-urea (MU) and rockphosphate-urea (RU) at final stage of sampling

Treatment	Humic acid (%)	Fulvic acid (%)
M_0R_0	0.381	0.665
M_0R_1	0.396	0.685
M_1R_0	0.342	0.436
M_1R_1	0.374	0.590
M_0U_0	0.356	0.702
M_0U_1	0.421	0.647
M_1U_0	0.348	0.554
M_1U_1	0.368	0.473
R_0U_0	0.337	0.642
R_0U_1	0.386	0.459
R_1U_0	0.366	0.614
R_1U_1	0.404	0.661
Mean	0.373	0.594
CD(0.05)	NS	0.156

Not significant

2.7.2.2. Microbe-urea interaction

The effects were not significant either for humic acid or fulvic acid contents of the soil. recorded the highest value of 0.421 per cent for humic acid and the least by M_1U_0 with 0.348 per cent. Regarding the fulvic acid contents the treatment M_0U_0 registered the highest value of 0.702 per cent and the lowest by M_1U_1 (0.473 per cent).

2.7.2.3. Rockphosphate urea interaction

The treatment R_1U_1 registered the highest content of humic and fulvic acids in soil. The lowest value of humic acid was recorded by R_0U_0 (0.337 per cent) and for fulvic acid by R_0U_1 (0.459 per cent). The variations in fulvic acid contents of soil due to the fertilizer treatments were found to be significant. But on perusal of data, the treatments were found to be on par except with R_0U_1 which recorded the lowest fulvic acid content.

2.7.2.4. Microbe-rockphosphate-urea interaction

The effect of three factor interaction of microbe-rockphosphate-urea did not influence humic and fulvic acid contents significantly. Though it was not significant the

Table 33. Humic and fulvic acid contents (per cent) of soil influenced by interaction effect of microbe-rockphosphate-urea at final stage of sampling

Treatment	Humic acid (%)	Fulvic acid (%)
$M_0R_0U_0$	0.339	0.708
$M_0R_0U_1$	0.423	0.622
$M_0R_1U_0$	0.373	0.697
$M_0R_1U_1$	0.420	0.672
$M_1R_0U_1$	0.336	0.557
$M_1R_0U_1$	0.349	0.295
$M_1R_1U_0$	0.360	0.530
$M_1R_1U_1$	0.388	0.650
Mean	0.373	0.594
CD(0.05)	NS	NS

Not significant

treatment $M_0R_0U_1$ was superior with humic acid content of 0.423 per cent, which is followed by 0.420 per cent by $M_0R_1U_1$. The lowest value of 0.336 per cent humic acid was observed by $M_1R_0U_0$, immediately preceded by $M_0R_0U_0$ treatment with 0.339 per cent.

The effects of micorbe-rockphosphate-urea were not significant on the humic and fulvic acid content of the soil. The treatment $M_0R_0U_0$ performed as a non significantly superior treatment with 0.708 per cent fulvic acid content. But the treatment, $M_1R_0U_1$ was found to be inferior with 0.295 per cent of fulvic acid.

2.7.3. Control vs coirpith treatments

The data presented in Table 34 showed that the effect of coirpith treatments over control on humic and fulvic acid contents of soil did not differ significantly. However, coirpith treatments maintained high humic acid content (0.373 per cent) as compared to control treated with glyricidia (0.360 per cent). With regards to the fulvic acid contents of soil, the coirpith treatment registered a lower value of 0.591 per cent as compared to the lower value of 0.740 by control.

Unhumified and humified substances are two major components of soil organic matter. The humified material

Table 34. Humic and fulvic acid content (per cent) of soil influenced by coir pith treatments over control at final stage of sampling

Treatments	Humic acid(%)	Fulvic acid(%)
Control	0.360	0.740
Coirpith treated	0.373	0.591
CD (0.05)	NS	NS

Not significant

represents the most active fraction of humic and fulvic acid components. It is now generally accepted that humic and fulvic acids are formed by a multistage process that includes decomposition of all plant components including lignin into simple monomers and metabolism of the monomers with an accompanying increase in the soil biomass. These help explain the improved humic and fulvic acid content with glyricidia and coirpith treated soil. Although many different types of reactions can lead to the production of humic and fulvic acids the main roles are played by the micro organisms and lignin rich substances. Lignin act as base material for the formation of humic substances, which are transformed by the activity of micro-organisms. The high contents humic acid in coirpith treatments can therefore be related to the lignin content of the coirpith than glyricidia which registered the low humic acid as described in section 2.7.3. This is in conformity with the results of Turski and Flis - Bujak (1970).

