ENRICHMENT OF COIRPITH COMPOST THROUGH ORGANIC AMENDMENTS

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Science in Agriculture

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VELLANIKKARA, THRISSUR - 680 654
KERALA, INDIA

1997

DECLARATION

I hereby declare that this thesis entitled "**Enrichment of Coirpith Compost through Organic Amendments**" 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 the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENTS

Bowing my head before THY for the benevolance showering on me everytime, without which completion of humble work would not have been a success.

With deep sense of gratitude, I take this opportunity to express my profuse thanks to Dr. R. Gopinathan, Chairman of my Advisory Committee who guided, inspired and encouraged me. Always with creative ideas he offered erudite guidance, constructive criticisms and valuable suggestions on every bit of my attempt which resulted in successful completion of the work.

I am extremely indebted to Dr. R. Vikraman Nair, Professor and Head, Department of Agronomy for the timely and immense help rendered by him with understanding and forbearance. In times of need, his suggestions were valuable and advices were helpful which I always remember with deep reverence.

My heartful thanks are expressed to Dr. P.K. Sushama, Department of Soil Science and Agricultural Chemistry for her prudent and valuable help in times of chemical analysis and her critical suggestions throughout the course of investigation and preparation of manuscript.

I express my gratitude to Dr. P.V. Prabhakaran, Professor and Head, Department of Agricultural Statistics for his suggestions in statistical analysis and interpretation of data.

My sincere thanks are due to staff members of the Department of Agronomy at various stages of my study.

I also thank Sri. Surendra Gopal, Assistant Professor and Dr. M.V. Rajendran Pillai, Associate Professor, Department of Pathology for their help in microbiological studies.

I am deeply obliged to Harikrishnan Nair for the immense and ever willing help rendered by him in statistical analysis and every other stages of my work.

I also thank Mustafa, Beenachaechi, Haneesh, Sudheesh, Satheesh, Bejoy Kannath, Vinayan, Jidesh, Nimmy and Lencychaechi for their assistance for proper conduct of this work.

My profound sense of thankfulness is due to temporary labourers Sri. M.K. Rajan, Sri. K.M. Cheriyan and Sri. P.K. Ashokan associated with DST scheme without whom this venture would not have been fruitful.

A word of thanks to Peagles, Mannuthy for neat and prompt typing.

The award of ICAR Junior Fellowship is also greatly acknowledged.

I express my hearty thanks to my friends, Duethi, Manju, Sreekala, Anu, Bavarah, Deepa Maveli, Priya, Manjula, Satheesh and Sunil for their generous co-operation.

No words of thanks can express my obligation to my Amma, Acchan, Ayyappan and Aravind for their prayers, moral support, sincere advices, encouragement and for bearing all the incoveniences caused all along this study.

NAIJA NAIR

Dedicated To

Devi Mookambika

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Introduction

INTRODUCTION

Wastes are inevitably produced by the agricultural, industrial and human activities. But its safe management is really a difficult problem. Among the solid wastes municipal solid waste, farm waste and industrial waste assume significance. The probable way to tackle this problem is recycling of solid wastes as organic matter. In tropics, due to high temperature and rainfall, organic matter is fast depleting and necessitates intense search for good quality manures to maintain the soil health.

Among the solid wastes, coirpith is one of the major industrial wastes of agricultural importance. It is a by-product of coir industry. According to Agbo, 1997 India produces 13,231 million nuts and 1321 million tonnes of coir dust annually. Accumulation of coirpith at this rate is alarming and necessitates its safe disposal for protecting the environment. Research evidences are many to convert coirpith, into compost through microbial processing (Krishna and Sreeramulu, 1983 and Jothimani and Sushama, 1994).

But apprehension exists on the possible ill-effects of coirpith on soil and crop. Its fluffy and fibrous nature, wide C:N ratio, low nutrients and high lignin content restrict the farmers from using the coirpith or coirpith based materials as manure or soil amendment on a wider scale (Gopinathan, 1996).

Ameliorating the coirpith compost through additions of suitable industrial and biodegradable organics can improve its manurial as well as soil enrichment value . The coirpith compost can be enriched utilising different types of locally available solid materials like municipal solid waste (MSW), cow dung, industrial solid waste of organic origin etc. There are reports on composting of domestic refuse and city waste (Johnson, 1990) for using them as soil enrichers. Major portion of MSW in third world countries is biodegradable organic waste (Erbel, 1993). This can be considered for enriching coirpith through various bioprocessing techniques. Similarly cowdung and industrial organic wastes can also be used for enriching the manurial value of coirpith compost. But research evidences are practically nil on this aspect. Complimentary and competitive roles, if any, of the enriching materials on the bio-processing techniques of coirpith also need to be researched. Therefore the present study was undertaken with the following objectives:

1. To investigate into the methodologies of enrichment of coirpith compost through proper organic amendments and bio-processing.

2. To study the effect of the best enriched coirpith compost on plant and soil.

Review of Literature

REVIEW OF LITERATURE

2.1 The Problem

Coirpith is the major waste product of coir industry, for which no effective disposal is now in vogue. The basic raw material for coir industry is coconut husk from which the process of extraction of fibre leaves about 50 to 60 per cent of total weight of husk as coirpith (Bhowmic and Debnath, 1985). Extraction of one kilogram coir fibre generates, two kilogram of coirpith. Husks from about 10,000 nuts yield one tonne each of fibre and pith (Swarupa and Reddy, 1996).

World's coconut production in 1994 was 9438 million nuts where India, ranks third among the other coconut producing countries in terms of production (Swarupa and Reddy, 1996). In India, southern states together accounts for 90 per cent of the production. The average annual collection of fibre dust in the recent years was estimated at around 14,000 metric tonnes in India (Agbo, 1997). For the present, coirpith is treated as waste and dumped as hillocks causing many pollution and disposal problems. The coir industry itself is in crisis, besides the associated environmental problem consequent to the continued dumping of coirpith. Hence, it becomes an absolute necessity to find out an effective way torecycle coirpith.

Coconut husks are used as fuel in limited quantity. But with mechanisation and growth in coir industry coir husk has become too costly as fuel in household. Coirpith as a fuel in traditional and smokeless choolas is also not getting popularised for difficulty in handling the dust, and its low calorific value as compared to saw dust or rice husk. Coirpith came to be utilised as a raw material in production of insulating materials, fibre boards, fire resistant boards etc. But low compressability of coirpith transported to industries after drying and high capital investment for factory installation and transport proved the above industrial options unprofitable (Prabhu *et al.*, 1983).

Coir dust, a light fluffy material is voluminous and easily blown by wind. It does not burn completely, emits continuous smoke and acts as breeding ground for unwanted micro and macroorganisms. It is often dumped on roadsides, river banks, lakes, estuaries and other water bodies obstructing the transport and flow of water (Rajamannar and Sreeramulu, 1982; Ramaswami, 1983 and Joseph, 1995). Seepage of acidic and phenolic materials to ground and soil water during monsoon causing pollution was reported by Swarupa and Reddy (1996). Environmental awareness among the public compels for safe and effective disposal of coirpith.

Because of lack of practically viable options, huge coirpith pyramids are mushrooming day by day inviting court directions to the closure of industrial units.

2.2 Coirpith as a source of manure

The question of considering coirpith as a source of organic material to soil attracted the researchers since many years. The coirpith with about 30 per cent carbon and a C:N ratio of 112:1 (Joseph, 1995) which is presently available in abundance can be a good source of carbon especially for tropical climates. The importance of organics as a source of humus and plant nutrients to increase soil fertility of tropical soils is well recognised. The organic matter content of cultivated soils of the tropics and subtropics is comparatively low due to high temperature and intense microbial activity. So soil humus has to be replenished through periodic additions of organic manures for maintaining soil productivity. Organic matter has beneficial effects on soil microorganisms and thus improves its Physical (Gaur *et al.*, 1971, 1973) and chemical characteristics (Gaur *et al.*, 1972). The direct effects relate to the uptake of humic substances favourably affecting the plant growth and metabolism

Organic matter check proliferation of plant parasitic nematodes (Gaur and Prasad, 1970; Prasad *et al.*, 1972). Further, the preparation of organic manures from rural and urban wastes (Erbel, 1993; Paulraj and Sreeramulu, 1994 and Joshi, 1996) industrial wastes (Sogni, 1988; Cabral and Vasconcelos, 1993; Menon *et al.*, 1993 and Gopinathan, 1996), animal wastes (Prasad *et al.*, 1989 and Thampan, 1993) etc. provide valuable manure for maintaining the soil health besides helping in the safe and hygienic disposal of solid wastes (Gaur *et al.*, 1995).

2.3 Properties of coirpith

Coirpith has a surface area of 290 m^2 per gram (Idiculla, 1983) and is a lignocellulosic material which binds fibres. Pith, as reported by Ravindranath (1991) has low bulk density (0.1525 g cc^{-1}), low particle density (0.49 g cc^{-1}), low thermal conductivity and a porosity of 76.77 per cent. It can absorb eight times its weight of water (82 per cent) and releases it slowly, Incorporation of 2 per cent by weight of pith with sandy soil, resulted in 40 per cent increase in water holding capacity (Natarajan, 1995). Raw coirpith contains 1.28 per cent fats and resins and 7.1 per cent ash (Satyanarayana *et al.*, 1984). It is rich in lignin (30 per cent), cellulose (26.5 per cent) pentosan (9.48 per cent), phenols (50 mg g^{-1}) (Ravindranath, 1991). Nutrient composition of raw coirpith as reported by Nagarajan *et al.* (1986), Bopaiah (1991) and Joseph (1995) was 0.21 to 0.50 per cent N; 0.01 to 0.09 per cent P_2O_5, 0.78 to 0.84 per cent K_2O, 26.10 per cent organic carbon, 0.4 per cent calcium, 0.36 per cent magnesium, 0.07 per cent iron, 12.5 ppm Mn, 7.5 ppm Zn and 3.1 per cent copper.