As noted by several workers (Kononova, 1966; Felback, 1971 and Schintzer and Khan, 1972), the fulvic acids are formed by secondary synthesis reaction and have properties distinctly different from the biopolymers of living organisms including the lignin of higher plants. The same fact may be taken into account for the decrease in fulvic acid contents in coirpith treatments as compared to glyricidia. As pointed out by Ram and Raman (1981), humic acid was the first transformation products of soil organic matter whereas fulvic acid was formed by further transformation and destructive synthesis.

As described in section 2.7.1 the microbial addition decreased both humic and fulvic acid contents. The effect on fulvic acid found to be significant (Table 31). As opined by Stevenson (1985), one third of the substances synthesised by the fungi including the biomass consisted of humic acid and he also recovered a humic acid type polymer from the mycelium tissue. So the production of humic substances by micro organisms may be partly an extra cellular process. Regarding the role of rockphosphate in the formation of humic substances, it is seen that the addition of the same had increased both humic and fulvic acid fractions. This may again be due to increased rate of mineralisation of coirpith as indicated in section 1. But by the addition of urea, the humic acid content in the soil increased while the fulvic acid contents decreased (Table 31). The increased nitrogen might have resulted in the hike in humic acid portion of soil which was formed to be significant also. The findings of Qui and Ding (1986) are also support these observations. As the increased in nitrogen contents in soil due to urea incorporation has favoured the synthesis of humic acid.

Summary

SUMMARY

The study on the decomposability and mineralisation pattern of coirpith in latosols was conducted during the period 1990-92 at the College of Horticulture, Vellanikkara to measure the rate of decomposition of coirpith incorporated with the laterite soil, to evaluate the efficiency of Pleurotus sajor caju on decomposition of coirpith and to determine the fertility value of resulting compost from coirpith as compared to green leaf manure. The investigation consisted of mainly two parts, an incubation study and field experiment. In order to measure the decomposability of coirpith as compared to glyricidia in laterite soil under incubation, the measurement of CO_2 evolution was carried out for a period of six months. Various enrichment techniques for lignin rich coirpith was also done with the use of adjunctants such as Pleurotus sajor caju, urea and rockphosphate. The same set of treatments was also repeated under field conditions. The salient features of the results are summarised below.

1. The available P and CEC of the soil at the experimental site were found to be low, while organic carbon, available N and available K were characterized under medium, soil fertility class.

2. Both the cumulative as well as rate of CO_2 evolution was found to be highly pronounced in the soil which was treated with *Glyricidia maculata*.

3. The lignin rich coirpith underwent high rate of mineralisation with the incorporation of *Pleurotus sajor caju* as indicated by a hike in the rate as well as cumulative CO_2 evolution in the soil.

4. There was an overall improvement in the rate as well as cumulative CO_2 evolution in the soil due to the enrichment of nitrogen in the form of urea with coirpith.

5. The influence of added phosphorus on the decomposability of coirpith was low compared to other adjunctants such as *Pleurotus sajor caju* and urea.

6. In all the treatments, the rate of CO_2 evolution was highest at second day of incubation. Thereafter it declined gradually till the 48th day and attained almost equilibrium values from 48th to 180th day of incubation.

7. Application of coirpith alone as well as coirpith in presence of various adjunctants did not alter the soil pH markedly and the soil remained acidic throughout the experimental period for one year.

8. Due to the addition of coirpith, both in the presence and absence of various adjunctants, the organic carbon content of the soil was improved to a slight extent.

9. With the advancement of period of sampling, the CEC of the soil was found to be decreased though it increased at the first stages of sampling of the soil with almost all the treatments.

10. There was progressive increase in the available N content of the soil with the advancement of period of sampling due to the mineralisation of raw as well as inoculated coirpith to the soil.