2.4 Constraints in using raw coirpith

Research results are indicative that coirpith being an organic material rich in lignin and cellulose has increased the buoyancy of the soil and provided optimum soil environment with the addition of plant nutrients (Durai and Rajagopal, 1983). Ramaswamy and Sreeramulu (1983) reported its suitability in rain water conservation and increasing the yield. Mayalagu *et al.* (1983) and Nagarajan *et al.* (1987) recorded increased yield of crop plants by pith application. found that coir dust can be used as an alternative to press mud. Also, if properly treated, coirpith can serve as a substitute for farm yard manure and other organic manures (Savithri and Khan, 1994). Rain water conservation abilities of coirpith when used as vertical mulches was also reported by Gopinathan (1996). But many constraints limit its use as a soil ameliorant on an appreciable scale.

Composition-wise, raw coirpith is low in nitrogen and phosphorus with wide C:N ratio. Its low biodegradability also limits its application to field crops (Fan *et al.*, 1982). According to Krishnan (1986) and Nagarajan *et al.* (1985) the raw coirpith application did not increase available soil nitrogen possibly due to the wide C:N ratio of 112:1 of coirpith and high lignocellulosic nature which cause immobilisation and slow mineralisation. Nitrification inhibition property was reported by Joshi *et al.* (1985). Experiments conducted by Nambiar *et al.* (1988) also proved the nitrification inhibition due to coir dust blending in coastal sandy soils of Kerala. Similar result was obtained for Bopaiah (1991) showing the constraints in using raw coirpith as soil amendment. Saravanan *et al.* (1991) reported that coirpith is slightly acidic in nature. Singaram and Pothiraj (1991) stated that since raw coirpith has high lignin content, uncomposted coirpith may not be advantageous for continuous application.

Gerritsen (1994) reported the unsuitability of raw coirpith as a substrate for plant growth. Gaur *et al.* (1995) also stated that the application of carbonaceous materials with wide C:N ratio would bring adverse effects on plant growth. The studies done by Natarajan (1995) proved that slow decomposition of coirpith in soil was due to its fibrous nature and high lignin content. Ramesh and Gunathilagaraj (1996) also reported the results on this line. Agbo (1997) also described raw coir dust as a waste material of low manurial value. Dangerously high salt levels had been recorded by Cresswell (1997) in coir dust samples from India.

2.5 Coirpith compost technology

Enrichment of bark wastes with poultry manure to reduce the decomposition span was reported by Dai *et al.* (1972) and Sailo *et al.* (1972). Shi *et al.* (1978) stated about the slow decomposition and hence a slow release of nitrogen from lignin rich organic materials. Fogg (1988) summarised a negative effect of nitrogen in organic matter with higher C:N ratio and vice versa. Among different methods tried, decomposition process was found to be the efficient method in bringing down the C:N ratio (Thambirajah and Kuthubutheen, 1989). Coirpith composted by *Pleurotus* sp, and treated with urea and rock phosphate helped to increase the nutrient availability (Jothimoni, 1993). Gaur *et al.* (1995) reported that the addition of other nitrogen sources such as sewage sludge, fish scrap, vegetable wastes, night soil, industrial wastes etc. to wide C:N wastes resulted in reduction of C:N ratio between 30 to 40 in a shorter time. Moorthy *et al.* (1996) proved the beneficial effect of using cowdung for the enrichment of coir dust.

Attempts to convert coirpith as an organic manure or soil enricher are numerous.

Bopaiah (1991) recommended five spawn bottle of *Pleurotus sajor-caju* fungus and 5 kg urea for decomposing 1 tonne of coirpith. The inclusion of coirpith and inoculants with inorganic fertilisers further improved the nitrogen status as observed by Perumal *et al.* (1991). Besides *Pleurotus* sp., *Trichoderma* sp. and *Aspergillus* sp. were found to be potent degraders of coirpith (Savithri and Khan, 1994).

Joseph (1995) reported the simplest way to convert coirpith into organic manure by composting using pith plus. Pith plus is activated charcoal with carbonaceous compounds of plant origin. It can prevent excess evaporation and hence can retain moisture helping the biodegradation process. Pith plus and urea 2 and 5 kilogram respectively was added into 580 kilogram of organic manure. At the end of 30 days, pith turned into compost mass of C:N ratio 24:1, enriched with 1.26, 0.06 and 1.20 per cent N, P and K respectively and micronutrients.

Moorthy *et al.* (1996) proved the composting of coirpith in a period of 4 months using coffee husk with the dual advantages of high moisture retention of coirpith and good nutritional status of cherry husk for continuous application, particularly to perennial crops which would bring down the irrigation cost, fertiliser bill apart from imparting far reaching benefits to soil health.

2.6 Influence of coirpith compost on crop and soil

According to Gaur *et al.* (1978, 1980) composting of organic materials with P addition could increase the availability of P and N. Krishna and Sreeramulu

(1983) reported the blending of coir waste with mussoriephos. Blending of urea and rock phosphate with pith resulted in immobilisation of urea nitrogen and controlled release of nitrogen (Joshi *et al.*, 1985).

Studies by Ramaswami *et al.* (1985) and Ramaswami and Kothandaraman (1985) indicated the usefulness of coirpith as its addition to the farm with fertilisers increased the output in rice, grapes and sorghum. Coirpith composted by microbial inoculation helped to narrow down C:N ratio from 112:1 to 24:1 and improved the nitrogen content from 0.26 to 1.06 per cent. Hence, composted coirpith can be used as organic manure for sodic soils in the place of farm yard manure (Savithri *et al.*, 1991). Selvi *et al.* (1991) proved that composting of coirpith was a measure of enhancing its efficiency as ameliorant for various crops.

Ravindranath (1991) reported that composting of coirpith resulted in reduction of C:N ratio and volume by 42 per cent, thus bringing down transportation charges. Composting of coirpith using enrichers for increasing the nutrient availability was reported by Jothimani (1993) and Jothimani and Sushama (1994). Moorthy (1993) made several improvements in composting and used the compost in nurseries and older plants of perennial crops like cocoa, cashew, areca, teak etc. Ammal and Durairajmuthiah (1996) estimated increased yield in rice field by composted coirpith (18.75 to 22.44 $g m^{-2}$) than raw coirpith. The beneficial effects of coirpith compost in coffee plantations were identified by Moorthy *et al.* (1996). According to them, nutrient content of composted coirpith was 1.06, 0.06 and 1.20 per cent NPK and of raw coirpith 0.26, 0.01 and 0.78 per cent NPK. The possibility of utilising coirpith, an ecofriendly natural product, for soils with poor drainage, aeration, salinity and alkalinity is recognised (Swarupa and Reddy, 1996). Earlier germination of seeds of tomato, lettuce and broccoli seed in coir dust compost than in peat was reported by Cresswell (1997).

Lokanathan and Lakshminarasimhan (1979) estimated that coir dust at @ 20 t ha^{-1} improved water retention capacity of the porous and open textured sandy soil. Mayalagu *et al.* (1983) reported that incorporation of coirpith might have reduced the bulk density and increased the infiltration rate thus improving rainfall entry and retention in soil. Maximum water holding was highest under coir waste treated plots (66.96 per cent) followed by farmyard manure application (66.26 per cent) and control (53.78 per cent). Efficiency of coirpith for rainwater conservation was proved by Ramaswamy and Sreeramulu (1983) and Rajagopal and Palchamy (1989). Soil physical characters like porosity and infiltration rate were increased by applying coir dust @ 2.5 t ha^{-1} and 5 t ha^{-1}.

Singaram and Pothiraj (1991) reported the beneficial effect of raw or composted coirpith on yield of maize and ragi in polluted soils. This was due to improvement in soil physical conditions and preventing the capillary rise of salts to the soil surface. Liyanage *et al.* (1993) explained the beneficial effects of coir dust in coconut gardens as the ability to retain moisture in the soil and better nutrient availability. Jayapaul *et al.* (1996), Joseph (1995) and Swarupa and Reddy (1996) also reported the moisture storing capacity of coirpith compost Gopinathan (1995) concluded that vertical mulching with coirpith in trenches across the slope can increase *in situ* rainwater harvest and reduce the run off upto 90 per cent over the control. The absorption trenches treated with coirpith could significantly extend the moisture availability to banana crop than those treated with municipal solid waste and farm waste.

Enhancement of cation exchange capacity (CEC) by compost application was reported by Reddy (1973). Raja and Raj (1979) and Balasubramaniyam (1981) reported the increase in CEC by applying pressmud. Ravikumar and Krishnamoorthy (1980) gave a positive relationship between organic carbon content and CEC of soil. CEC was increased from 8.60 C mol(+)kg^{-1} of soil to 9.25 C mol(+)kg^{-1} due to coirpith applied @ 10 t ha^{-1} (Clarson, 1983; Clarson *et al.*, 1983). Venkataraman (1984) proved the generation of higher concentrations of cations by adding organic materials than ~~the control~~. Increased and acceptable CEC of soil by composted pith application was also revealed by Venugopal (1995) and Cresswell (1997).

Work by Shanmugham and Ravikumar (1980) proved an increase in organic carbon content of soil by the application of organic residues in alkali soils. Considerable buildup of organic carbon in coastal sandy soils was reported by Nambiar *et al.* (1983). Pushpanathan and Veerabadran (1991) proved a higher organic carbon content by composted coirpith application than other organic manures. An increase of 0.61 per cent carbon in soil was recorded by Santhi *et al.* (1991) due to decomposed pith application. Selvi *et al.* (1991) also obtained the same result by coirpith compost over FYM application.