11. Although there was increase in the available P status of the soil by the application of coirpith in conjunction with microbe, rockphosphate and urea. It gradually decreased after fourth month of sampling.

12. Compared to coirpith treaments, the decomposition of glyricidia released more available K in the soil, but a reduction of the same was noticed from seventh month onwards.

13. Addition of <u>Pleurotus</u> <u>sajor</u> <u>caju</u> to coirpith decreased both humic and fulvic acid contents of the soil.

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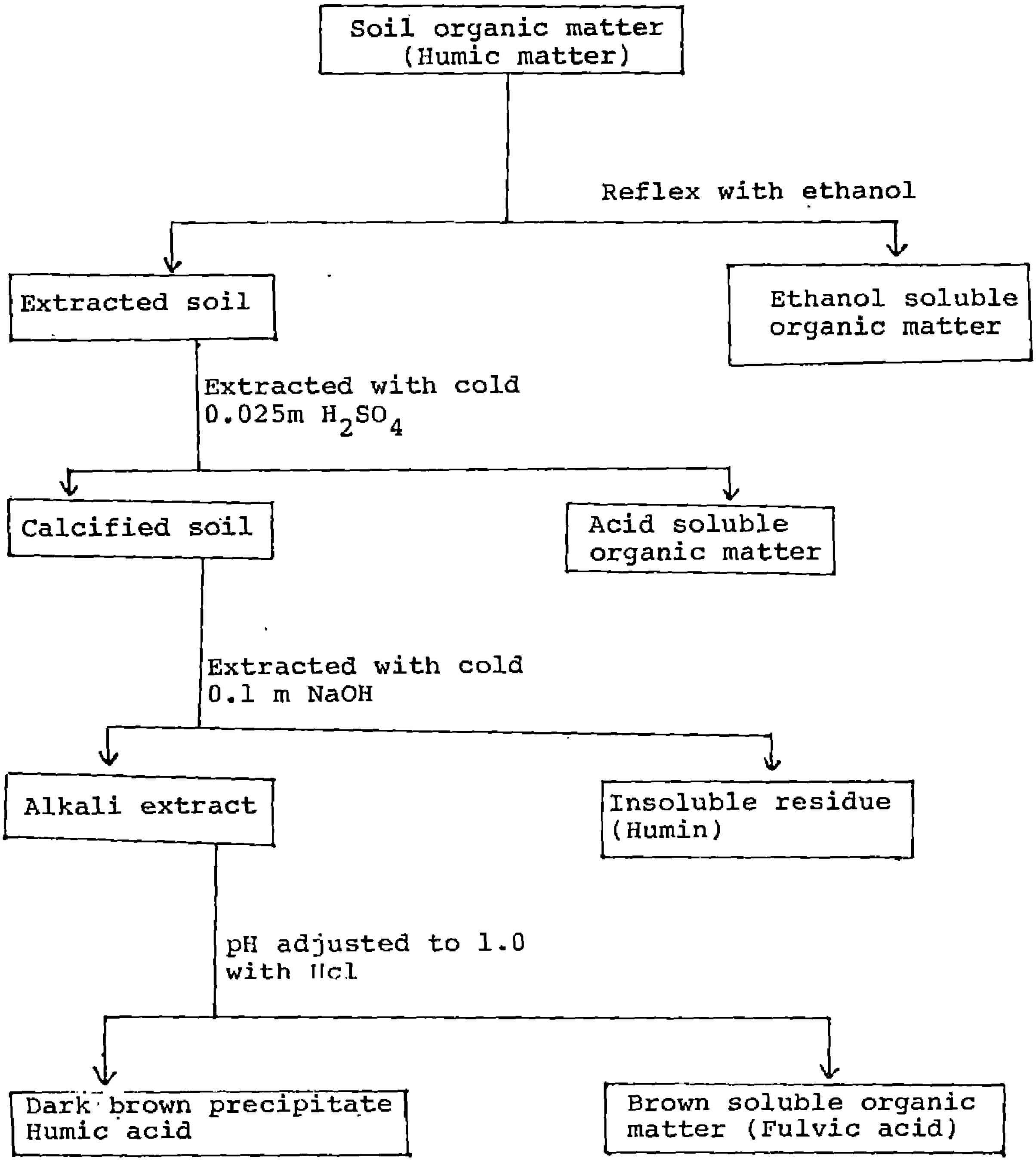
Appendices