Increase in the available nitrogen status of the soil from 252 kg ha^{-1} to 462 kg ha^{-1} was reported due to composted coirpith application by Clarson *et al.* (1983). Ramaswamy *et al.* (1985) stated that available nitrogen in rice fields can be increased by adding coirpith compost @ 5 t ha^{-1} with 75 per cent of NPK dose. Joshi *et al.* (1985) recorded a 17 per cent increase in the soil nitrogen status by pith incorporation. Muthulakshmi (1988) reported the highest available nitrogen (138 ppm) in inoculated coir pith compared to other treatments. Studies by Loganathan (1990) revealed that composted coirpith and coirpith plus biofertilisers registered higher levels of nitrogen (211.8 and 230.7 kg ha^{-1}

respectively) in the soil over inorganic nitrogen alone (201.9 kg ha^{-1}). Santhi *et al.* (1991) estimated a 17 per cent increase in soil nitrogen by adding composted coirpith. This indicated a 25 per cent savings in amount of inorganic fertilisers required for crop growth. But the incorporation of raw coirpith alone reduced the nitrogen status (Savithri *et al.*, 1991). Selvi *et al.* (1991) also reported the results on this line. The experiments conducted by Lavanya and Manickam (1993) recorded an increased nutrient content in ragi crop by adding compost with 75 per cent of recommended dose of NPK

Mandal and Chatterjee (1972) reported a reduction in formation of insoluble iron phosphate and hence enhanced P availability in soils treated with coirpith. Mandal and Mandal (1973) also observed a lowering of iron and aluminium fixation. Desirable effects on available phosphorus content with organic matter addition was documented by Ramaswami, 1977; Paramasivam, 1979; Raja and Raj, 1979. Clarson (1983) and Clarson *et al.* (1983) reported an increase in available phosphorous content of the soil from 30 kg ha^{-1} to 35 kg ha^{-1} with composted coirpith @ 10 t ha^{-1}. According to them, this increase was due to solubilising nature of organic acids produced during decomposition. Loganathan (1990) and Nagarajan *et al.* (1991) also stated an increase in available phosphorous by coirpith compost application. They also reported positive effects on crop yields owing to higher P values. Perumual *et al.* (1991) estimated an increase in the P availability from 15.51 kg ha^{-1} by adding inorganic fertilisers alone to 17.61 kg ha^{-1} by composted coirpith and 18.44 kg ha^{-1} by composted coirpith with inorganic fertilisers. The available P content in the soil increased by 30 per cent indicating enhanced P use efficiency by composted coirpith along with NPK fertilisers (Santhi *et al.*, 1991). Selvi *et al.* (1991) also got similar results from their trial. Lavanya and Manickam (1993) reported higher P uptake by ragi crop in fields treated with coirpith compost and 75 per cent of recommend dose.

Clarson (1983) and Clarson *et al.* (1983) reported increase in the availability of potassium content from 190 kg ha^{-1} to 250 kg ha^{-1} in soils treated with @ 10 t ha^{-1} coirpith. Nagarajan *et al.* (1990) recorded increase in the potassium contents in soil from 338 kg ha^{-1} to 508 kg ha^{-1} by coirpith plus 75 per cent of the recommended dose of nitrogen. Composted coirpith profoundly increased the K contents in soil and reduced K fertiliser requirements according to Nagarajan *et al.* (1990) and Santhi *et al.* (1991). Nagarajan (1991) reported an increase from 0.72 to 11.2 per cent in K availability in soil by coirpith application in groundnut fields. Perumal *et al.* (1991) proved the beneficial effects of incorporation of composted coirpith in soil compared. Compost raised available K content to 652 kg ha^{-1}. Lavanya and Manickam (1993) estimated an increased K content in ragi crop by compost application along 75 per cent of the recommended dose of NPK. Beneficial effects of coirpith compost on groundnut, sorghum, maize and finger millet in sandy and clay loam soils and the possibility of economising K fertiliser application was reported by Savitri *et al.* (1991). Ammal and Durairajmuthiah (1996) also reported a savings of K fertiliser to the extent of 132 kg ha^{-1} in composted coirpith, 62 kg ha^{-1} in raw coirpith and 106 kg ha^{-1} in FYM added treatments. Swarupa and Reddy (1996) pointed out the possibility of utilising pith compost as a supplier of potassium for the crops since it is rich in K content.

2.7 Existing knowledge gap

Despite the positive responses of coirpith compost on crop and soil, it still has only a little acceptability among the farmers. The main reason attributed is comparatively low manurial status of conventionally produced coirpith compost. Observational studies conducted by Gopinathan (1996) revealed that coirpith compost can be further enriched by bioprocessing techniques involving locally available organic residues and waste materials. Organic meals produced by enriching coirpith with bioprocessed effluent slurry of bone based industries, showed good crop response and acceptance by farmers. A variety of other easily available organic residues like municipal solid waste, poultry and goat manure and farm yard manure can also be used for this purpose. Detailed investigation is therefore essential to standardise the enriching techniques and hence the present study.

Materials and Methods

MATERIALS AND METHODS

The investigations for preparing different types of enriched coirpith compost (ECC) through organic amendments were conducted at College of Horticulture, Vellanikkara during April 1996 to August 1997. The study consisted of 3 parts as below:

1. standardisation of amelioration techniques of ECC.

2. pot culture studies for rapid testing of the selected ECC to study the effect on plant

3. field investigation with the selected ECC, to study the effect on plant and soil.

3.1 Standardisation of amelioration techniques of coirpith compost

3.1.1 Study materials

Materials used for this part of the study were raw coirpith, Kerala Chemicals and Proteins Limited (KCPL) sludge, cowdung and municipal solid waste (MSW). Raw coirpith was collected from St. Joseph's Fibre Works, Kandassankadavu where coir fibre is being mechanically extracted. The KCPL sludge, presently a waste material, is an industrial organic effluent produced by Kerala Chemicals and Proteins (KCPL) Ltd., Thrissur during the process of manufacturing ossein from crushed animal bones. The required cowdung for the enrichment studies was procured from the University Livestock Farm, Mannuthy where animals were fed with feeds of uniform composition. Another enricher in the present study, the MSW was collected from the sorted biodegradable solid waste accumulated at the municipal trenching site, Laloor, Ayanthole, Thrissur.

Among the study materials, barring cowdung, all others are considered for the time being, as waste materials and therefore, associated with severe environmental as well as disposal problems. The source, quantity and problems due to these solid waste are furnished in Table 1. Plates 1a to 1c reflects the magnitude of field problems encountered with the present way of disposal of these materials. Tables 2, 3 and 4 provide the physico-chemical properties and composition of coirpith, KCPL sludge and MSW of Thrissur municipality, respectively.

As evident from the Tables 2 to 4 the coirpith contains 0.68, 0.026 and 0.360 per cent NP and K respectively and C:N ratio is 60:1. KCPL sludge has 1.13, 5.60 and 0.31 per cent NP and K respectively. About 80 per cent of MSW of Thrissur Municipality is biodegradable in nature and 20 per cent non-biodegradable.

Table 1. Source, quantity and problems of solid waste materials under study

Study materials	Source, quantity and problems
1. Coirpith	Coirpith, a highly lignocellulosic material is available in large quantities as a byproduct of coir industry. There are about 84,000 retting and coir extracting units in Kerala, 650 brown coir units in Tamil Nadu, Karnataka and Andhra Pradesh and 500 coir factories in Tamil Nadu (Kamaraj, 1994). Through all these units, an estimated 7.5 million tonnes of coirpith is produced annually in India. Kerala contributes 80% of this. In the coastal tract of Thrissur alone about 250 coir extraction units produce one lakh tonnes of coirpith per year. Its abundant availability and under unitlisation poses disposal as well as environmental problems. Illegal dumping of coirpiths along river banks, lakes, other water bodies and road sides are in increasing proportions every year (Plate 1). The tannins that ooze from the dumpyards during monsoon create pollution problems.
2. KCPL sludge	The Kerala Chemicals and Proteins Ltd. (KCPL) factory is situated at Kathiku dam near Koratty in Thrissur district. This is a joint sector company promoted by the Kerala State Industrial Development Corporation Ltd. in technical and financial collaboration with two leading Japanese companies viz., M/S mitsubishi Corporation and Nitta Gelatin Inc. The company produces Ossein, an intermediate product in the manufacture of gelatin and dicalcium phosphate (DCP) from crushed animal bones. The combined effluents from various sources in the factory (bone charging and washing section, Ossein washing section, DCP filtration system, laboratory etc.) are collected and subjected to different

Study materials	Source, quantity and problems
	treatments like equalisation, flash mixing, flocculation, clarification, filtration, etc. to separate the sediment sludge and clear overflow. The overflow is left out into Chalakkudy river at pH 7-7.2 and the sediment sludge is left in open. About 7-10 tonnes of filtered sludge is accumulating daily for which no effective disposal system is in vogue (Plate 2). The sludge is causing environmental problems also. Due to uncontrolled putrification processes, the sludge is emitting nauseating and asphyxiant smell to surrounding atmosphere and restrict clean and pleasant air to the company staff and near by inhabitants.
3. Municipal Solid Waste (MSW)	Thrissur municipality, with a total geographical area of 12.65 km^2 is divided into 32 administrative wards. Rapid exploratory survey revealed that the average MSW production is 1.2 kg/day/ person making the total to 90 t/day. The municipality spends about Rs.2 crores annually for the collection and disposal of MSW. A satisfactory and scientific system is not yet achieved. Presently, the entire waste materials are dumped at the dumping site at Laloor situated 3 km west to the heart of the town. The dumping site is surrounded by thickly populated residential area. In the name of `sanitary landfill' solid wastes are simply heaped since several decades (Plate 3). Heavy pathogen load, continuous release of noxious foul smelling gases from untreated garbage, breeding of mosquitoes, flies and other harmful insects etc. make the nearby inhabitants live in a dangerously unhealthy environment. Public protests are common when suffering assume intolerably high proportions which compel the administration to resort to some stop gap arrangements (Gopinathan, 1994).

Table 2. Physico-chemical properties of coirpith

	Characters	Value
1.	Bulk density (g cm^{-3})	0.15
2.	Particle density (g cm^{-3})	0.49
3.	Porosity (%)	76.70
4.	Maximum water holding capacity (%)	624.00
5.	pH	5.80
6.	Electrical conductivity (mhos/cm)	1.50
7.	Lignin (%)	37.00
8.	Organic carbon (%)	40.60
9.	Total nitrogen (%)	0.68
10.	C:N ratio	60:1
11.	Total P (%)	0.026
12.	Total K (%)	0.360
13.	Total Ca (%)	0.80
14.	Total Mg (%)	0.42
15.	Total Mn (ppm)	64.50
16.	Total Fe (ppm)	1395
17.	Total Zn (ppm)	80.00
18.	Total Cu (ppm)	45.50
19.	Total phenolic compounds (mg g^{-1})	90.00

Source: Gopinathan, 1996

Table 3. Physico-chemical properties of KCPL effluent sludge

	Characteristics	Value
1.	Colour and appearance	light to deep grey wet cobbled/flake form
2.	Bulk density (g cm^{-3})	0.61
3.	Particle density (g cm^{-3})	1.30
4.	pH	6.60
5.	Total N (%)	1.13
6.	Total P (%)	5.60
7.	Total K (%)	0.31
8.	Total Ca (%)	21.30
9.	Total Mg (%)	0.51
10.	Total S (%)	0.40
11.	Organic carbon (%)	14.30

Source: Gopinathan, 1996

Table 4. Composition of MSW in Thrissur Municipality (result of 10 random samples drawn during April to June 1996)

Refuse category		% of total weight
I.	Biodegradables	
	1. Vegetables and fruit waste	18.10
	2. Garden prunings, farm waste and house hold waste	33.00
	3. Paper and paper boards	9.10
	4. Cellulose rich materials like bamboo baskets, hard boards and wooden pieces	8.80
	5. Fish market waste	2.60
	6. Slaughter waste	3.20
	7. Cloth	1.60
	8. Residues like ash, dirt etc.	3.20
	Total	79.60
II.	Non biodegradables	
	1. Plastics	8.20
	2. Metal	3.30
	3. Glass	3.20
	4. Rubber	2.00
	5. Demolished materials like bricks, stones, cement blocks, sand particles etc.	3.70
	Total	20.40

Source: Gopinathan, 1996

Plate 1 Extent and magnitude of field problems

Plate 1a Coirpith mounds along the river banks at Kandassankadavu

Plate 1b KCPL effluent sludge being accumulated to the tune of 15 t day^{-1}


KCPL SLUDGE

Plate 1c Municipal solid waste is being dumped at Laloor trenching site @ 90 t day^{-1}

Table 5. Treatment combinations and their codes

Treatments	Treatment code	Levels of ameliorants			
		Coirpith (C)	KCPL sludge (K)	Cowdung (D)	MSW (M)
T_1	CKDM	1	1	1	1
T_2	2 CKDM	2	1	1	1
T_3	3 CKDM	3	1	1	1
T_4	4 CKDM	4	1	1	1
T_5	3/4 CKDM	3/4	1	1	1
T_6	1/2 CKDM	1/2	1	1	1
T_7	1/4 CKDM	1/4	1	1	1
T_8	C 3/4 KDM	1	3/4	1	1
T_9	C 1/2 KDM	1	1/2	1	1
T_{10}	C 1/4 KDM	1	1/4	1	1
T_{11}	CK 3/4 DM	1	1	3/4	1
T_{12}	CK 1/2 DM	1	1	1/2	1
T_{13}	CK 1/4 DM	1	1	1/4	1
T_{14}	CKD 3/4 M	1	1	1	3/4
T_{15}	CKD 1/2 M	1	1	1	1/2
T_{16}	CKD 1/4 M	1	1	1	1/4
T_{17}	Control	TNAU technique			

3.1.2 Treatments

Coirpith being the major study material, its three higher levels viz. two, three and four times than that of the other three enrichers were included besides keeping a 1:1:1:1 combination of all the four. Further, three levels viz. 75, 50 and 25 per cent of each ameliorant keeping the other three at 100 per cent, were also tried along with the TNAU technique of making coirpith compost (Bopaiah, 1991). Accordingly 17 treatment combinations were there as given in Table 5.

3.1.3 Design

17x3 completely randomised block design.

3.1.4 Enriching techniques

Enrichment of coirpith, as per the above treatments was tried in accordance with the established principle of aerobic composting.

Sorted biodegradables of MSW were chopped manually into pieces of 5-10 cm size. Coirpith collected from the factory was sieved through 4 mm sieve to remove the broken fibres and such other residues. The cowdung and KCPL sludge were made into slurry form by adding required quantity of water. To each 100 l of this slurry 10 kg of garden soil was also added as a natural source of inoculum (Golueke, 1977) of host of bacteria and other organisms.

The coirpith and MSW thus processed were mixed as per the proportions of treatments prior to composting. Pits of size 2m x 1m x 1m size were dug in open and charged with the above mix of substrates in layers of 30 cm thickness. Before, filling the pits the bottom was covered with polythene sheet. The cowdung-KCPL sludge - soil slurry prepared as above was applied in equal volume so as to make the full dose of slurry specified for that treatment, sandwitched between layers. Moisture content of the entire substrate-slurry mass was maintained at 70-80 per cent, the ideal wetness for identical situation (Gopinathan, 1996). Throughout the active phase of decomposition the required wetness was provided by sprinkling water whenever necessary. The contents of the pits were protected from sunlight, and mixed thoroughly at fortnightly interval. Pits were maintained properly till decomposition was completed and quality compost formed.

3.1.5 Observations

Daily variation of temperature and pH during the entire composting phase was observed. Qualitative observation on colour and appearance of the compost was done periodically to judge on the maturity of the composting process. Number of days required for completing the composting process was also recorded. Major nutrients N, P, K and carbon content were analysed for all sets of ECC at the final stage, besides their lignin content, following the approved procedure

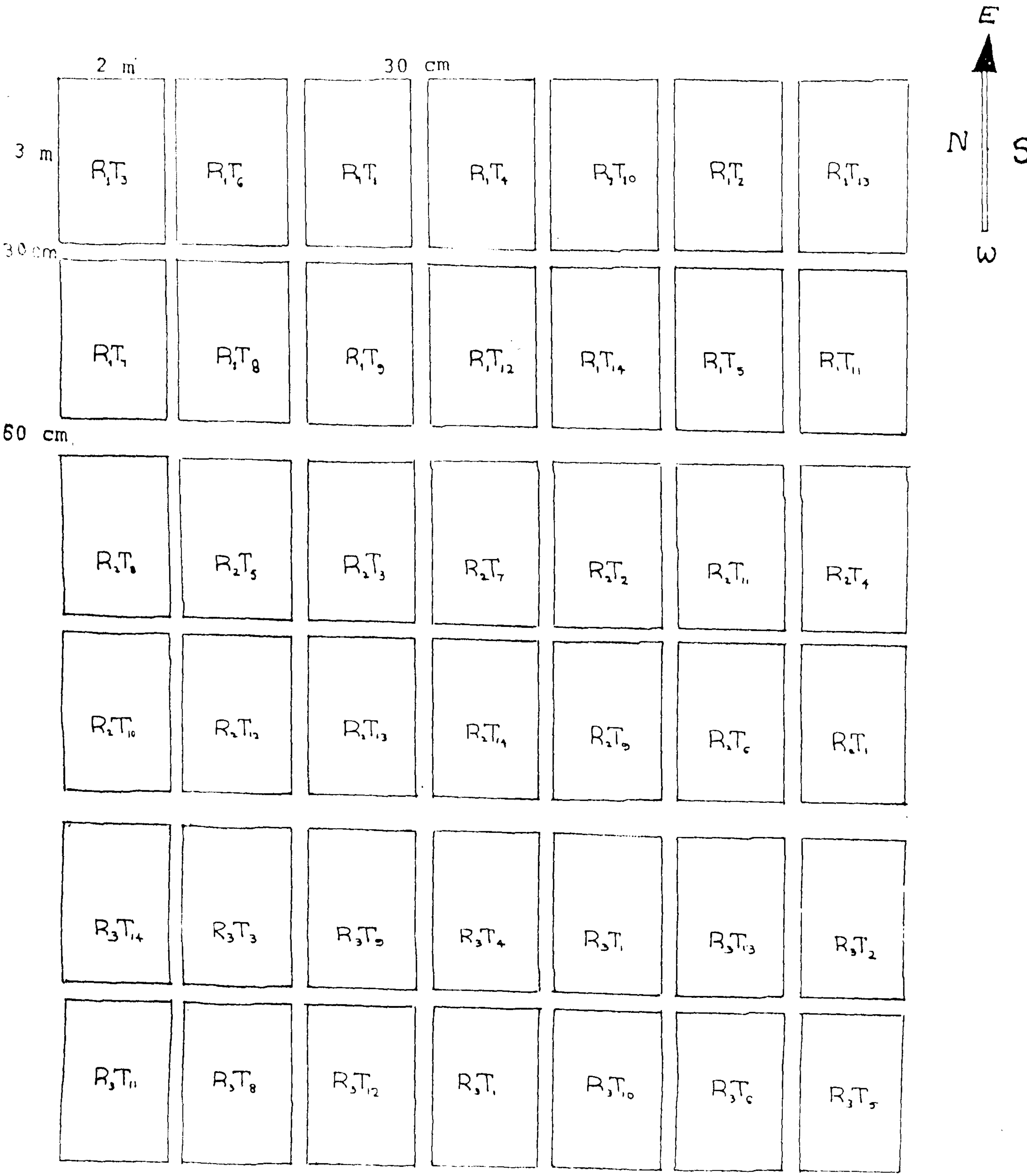
C/N ratio of each ECC was also worked out. Microbial count was observed in mesophillic, thermophillic and maturity stages following the serial dilution and plate count method (Johnson and Curl, 1972). For bacterial culturing, nutrient agar medium was used. For fungus and actinomycetes, potato dextrose and czapekdoze agar medium were used, respectively.

3.2 Pot culture studies for rapid testing of different types of ECC

A pot culture study was conducted for rapid testing of the best selected ECC prepared as above. The study was to investigate whether the chemically superior ECC was responding in a biologically matching way too. Deleterious influence of ECC on crop, if any, due to new type of enrichers [illegible] also need to be evaluated in a quick way before taking them to the field.

3.2.1 Materials

The indicator crop bhindi, variety Arka Anamika was raised in pots of 36 cm height and 30 cm diameter in which 8 kg of seived fertile topsoil was filled. Four levels equivalent to 6, 12, 24 and 36 t ha^{-1} of the best selected ECC were applied to each pot in comparison to 2 controls. In control one, soil



R_1 ——> Replication 1 R_2 ——> Replication 2

R_3 ——> Replication 3

Fig.1 Layout plan of the field trial. Design: RBD

alone was taken and in the other soil, with 12 t ha^{-1} of farm yard manure (FYM) was used. Plant were observed for the maximum height, maximum number of leaves and total number of pods produced.