APPENDIX I

Flow chart for soil organic matter fractionation



Appendix II

Abstract of Anova

Cumulative CO_2 evolution as influenced by treatments at different periods of incubation

Source	df	Mean square at different periods of incubation													
		2	4	6	8	16	24	32	40	48	60	90	120	150	180
Control Vs treated	1	375.61**	1514.44**	2799.52**	4360.53**	6188.65**	8502.08**	12197.14**	19176.65**	24606.49**	45152.13**	108354.44**	193425.41**	254079.94**	298465.68**
Microbe (M)	1	2185.93**	7295.11**	11295.05**	32387.67**	29917.03**	38778.34**	47991.11**	55781.34**	65869.98**	71064.50**	69006.13**	68635.12**	79840.08**	91977.61**
Rockphosphate (R)	1	12.80	8.53	34.11	3.84	3.00	2.31	5.28	16.53	1.62	28.96	772.25	2415.13**	6182.72	11295.05
Urea (U)	1	48.41*	305.79*	227.70**	678.22**	642.61**	605.17**	521.97	314.75	343.74	158.60	5.44	171.13	1123.38	2028.84
MR	1	11.71	1.30	66.82	2.14	0.56	7.96	0.57	19.91	29.95	292.82	1903.45*	1038.12*	13645.52*	15155.45*
MU	1	117.66**	31.28	116.13*	12.75	44.65	106.73	211.56	377.30*	362.34	384.48	83.21	146.21	273.78	310.01
RU	1	16.59	12.48	8.16	2025.66**	199.00*	283.46*	360.46	489.53*	796.80	791.62	447.01	7.60	1104.50	1584.85
MRU	1	21.39	10.35	3.98	1942.51**	184.51*	269.35*	348.68	556.78*	1033.31*	1270.08	1205.41	1024.13	840.50	946.13
Error	27	11.05	49.84	19.85	55.23	43.41	63.35	127.30	88.36	191.60	304.27	432.67	245.87	1825.83	3039.87

* Significant at 1 per cent level ** Significant at 5 per cent level

Appendix III

Abstract of Anova

Soil pH as influenced by treatments at different periods of sampling

:ce	df	Mean square at monthly intervals											
		1	2	3	4	5	6	7	8	9	10	11	12
:rol Vs treated	1	0.07	0.09	0.266**	0.320*	0.333**	0.014	0.105	0.067	0.013	0.361**	0.488**	0.138**
robe (M)	1	0.00003	0.003	0.188**	0.383**	0.001	0.405**	0.038	0.015	0.026	0.025	0.158**	0.025
kphosphate (R)	1	0.010	0.340**	0.173**	0.008	0.138**	0.101	0.020	0.195**	0.0004	0.008	0.236**	0.038*
a (U)	1	0.49*	0.661**	0.894**	2.258**	1.088**	1.575**	1.853**	1.361**	1.197**	0.031	0.119**	0.090**
	1	0.021	0.340**	0.075	0.020	0.911**	0.080	0.281*	0.211**	0.164*	0.045	0.006	0.138**
	1	0.073	1.445**	0.075	0.0010	0.001	0.138*	0.008	0.002	0.031	0.008	0.006	0.525**
	1	0.004	0.101	0.013	0.080	0.180**	0.008	0.001	0.008	0.126*	0.038	0.059	0.138**
	1	0.0038	0.020	0.085	0.003	0.340**	0.003	0.151	0.211**	0.012	0.080	0.066*	0.038*
or	27	0.115	0.043	0.023	0.060	0.018	0.032	0.051	0.024	0.033	0.037	0.014	0.008
al	35												