The treatments were replicated thrice in CRD. The required quantities of ECC to suit the treatment levels as above were mixed with the soil for imposing respective treatments. Bhindi seeds were sown and grown properly.

3.3 Field investigation with the selected ECC on its effect on plant and soil

ECC was field tested on bhindi crop for a detailed investigation.

3.3.1 Layout of the field

Experiment was laid out near the crop museum, attached to the Department of Agronomy, College of Horticulture, Vellanikkara during November 1996 to January 1997. The land was thoroughly ploughed and plots of size 3x2 m^2 were laid out at the experimental site. Gross area of the site was 380 m^2. The layout of field is shown in Fig.1.

3.3.2 Treatments

Field experiment was conducted with fourteen treatments as given below:

Treatments	Treatment expansion
T_1	FYM 12 t/ha
T_2	ECC 6 t/ha
T_3	ECC 12 t/ha
T_4	ECC 24 t/ha
T_5	ECC 36 t/ha
T_6	ECC 12 t/ha + NPK 1/4 of the recommended dose
T_7	ECC 12 t/ha + NPK 1/2 of the recommended dose
T_8	ECC 12 t/ha + NPK 3/4 of the recommended dose
T_9	ECC 12 t/ha + NPK full dose
T_{10}	ECC 6 t/ha + NPK 1/4 of the recommended dose
T_{11}	ECC 6 t/ha + NPK 1/2 of the recommended dose
T_{12}	ECC 6 t/ha + NPK 3/4 of the recommended dose
T_{13}	ECC 6 t/ha + NPK full dose
T_{14}	Control (absolute)

3.3.3 **Design:** 14 x 3 RBD

3.3.4 Crop husbandry

Seeds of bhindi variety Arka Anamika were dibbled in trenches at a spacing of 60x30 cm. The entire quantity of ECC and ordinary coirpith compost as per the treatments were given as basal. Fertilisers were applied as per the package of practices, - crops (KAU, 1996) recommendations. It was an irrigated crop.

3.3.5 Observations

Observations as below were recorded. Plant height and number of leaves at monthly intervals, number of flowers at 60 DAS; fruit characters at 15 days interval.

Soil analysis: Available N, P and K, cation exchange capacity (CEC) and waterholding capacity (WHC).

Uptake studies: N, P and K content in plants by the end of crop season.

Cost of cultivation of each treatment.

Chemical analysis of plant and soil was done as per the standard procedure suggested by Jackson (1958). Water holding capacity was measured using pressure plate apparatus (Richards, 1947) at applied pressures of 30 k Pa and 500 k Pa.

3.4 Statistical analysis

Data generated on the various parameters of the experiment were analysed statistically by using the analysis of variance technique. In case the effects were found to be significant, Dun kans Multiple Range Test was used for making logical comparisons among treatment means (Panse and Sukhatme, 1985).

Results and Discussion

RESULTS AND DISCUSSION

4.1 Standardisation of amelioration techniques

Enriching techniques employed were basically in accordance with the principles of aerobic composting. The time series data on temperature, pH and microbial population, nutrient contents and other desirable qualities of the composted products are furnished below.

4.1.1 Temperature

The variations in temperature, due to different levels of enrichment and composting techniques pooled at weekly interval from the date of incubation till the maturity of compost is presented in Table 6. The general trend in temperature variation was a sudden hike from the ambient level to around 53°C in the first week and a further increase to above 60°C during the second and third week. There was a gradual decrease from fourth to twelfth weeks. Thereafter, the temperature attained a steady value around 30°C. Majority of the treatments attained maximum level of temperature during the second week and the rest in the third week. The temperature peak varied between 57.3°C (3CKDM) and 66.3°C (C1/4KDM). Among the weeks, between treatments there was no

Table 6. Observations on temperature of the compost pits (°C) at weekly interval

Treat-ment No.	Code	Weeks															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T_1	CKDM	30.7	49.3^{cde}	61.0	62.3	53.7	45.0^{e}	42.3	40.0	39.3	37.7	34.3^{de}	33.3	31.7^{cd}	31.3	31.3	30.7
T_2	2 CKDM	30.0	23.0^{abcd}	32.0	31.3	56.3	53.3^{abc}	45.7	44.3	38.7	38.0	34.3^{de}	33.7	33.3^{abcd}	32.3	30.7	30.7
T_3	3 CKDM	31.3	48.7^{de}	57.3	58.7	52.7	46.7^{de}	48.7	45.3	42.3	40.3	40.7^{a}	33.0	32.7^{bcd}	33.0	30.0	30.0
T_4	4 CKDM	31.7	47.7^{e}	61.7	57.0	52.0	48.7^{cde}	47.0	45.3	47.3	40.7	39.7^{abc}	32.7	32.7^{bcd}	33.0	31.0	30.0
T_5	3/4 CKDM	30.7	51.7^{bcde}	64.7	63.3	58.0	52.3^{bc}	47.7	44.3	43.3	41.7	35.0^{bcde}	34.3	33.3^{abcd}	31.7	31.7	30.0
T_6	1/2 CKDM	32.0	54.0^{abc}	65.3	64.0	56.0	56.0^{ab}	51.3	47.7	41.3	40.7	39.0^{abcd}	36.0	36.0^{abc}	32.7	30.0	29.3
T_7	1/4 CKDM	31.3	54.7^{ab}	65.3	64.0	56.0	56.0^{ab}	49.0	43.0	40.7	39.7	38.7^{abcd}	38.7	34.0^{abc}	32.7	31.7	29.7
T_8	C 3/4 KDM	30.7	49.3^{cde}	34.7	62.3	54.0	52.7^{abc}	46.3	45.0	38.0	37.7	37.7^{abcde}	33.3	31.0^{d}	32.0	30.7	29.7
T_9	C 1/2 KDM	30.3	53.0^{cde}	65.0	62.0	58.7	52.3^{abcd}	45.7	42.7	38.7	38.0	33.3^{bc}	33.3	32.0^{e}	31.3	30.7	30.7
T_{10}	C 1/4 KDM	30.3	34.0^{abc}	66.3	64.7	58.3	52.7^{abc}	47.7	43.3	43.0	41.0	40.7^{a}	37.7	36.0^{a}	31.3	31.0	30.0
T_{11}	CK 3/4 DM	31.3	54.3^{abc}	62.3	63.7	62.0	53.7^{abc}	47.0	42.0	39.7	39.0	37.0^{abcde}	32.7	32.0^{bcd}	32.7	28.0	30.0

Contd.

Table 6 (Contd.)

Treatment No.	Code	Weeks 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T_{12}	CK 1/2 DM	30.7	55.7^{ab}	64.3	63.7	60.0	56.3^{ab}	49.3	41.7	43.3	44.0	40.0^{ab}	38.7	34.7^{ab}	31.3	31.3	30.0
T_{13}	CK 1/4 DM	31.3	55.3^{ab}	64.7	60.7	61.7	52.3^{bc}	48.0	41.7	40.7	39.3	36.7^{abcde}	35.3	33.3^{abcd}	29.7	31.0	30.3
T_{14}	CKD 3/4 M	31.7	54.3^{abc}	59.7	62.3	56.3	54.0^{abc}	48.3	41.3	38.3	38.3	36.7^{abcde}	34.7	33.0^{a}	31.3	32.0	30.0
T_{15}	CKD 1/2 M	30.3	54.3^{abc}	59.7	62.3	56.3	54.0^{abc}	48.3	41.3	38.3	38.3	36.7^{abcde}	34.7	33.0^{bcd}	31.3	32.0	30.0
T_{16}	CKD 1/4 M	37.7	57.0^{a}	63.7	60.3	59.0	58.0^{a}	48.0	44.7	41.7	36.0	34.7^{cde}	34.3	31.7^{cd}	31.0	31.0	30.3
T_{17}	Control	30.7	47.7^{e}	59.7	61.3	57.3	51.3^{bcd}	48.0	45.3	31.3	38.0	35.0^{bcde}	34.3	32.0^{bcd}	31.7	30.7	30.0

Note: Treatment means in a column with the same alphabet do not differ significantly

significant difference between treatments except for first, fifth, tenth and twelfth weeks.

4.1.2 pH

Weekly variation in pH for various treatments are given in Table 7. The pH, in general, also showed an initial increase from acid range to alkaline level from the second week onwards. Then it attained a peak value within sixth week of incubation and thereafter levelled near to alkaline stage. The peak value of pH among the treatments varied from 7.1 to 7.4 (third to eighth week). However, the treatment variations were significant in most of the weeks unlike in the case of temperature.

4.1.3 Microbial population

Population of bacteria, actinomycetes and fungi at mesophilic, thermophilic and maturity stages are provided in Table 8. In general, the population of all the three types of microbes reached their peak at thermophilic stage (first to sixth week) and they decreased significantly at the maturity stage. However, the counts of all the three sets of microbes at maturity were substantially higher than those of the mesophilic stage. In all the treatments the counts of microbes in general differed significantly except for the bacteria in mesophilic stage.

Table 7. Observations on pH of the compost at weekly interval

Treat-ments	Code	Weeks 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T_1	CKDM	5.7^{e}	5.8^{d}	6.8	7.2^{abcd}	7.2	7.3	7.4^{a}	7.2	7.2	6.9^{abcd}	6.7^{d}	6.8^{cd}	6.9^{abcd}	6.8	6.7^{e}	6.9
T_2	2 CKDM	5.8^{de}	5.9^{d}	6.9^{abcde}	7.1	7.2	7.2^{abc}	7.2	7.1	6.9	6.9^{cde}	6.8^{cd}	6.8^{cd}	6.9^{abcd}	6.9	6.9^{ab}	6.9
T_3	3 CKDM	5.9^{cde}	6.4^{c}	6.8	6.9^{cde}	7.1	7.0	6.9^{c}	7.1	7.0	6.9^{bcd}	6.8^{cd}	6.8^{cd}	6.8^{bcd}	6.9	7.0^{a}	6.9
T_4	4 CKDM	6.1^{abcd}	6.4^{c}	6.7	6.9^{bcde}	7.2	7.0	7.0^{c}	7.1	6.9	6.9^{bcd}	7.0^{abc}	6.9^{bc}	6.9^{abc}	6.8	6.8^{de}	6.9
T_5	3/4 CKDM	6.1^{abcd}	6.4^{c}	6.9	7.2^{abcd}	7.3	7.1	7.1^{abc}	7.0	7.1	7.1^{ab}	7.1^{ab}	7.2^{ab}	7.0^{a}	6.9	6.8^{de}	6.9
T_6	1/2 CKDM	6.4^{a}	6.6^{abc}	6.7	6.8^{e}	7.2	7.2	7.0^{c}	7.0	7.1	7.1^{a}	7.1^{a}	7.3^{a}	7.0^{a}	6.9	6.8^{cde}	6.9
T_7	1/4 CKDM	6.1^{abcd}	6.4^{c}	6.8	7.2^{abcde}	7.2	7.3	7.1^{bc}	7.1	7.1	6.9^{bcd}	6.9^{abcd}	6.9^{cd}	6.9^{abcd}	7.0	6.9^{ab}	6.9
T_8	C 3/4 KDM	6.3^{ab}	6.4^{c}	6.8	7.2^{abcd}	7.1	7.1	7.0^{c}	7.0	6.9	7.0^{abcd}	7.0^{abc}	6.8^{cd}	6.7^{cd}	6.9	6.9^{abcd}	7.0
T_9	C 1/2 KDM	6.1^{abcd}	6.5^{bc}	6.3	7.4^{a}	7.2	7.4	7.0^{c}	6.9	7.0	7.0^{abcd}	6.9^{bcd}	6.7^{d}	6.7^{bcd}	6.9	6.8^{bcde}	6.9
T_{10}	C 1/4 KDM	6.2^{abc}	6.6^{abc}	6.8	7.3^{abc}	7.1	7.1	6.9^{c}	7.1	7.0	7.1^{ab}	7.0^{abc}	6.9^{bc}	6.9^{abc}	6.9	6.9^{ab}	7.0

Contd.

Table 7. (Contd.)

Treat-ments	Code	Weeks															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T_{11}	CK 3/4 DM	abc 6.2	ab 6.7	7.2	ab 7.4	7.4	7.1	bc 7.1	7.2	7.0	abcd 7.0	bcd 6.9	bc 6.9	ab 6.9	6.9	a 7.0	6.9
T_{12}	CK 1/2 DM	abc 6.2	ab 6.8	7.0	ab 7.3	7.4	7.3	ab 7.3	7.1	7.1	abc 7.1	abc 7.0	cd 6.8	abc 6.9	6.9	ab 6.9	6.9
T_{13}	CK 1/4 DM	ab 6.4	a 6.9	7.2	a 7.4	7.3	7.1	c 7.0	7.1	6.9	de 6.9	abcd 6.9	cd 6.9	abc 6.9	7.0	ab 6.9	7.0
T_{14}	CKD 3/4 M	abcd 6.1	c 6.4	6.9	cde 6.9	7.1	7.2	ab 7.3	7.1	7.2	cde 6.9	cd 6.8	cd 6.8	abcd 6.8	6.9	ab 6.9	7.1
T_{15}	CKD 1/2 M	abcd 6.1	c 6.4	6.8	abcd 7.2	7.2	7.2	bc 7.1	7.0	6.9	e 6.7	abcd 6.9	cd 6.9	bed 6.8	6.8	abcd 6.9	7.0
T_{16}	CKD 1/4 M	bcde 6.0	c 6.3	7.1	abcde 7.1	7.2	7.1	c 7.0	6.9	6.9	de 6.9	cd 6.8	cd 6.8	d 6.7	6.9	bcde 6.8	6.9
T_{17}	Control	bcde 6.0	c 6.3	6.9	de 6.9	7.1	7.0	c 7.0	6.9	6.9	de 6.9	abc 7.0	bc 7.0	ab 6.9	6.9	abcd 6.9	6.9

Note: Treatment means in a column with the same alphabet do not differ significantly

Table 8. Observations on microbial population (10^5 CFU) in the compost

Treat-ments	Code	Mesophyllic stage			Thermophyllic stage			Maturity stage		
		Bacteria	Actinomycetes	Fungi	Bacteria	Actinomycetes	Fungi	Bacteria	Actinomycetes	Fungi
T_1	CKDM	53.67	3.67^{efg}	42.67^{a}	286.0^{a}	163.3^{a}	44.00^{bcde}	97.00^{bcd}	43.00^{a}	47.00^{a}
T_2	2 CKDM	44.00	2.07^{fg}	38.00^{ab}	206.3^{b}	116.0^{cd}	40.00^{bcdef}	56.67^{d}	40.67^{abc}	38.00^{abc}
T_3	3 CKDM	43.00	1.67^{g}	37.00^{ab}	116.7^{c}	117.3^{cd}	31.35^{df}	98.33^{bcd}	26.00^{d}	34.00^{bcd}
T_4	4 CKDM	42.00	2.33^{g}	42.33^{a}	197.0^{b}	110.0^{cd}	30.33^{f}	70.67^{e}	33.67^{abcd}	37.00^{abc}
T_5	3/4 CKDM	57.00	6.00^{cdefg}	34.00^{ab}	358.7^{a}	112.7^{cd}	51.33^{abc}	120.00^{a}	36.33^{abcd}	42.00^{ab}
T_6	1/2 CKDM	46.33	10.33^{abcd}	30.33^{bc}	334.3^{a}	105.7^{d}	45.33^{bcd}	111.33^{ab}	34.00^{abcd}	37.67^{abc}
T_7	1/4 CKDM	40.67	9.67^{abcde}	29.67^{bc}	331.0^{a}	108.3^{cd}	38.67^{cdef}	89.67^{cd}	30.67^{bcd}	33.33^{bcd}
T_8	C 3/4 KDM	49.67	13.00^{a}	32.07^{ab}	351.7^{a}	150.7^{a}	62.00^{a}	100.67^{bcd}	33.00^{abcd}	34.33^{bcd}
T_9	C 1/2 KDM	51.67	$7.00^{abcdefg}$	32.33^{ab}	327.7^{a}	126.7^{bc}	51.67^{ab}	104.67^{bc}	35.67^{abcd}	35.00^{bcd}
T_{10}	C 1/4 KDM	37.00	12.00^{abc}	31.33^{b}	313.3^{a}	119.0^{bcd}	40.67^{bcdef}	89.00^{cd}	42.00^{ab}	42.33^{ab}

Contd.

Table 8. (Contd.)

Treatments	Code	Mesophyllic stage: Bacteria	Mesophyllic stage: Actinomycetes	Mesophyllic stage: Fungi	Thermophyllic stage: Bacteria	Thermophyllic stage: Actinomycetes	Thermophyllic stage: Fungi	Maturity stage: Bacteria	Maturity stage: Actinomycetes	Maturity stage: Fungi
T_{11}	CK 3/4 DM	36.00	11.00 abcd	33.33 ab	336.7 a	124.7 bcd	61.00 a	95.33 cd	35.00 abcd	30.33 bcd
T_{12}	CK 1/2 DM	42.00	5.00 defg	29.6 bc	318.0 a	107.0 d	43.33 bcde	65.67 d	41.00 abcde	26.33 cd
T_{13}	CK 1/4 DM	48.33	7.00 abcdefg	21.00 c	327.7 a	113.3 cd	37.67 def	93.67 bcd	35.00 abcd	29.33 cd
T_{14}	CKD 3/4 M	35.33	9.00 abcdef	20.67 c	295.7 a	106.0 cd	37.00 def	95.00 ef	39.33 abc	32.33 bcd
T_{15}	CKD 1/2 M	34.67	6.33 bcdefg	20.00 c	329.3 a	109.0 cd	32.00 ef	90.33 cd	27.00 d	31.00 bcde
T_{16}	CKD 1/4 M	31.00	12.67 ab	34.67 ab	107.3 a	105.3 d	40.33 bcdef	59.67 c	34.67 abcd	29.23 cd
T_{17}	Control	33.67	10.67 abcd	29.33 bc	305.0 a	108.3 cd	46.67 bcd	33.33 f	30.33 cd	23.33 d

Note: Treatment means in a column with the same alphabet do not differ significantly

The population range for bacteria at thermophilic stage varied between 116.7x10^5 (3CKDM) to 358.7x10^5 (3/4CKDM). This highest count was also on par with others except treatments 2CKDM, 3CKDM and 4CKDM. Similarly peak value of actinomycetes in the thermophilic stage varied between 105.3x10^5 (CKD1/4M) and 163.3x10^5 (CKDM). For fungi the range was between 30.33x10^4 (3/4CKDM) and 62x10^4 (CK3/4 DM). In mesophilic phase, the peak value never exceeded 57x10^5 (3/4CKDM), 13x10^5 (C3/4KDM), and 42.67x10^4 (CKDM), respectively for bacteria, actinomycetes and fungi. The upper limits for these microbes were 120x10^5 (3/4CKDM), 43x10^5 (CKDM), and 47x10^4 (CKDM) respectively at maturity phase.