Significant at 1 per cent level; * Significant at 5 per cent level

Appendix IV

Abstract of Anova

Organic carbon as influenced by treatments at different periods of sampling

rce	df	Mean square at monthly intervals											
		1	2	3	4	5	6	7	8	9	10	11	12
trol Vs treated	1	0.0215	0.076	0.00005	0.0039	0.033	0.0037	0.038	0.00005	0.0063	0.0002	0.0019	0.013
robe (M)	1	0.254**	0.493**	0.146**	0.096	0.503**	0.001	0.024**	0.009	0.008	0.039**	0.270**	0.0001
kphosphate (R)	1	0.062	0.062**	0.198**	0.005	0.194**	0.002	0.006	0.033**	0.024	0.085**	0.003	0.101**
a (U)	1	0.295**	0.295**	0.045*	0.081	0.062	0.002	0.010	0.004	0.039*	0.003	0.007	0.005
	1	0.0002	0.026	0.007	0.121	0.330**	0.007	0.008	0.011*	0.062**	0.024**	0.218**	0.004
	1	0.326**	0.647**	0.065*	0.004	0.008	0.011	0.024**	0.001	0.015	0.00003	0.095**	0.0004
	1	0.0002	0.050	0.004	0.032	0.017	0.001	0.005	0.006	0.0003	0.005	0.0001	0.067**
	1	0.002	0.185*	0.054*	0.144	0.155**	0.002	0.001	0.007	0.018	0.068**	0.054*	0.015
or	27	0.022	0.036	0.009	0.052	0.016	0.003	0.003	0.002	0.006	0.003	0.003	0.005
al	35												

Significant at 1 per cent level; * Significant at 5 per cent level

Appendix V

Abstract of Anova

Cation exchange capacity as influenced by treatments at different periods of sampling

urce	df	Mean square at monthly intervals											
		1	2	3	4	5	6	7	8	9	10	11	12
ntrol Vs treated	1	27.05	40.530*	25.92	11.810	7.670	47.910**	24.036**	2.490	0.977	15.111*	3.848	7.556*
crobe (M)	1	3.413	4.033	0.478	10.649	8.000	1.182	0.051	21.615**	42.067**	8.559	1.019	1.553
ckphosphate (R)	1	53.071*	38.456*	0.057	0.865	0.005	9.912**	1.280	14.851**	20.689**	94.634**	0.624	21.044**
ea (U)	1	0.894	2.691	25.830	12.878	11.045	5.453*	6.771**	1.566	3.426*	18.681*	6.780*	33.477**
	1	36.787	31.126*	0.044	62.273*	18.301*	3.106	0.051	7.762*	8.211**	3.322	0.444	0.025
	1	0.164	0.106	15.778	3.485	5.611	4.508	0.320	3.948	4.314**	0.188	4.212	0.046
	1	17.657	16.762	6.707	4.743	0.551	0.272	38.720**	19.127**	3.131*	13.300*	5.112	2.755
J	1	21.599	13.210	33.559	0.278	3.380	34.217**	0.115	0.001	0.747	18.681*	7.970*	0.257
ror	27	10.932	6.639	7.076	4.020	3.718	0.974	0.414	1.159	0.613	2.810	1.186	1.175
tal	35												

Significant at 1 per cent level; * Significant at 5 per cent level

Appendix VI

Abstract of Anova

Available nitrogen as influenced by treatments at different periods of sampling

Source	df	Mean square at monthly intervals											
		1	2	3	4	5	6	7	8	9	10	11	12
Control Vs treated	1	15874.55**	16621.20**	15938.56**	1823.58	13195.54	68.153	1260.86	311.46	5571.28	5653.39	5124.94	6128.97
Microbe(M)	1	188.58	109.39	1098.63	467.42	316.26	5113.13**	10907.65**	3194.00	20145.26**	19840.32**	7317.48	2189.57
Rockphos-phate(R)	1	9112.50**	10822.38**	8557.59**	7960.06*	766.36	4505.38**	1984.50*	5.04	25509.76**	25290.00**	22967.61**	12644.48**
Urea (U)	1	2177.39*	2867.14*	5615.35*	1547.07	0.001	1727.25**	16471.13**	20772.31**	14335.48**	14577.78**	13484.93*	9142.90*
MR	1	9322.95**	9156.43**	5588.89*	13940.33*	3595.52	52.28	26277.78**	47732.79**	59503.88**	59064.84**	48368.28**	34249.99**
MU	1	2096.28	4505.38**	6302.84*	37.20	3456.96	3388.70**	583.11	15142.35**	9518.55**	9282.03**	6935.47	3993.95
RU	1	4218.21**	5932.33**	2732.45	2666.33	11332.96	15.54	2861.46**	3584.93	7859.45*	8032.78*	20417.16**	22234.14**
MRU	1	14552.18**	14916.37**	10661.65**	52.28	894.65	1819.55**	4685.12**	7287.26*	79291.57**	78824.35**	40762.26**	35758.06**
Error	27	496.083	449.39	987.45	1775.68	3176.36	189.984	429.10	9.73	1954.20	1948.89	160.15	210.28
Total	35												