4.1.4 Major nutrient contents

The contents of major nutrients such as N, P, K, Ca and Mg in the composted samples at the end of maturity phase is reported in Table 9. Perusal of data showed that the treatment CKDM had the highest amount of nitrogen (1.56 per cent) followed by C3/4KDM with 1.47 per cent nitrogen. In the case of phosphorus content, treatment C3/4KDM recorded the highest value of 3.21 per cent followed by treatments 1/4CKDM, C3/4KDM, CKDM, 1/2CKDM and 3/4CKDM which were statistically on par with each other. Treatment CK3/4DM with 0.94 per cent potassium content had the highest K content followed by CKDM, 2CKDM, 4CKDM and CKD3/4M which were on par. Considerably high value of calcium content was recorded in treatment 1/4 CKDM

Table 9. Major nutrients (%) is compost samples at maturity phase

Treat- ments	Code	Nitrogen	Phos- phorus	Pota- ssium	Calcium	Magne- sium
T_1	CKDM	1.56 a	3.07 a	0.90 ab	3.43 ab	0.19 a
T_2	2 CKDM	1.30 ef	2.02 c	0.88 ab	3.04 cd	0.19 c
T_3	3 CKDM	1.09 h	2.02 c	0.81 bc	2.14 fg	0.12 k
T_4	4 CKDM	1.09 h	1.59 e	0.86 ab	1.83 g	0.17 e
T_5	3/4 CKDM	1.41 bc	3.02 a	0.67 de	3.07 bc	0.19 b
T_6	1/2 CKDM	1.37 cde	3.04 a	0.75 cd	3.32 abc	0.17 d
T_7	1/4 CKDM	1.40 bcd	3.08 a	0.65 de	3.61 a	0.17 e
T_8	C 3/4 KDM	1.47 b	3.07 a	0.66 de	2.67 de	0.16 f
T_9	C 1/2 KDM	1.32 def	1.91 cd	0.61 e	2.37 ef	0.15 i
T_{10}	C 1/4 KDM	1.21 g	1.74 de	0.60 e	2.04 fg	0.15 h
T_{11}	CK 3/4 DM	1.43 bc	3.21 a	0.94 a	3.01 cd	0.16 f
T_{12}	CK 1/2 DM	1.32 def	2.57 b	0.84 abc	2.41 ef	0.16 f
T_{13}	CK 1/4 DM	1.25 fg	2.57 b	0.81 bc	2.35 ef	0.14 j
T_{14}	CKD 3/4 M	1.30 ef	2.57 b	0.85 ab	3.01 cd	0.15 j
T_{15}	CKD 1/2 M	1.25 fg	2.39 b	0.75 cd	3.01 cd	0.15 i
T_{16}	CKD 1/4 M	1.31 ef	2.42 b	0.67 de	3.01 cd	0.15 g
T_{17}	Control	1.05 h	0.10 f	0.61 e	0.47 h	0.12 k

Treatment means in a column with the same alphabet do not differ significantly

(3.61 per cent) which was on par with CKDM and 1/2 CKDM. Treatment CKDM had the highest magnesium content of 0.193 per cent. This was followed by treatment 3/4CKDM and 2CKDM. However, in all theses cases, the control treatment recorded the lowest nutrient content.

4.1.5 Organic carbon, C:N, Lignin and Moisture content

The organic carbon content, C:N, lignin and moisture content of the composted samples at the end of maturity phase is given in Table 10. In general, the control treatment recorded the highest organic carbon, C:N and lignin content. Organic carbon content ranged from 24.59 per cent for treatment CKDM to 29.30 per cent for the control treatment. In the case of C:N ratio, also CKDM and C3/4KDM recorded the lower values of 15.76 and 17.07, respectively. The values for lignin content varied between 3.30 (CK3/4DM) to 7.58 per cent (control treatment). The highest moisture content (47.42 per cent) was recorded for treatment 3CKDM which was on par with treatment 2CKDM with 46.83 per cent moisture. There was no wide variation among these treatments in moisture content. Percentage components in ECCs and ordinary coirpith compost is given in Fig.2. Plate 2 provides visual observation of the non-composted raw coirpith and enriched coirpith using this technique.

Table 10 Observations on oranic carbon, C:N ratio, lignin and moisture content (%) in compost

Treat-ments	Code	Organic carbon	C:N ratio	Lignin	Moisture
T_1	CKDM	24.59 d	15.76 h	3.55 de	46.23 bc
T_2	2 CKDM	25.53 cd	19.59 cde	4.01 c	46.83 ab
T_3	3 CKDM	27.70 b	24.99 b	4.54 b	47.42 a
T_4	4 CKDM	27.60 b	25.48 b	4.55 b	46.25 bc
T_5	3/4 CKDM	25.89 c	18.36 efg	4.74 b	45.58 cde
T_6	1/2 CKDM	25.20 cd	18.46 efg	3.93 cd	45.57 cde
T_7	1/4 CKDM	25.17 cd	17.98 fg	3.62 cde	45.37 cde
T_8	C 3/4 KDM	25.15 cd	17.07 gh	3.51 de	45.92 bc
T_9	C 1/2 KDM	24.87 cd	19.08 gh	3.41 de	46.[illegible]3 bc
T_{10}	C 1/4 KDM	24.84 cd	20.53 c	3.37 e	46.10 bc
T_{11}	CK 3/4 DM	24.60 d	17.21 g	3.30 e	45.83 bed
T_{12}	CK 1/2 DM	24.55 d	18.56 defg	3.51 de	46.11 bc
T_{13}	CK 1/4 DM	25.13 cd	20.06 cd	3.71 cde	46.15 bc
T_{14}	CKD 3/4 M	24.90 cd	19.29 cdef	3.54 de	46.34 bc
T_{15}	CKD 1/2 M	25.09 cd	20.13 c	3.64 cde	44.52 c
T_{16}	CKD 1/4 M	25.53 cd	19.47 cdef	3.45 e	44.59 e
T_{17}	Control	29.30 a	28.21 a	7.58 a	44.79 dc

Treatment means in a column with the same alphabet do not differ significantly

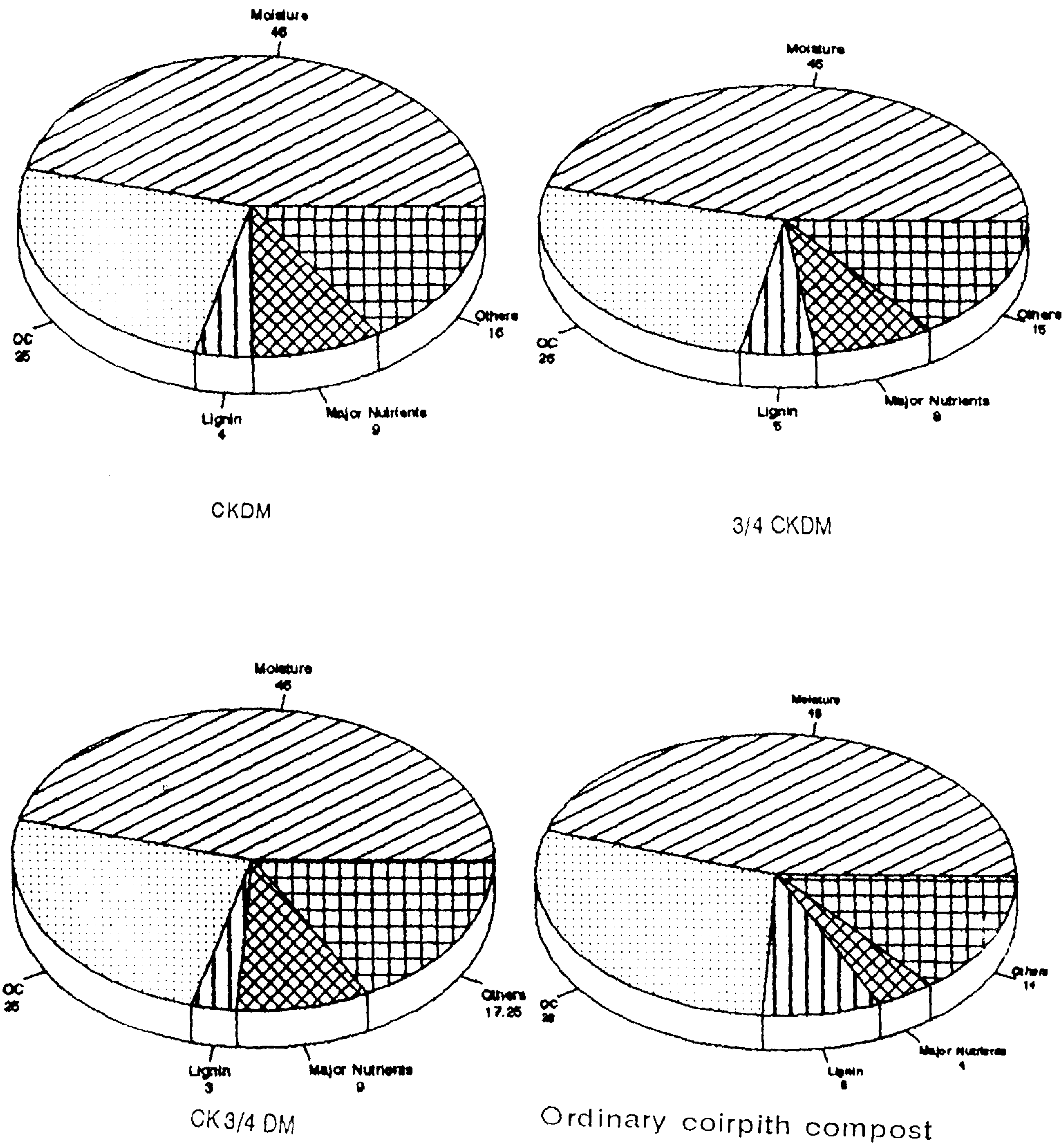


Fig.2 Percentage components present in enriched coirpith composts and ordinary coirpith compost

Plate 2 Enriched coirpith compost and raw coirpith


ENRICHED COIRPITH COMPOST
COIRPITH

The end product of any composting technique is a microbiologically processed and stable organic matter which is qualitatively superior to the initial substrate. This is called compost. The acceptability and utility of compost in agriculture is basically determined by its nutrient content and other desirable characters. In the present study, out of the 16 levels of enrichments tried, almost all of them were, in general, found superior to the standard practice of composting of coirpith both in terms of major nutrient contents, low level of C:N and lignin content. Therefore, all the enrichment techniques need appreciation and are advisable for improving the utility of coirpith. However, the best three of the 16 sets of treatments based on their nutrient contents and desirable characters namely, T_1 (CKDM), T_5 (3/4CKDM) and T_{11} (CK3/4DM) are selected along with the control to discuss the processes and influence of enrichment technique in order to avoid the bulk in interpretation of the data and also for imparting brevity and clarity in the inference.