** Significant at 1 per cent level   * Significant at 5 per cent level

Appendix VII

Abstract of Anova

Available phosphorus as influenced by treatments at different periods of sampling

Source	df	Mean square at monthly intervals											
		1	2	3	4	5	6	7	8	9	10	11	12
Control Vs treated	1	6.920	0.281	53.612**	34.329*	27.301**	1.265	102.15**	2.966	2.768	59.245**	7.994**	1.167
Microbe (M)	1	1.015	31.173*	2.273	3.156	10.326*	75.381**	35.596**	39.636**	22.606**	7.465*	23.838**	34.966**
Rockphosphate (R)	1	0.977	0.844	0.420	0.747	20.448*	2.675	21.232**	0.690	9.919	1.411	2.348	0.015
Urea (U)	1	18.125	76.240**	25.943**	0.412	0.142	0.509	3.489	17.308*	22.593**	1.866	3.218	0.017
MR	1	33.587	24.753*	69.971**	0.006	0.984	4.831	9.338**	40.424**	9.928	57.803**	34.717**	24.273**
MU	1	1.555	3.267	0.068	42.587*	1.755	4.485	1.961	1.558	14.472*	1.556	0.081	6.471*
RU	1	11.257	1.732	35.341**	27.447	0.164	16.632**	11.241**	5.364	16.808*	8.471*	5.421*	5.276
MRU	1	6.345	6.209	20.300**	16.291	4.963	20.269**	22.281**	13.569*	4.842	16.797**	2.805	12.840**
Error	27	7.943	5.063	1.527	7.264	1.832	1.502	1.268	2.043	2.805	1.159	0.721	1.351
Total	35												

** Significant at 1 per cent level; * Significant at 5 per cent level

Appendix VIII

Abstract of Anova

Available potassium as influenced by treatments at different periods of sampling

Source	df	Mean square at monthly intervals											
		1	2	3	4	5	6	7	8	9	10	11	12
Control Vs treated	1	5552.82	42534.7**	82418.00**	786.70	1415.10	32105.8**	1002.40	7996.90*	32645.6**	13338.89**	4893.90	2093.05
Microbe (M)	1	14.31	4940.18	882.00	283.22	15.68	4940.18*	63.56	714.42	641.82	16561.99**	10599.68	17428.61**
Rockphosphate (R)	1	2432.53	7762.58	768.32	8115.38	16561.99*	5222.42*	21450.38**	15806.42**	474.32	22641.92**	4531.52	14263.61**
Urea (U)	1	1714.05	432.18	2450.00	8844.50	2257.92	1067.22	63.56	8844.50*	317.52	15.68	15.68	18297.84**
MR	1	1582.03	1812.02	1003.52	2548.98	4014.08	165.62	63.56	118.58	564.48	1897.28	62.72	11567.21**
MU	1	6300.03	5222.42	2857.68	714.42	8659.28	283.22	16.10	165.62	2257.92	2257.92	20321.28*	963.61
RU	1	5392.11	1067.22	1897.28	4665.78	141.12	3411.38	11442.06**	2164.82	1241.02	20889.68**	37647.68**	15717.64**
MRU	1	556.11	8844.50	6271.99	8115.38	1415.12	12074.58**	6906.06*	4399.22	1693.62	36883.28**	30356.48**	24266.04**
Error	27	4148.61	3705.13	2442.02	2348.23	1922.54	1332.22	760.46	1536.35	2085.89	728.83	3789.62	955.10
Total	35												

** Significant at 1 per cent level; * Significant at 5 per cent level

Appendix IX

Abstract of Anova

Humic and fulvic acids as influenced by different treatments

Source	df	Humic acid	fulvic acid
Control Vs treated	1	0.0012	0.076
Microbe(M)	1	0.0074	0.21**
Rockphosphate (R)	1	0.0044	0.060
Urea (U)	1	0.0148*	0.036
MR	1	0.0005	0.036
MU	1	0.0041	0.001
RU	1	0.0002	0.107*
MRU	1	0.0014	0.059
Error	27	0.0029	0.023
Total	35		

** Significant at 1 per cent level

* Significant at 5 per cent level

APPENDIX X

Cumulative CO_2 evolution (mg/carbon content of material) and rate of CO_2 evolution (mg/carbon content per day) as influenced by different treatments of coirpith over control at different periods of incubation

Period of incubation, days	Cumulative CO_2 evolution		Rate of CO_2 evolution	
	Control	Coirpith treated	Control	Coirpith treated
2	0.370	0.106	0.185	0.051
4	0.649	0.172	0.162	0.043
6	0.879	0.232	0.147	0.037
8	1.103	0.292	0.138	0.036
16	1.420	0.394	0.088	0.025
24	1.736	0.494	0.072	0.021
32	2.051	0.579	0.064	0.018
40	2.401	0.650	0.060	0.016
48	2.673	0.716	0.056	0.015
60	3.275	0.816	0.059	0.014
90	4.394	0.964	0.050	0.011
120	5.488	1.119	0.046	0.009
150	6.360	1.314	0.042	0.006
180	7.054	1.496	0.038	0.002

DECOMPOSABILITY AND MINERALISATION PATTERN OF COIRPITH IN LATOSOLS

By

S. JOTHIMANI

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture
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1993

ABSTRACT

An investigation on the decomposability and mineralisation pattern of coirpith in latosols was carried out at the Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara, Thrissur during the period 1990-92.

The experimental soil was laterite and the various treatments employed for mixing with the soil comprised of coirpith raw as well as enriched with *Pleurotus sajor caju*, urea and rockphosphate. The individual and diffferent combinations of these factors were compared with the control (*Glyricidia maculata*) applied to the soil. The study involved an incubation experiment and field trial.

In order to measure the decomposition of coirpith compared to glyricidia in laterite soil under incubation, the measurement of CO_2 evolution was carried out for a period of six months. A field experiment was conducted to study the influence of additives such as microbe, rockphosphate and urea on decomposition of coirpith. The fertility value of the resulting compost was evaluated by estimating pH, organic carbon, cation exchange capacity, available N, P and K of the soil at monthly intervals for a period of one year. Humic and fulvic acid contents of soil

were estimated one year after the incorporation of treatments in the soil.

The mineralisation of lignin rich coirpith was found to be accelerated due to the addition of both Pleurotus sajor caju and mineral N in the form of urea. With all the treatments and treatment combinations the rate of CO_2 evolution was found to be the highest at the second day of incubation and appreciable changes were associated in general, up to 48th day of incubation. There after it declined and attained almost equilibrium values at the end of sixth month.

Due to the incorporation of either the glyricidia or coirpith with and without the various adjunctants a steady state of acidic reaction was maintained in the soil. Even with the application of coripith alone, there was only slight reduction in soil pH. There was not much variation between glyricidia and coirpith treatments on organic carbon content of the soil. Both the microbe and urea enrichment to coirpith reduced the organic carbon content due to faster decomposition whereas it was slightly improved by the addition of rockphosphate. Though there was hike in the CEC of the soil immediately after the addition of organic materials, the values tended to decrease at the end.

There was progressive increase in the available nitrogen contents of the soil with the advancement of period of incubation due to the mineralization of glyricidia and coirpith. Among the coirpith treatments, the maximum value was noticed when coirpith was enriched with all the additives. The addition of organic materials also favoured an improvement in available P content of the soil. The contents of available P in the soil increased when coirpith was incorporated with urea. Regarding the release of available K from the soil, the glyricidia incorporation always showed a better performance as compared to coirpith treatments. The microbial inoculation seemed to decrease the humic and fulvic acid contents from their original levels due to decrease in organic carbon content of the soil. This was noticed one year after incorporation of treatments into the latosols.