Figure 3 depicts the variations in temperature, pH and the microbial population in the three best selected treatments and control. The temperature curves reflect a classical pattern of sequential microbiological processes involved in aerobic composting through mesophilic, thermophilic and subsequent maturing processes. This is characterised by the initial temperature hike in the mesophilic range (varying from

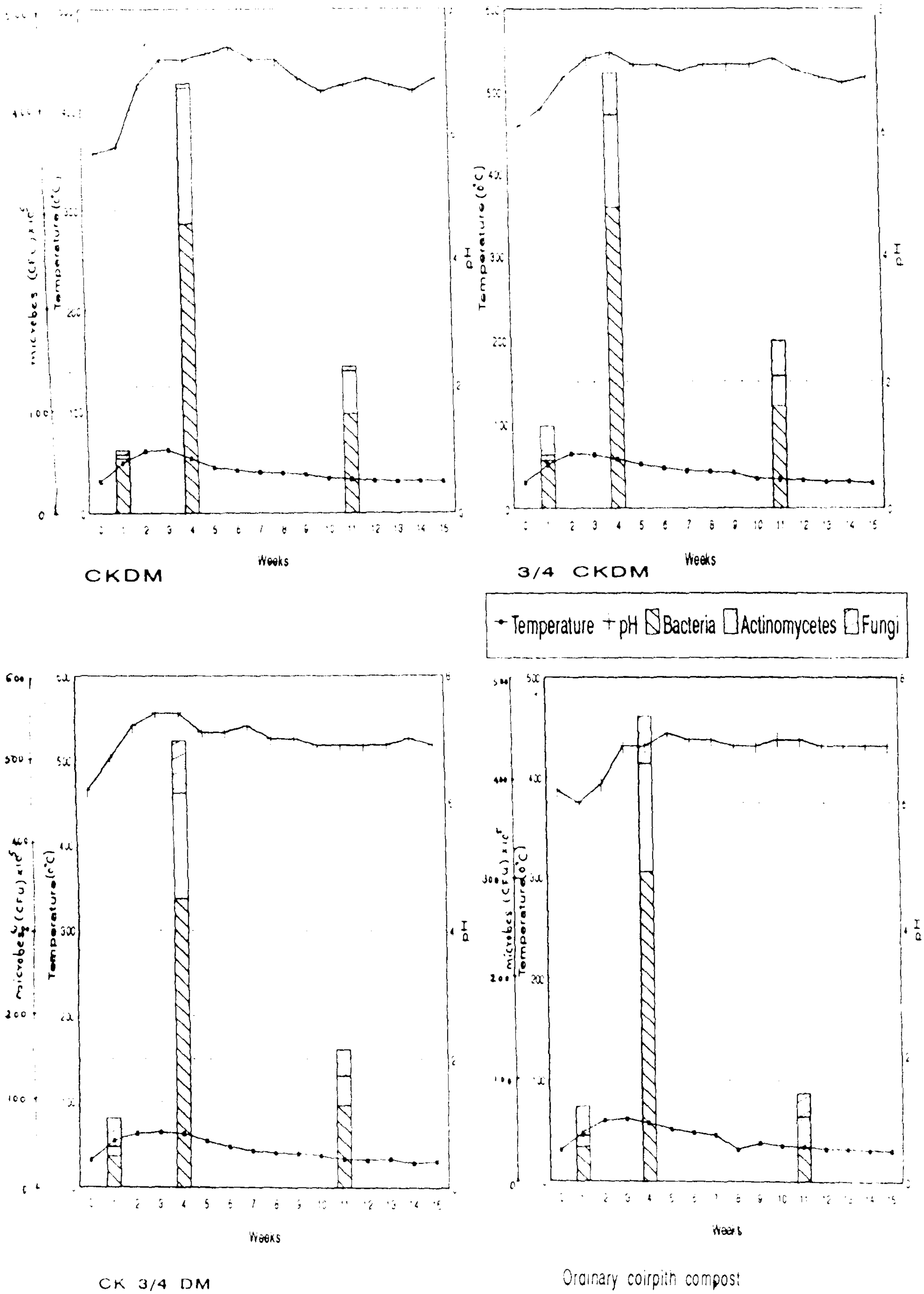


Fig.3 Pattern of variation in temperature, pH and microbes over time

30 to 40°C), a consequent peak in the thermophilic stage (57.3 to 66.3°C) and stabilisation around the ambient temperature during the maturity phase. Though the cut off points between these stages in general are not so sharp, and they often tend to blend into the next, there is perceptible difference in the temperature variation in various stages for all the treatments. This trend is more pronounced, in majority of enriching treatments despite, the proportion and nature of the enriching substrate as compared to the major substrate, coirpith. Similarly, there was slight decrease in temperature levels especially at the thermophilic phase with the enrichment treatments namely T_3 (3CKDM) and T_4 (4CKDM), where the proportion of coirpith was 3 and 4 times, respectively than the rest. These informations are indicative of the fact that enriching materials do enhance the composting process of coirpith by favouring the microbial population build up. Gaur *et al.* (1995) and Moorthy *et al.* (1996) also reported similar results in composting.

Aerobic composting is essentially a biological process involving a host of microorganisms ranging from bacteria, actinomycetes and fungi. It is also a dynamic process brought about by the succession of a set of microbes with specific roles and functions but extremely interrelated in the total process of composting (Biddlestone and Grey, 1985 and Gaur, *et al.*,1995). During composting both quantitative and qualitative changes occur in the substrate as well as active flora because of various biochemical conversions or relatively complex organic forms to simpler and stable forms. Infact, this is an assimilation process, where by the microbial population by themselves get flourished at the expenditure of stored energy of the substrate. Liberation of heat energy therefore, is reflective of the rate and quantum of conversion process accelerated by microbial colonies.

As evident from Figure 3 the trend and extent of microbial proliferation is almost comparable with all the enrichment techniques. For example, the peak population range for bacteria at thermophilic stage, varied around 330×10^5 in almost all the enrichment techniques except in 3CKDM where the proportion of the coirpith was 3 times higher than the enrichers. Also in 4CKDM (197×10^5) and in control (305×10^5) the thermophilic bacterial peak was significantly lower to others. Similarly the thermophilic peak value of actino mycetes varied around 120×10^5 in all the enriched treatments except in CK1/4DM. In control also, this was significantly lower than many others. With the case of fungi, though this much generalisation was not possible, majority of the enrichment techniques nursed and maintained maximum population.

The temperature variation as observed above are, in general, in accordance with the proliferation levels of microflora. When composting begins, i.e., from zero to first week, mesophilic flora, predominate and predisposes a favourable environment for the other flora to get themselves activated. This results in increased oxidation process and the resultant temperature which attract the thermophilic flora to multiply. The increased population of bacteria during the mesophilic as well as the initial stages of thermophilic is therefore understandable. They are associated mostly with the degradation of carbohydrates into nitrogen rich proteins, and much simpler substances. Actinomycetes thrive better at the thermophilic stages (Gaur *et al.*, 1995) and degrade cellulose rich materials. Lipid and lignin degrading bacteria do also get flourished at this stage which help in the breakdown of longchain polysaccharides, lignin and hemicellulosic substances. The sequential and series of biochemical processes happening at both the mesophilic and thermophilic stages therefore, do offer better explanation for changes in temperature as well as microbial population.

Fungi also have their role in almost equal proportions in all the stages but become slightly predominated at maturity stage. Majority of this group of organisms are saprophytic and convert partially decomposed organic forms to stable products. Once decomposition process start stabilised, there leaves little raw substrates to get disintegrated and therefore, microbial activity also diminishes to that extent.

The low and nearly steady state of temperature at the maturity phase is hence explainable. Gloueke (1977) and Gaur *et al.* (1995) also corroborated the same trend in temperature changes.

The general pattern of pH variation as evident from Figure 3 is also reflective of the above processes. Initial increase from acid range around 6 to alkaline level from 2nd week onwards and its consequent stabilisation at the neutral level towards the maturity phase is exactly in accordance with the established processes of composting (Biddlestone and Gray 1985, Gloueke, 1977). There is an intrinsic relationship of temperature, microbial population and pH variation with time during composting. This finding is also supportive to the fact that enriching techniques ensure appropriate environment for the composting processes (Gaur *et al.*, 1995).

The contents of Table 11 on the period required for completion of composting is an inference derived from the Tables 6, 7 and 8. It is inferred that the period required for composting remains more or less around 90 days with majority of the treatments. Even with the control, where, fungal inoculum (Bopaiah, 1991) was provided, it required 98 days to complete the composting process. This strongly signals that without introducing any inoculum, coirpith can be composted and enriched by following the present technique. The days required for composting can even be reduced to 84 days as

Table M Average number of days required for completion of composting process under various enrichment techniques

Treatments	Code	Days required
T_1	CKDM	84
T_2	2 CKDM	91
T_3	3 CKDM	98
T_4	4 CKDM	98
T_5	3/4 CKDM	91
T_6	1/2 CKDM	91
T_7	1/4 CKDM	98
T_8	C 3/4 KDM	98
T_9	C 1/2 KDM	91
T_{10}	C 1/4 KDM	91
T_{11}	CK 3/4 DM	91
T_{12}	CK 1/2 DM	98
T_{13}	CK 1/4 DM	98
T_{14}	CKD 3/4 M	91
T_{15}	CKD 1/2 M	98
T_{16}	CKD 1/4 M	84
T_{17}	Control	98

revealed from treatments CKDM and CKD1/4M in the present study.

There are reports by Gaur *et al.*, 1995 on accelerated composting through introduced inoculum. But the present observation on ineffectiveness of inoculum can also be supported by many known documentary evidences (Gloueke, 1977 and Finstein and Moris, 1975). This ineffectiveness can be due to the fact that isolated fungal culture as done in control treatment can be comparatively less efficient than the cowdung - KCPL sludge - soil slurry mix given to all the enrichment treatments. This slurry can harbour nurse and help to multiply a host of natural microbes involving bacteria actinomycetes, and fungi which are essential for the sequential degradation of any composting material. Further, it is also known that (Gaur ad Sadasivam, 1980 and Gloueke, 1977) as the diversity of substrate material increases, there can be an infinitive number of microbial strains to act upon. Therefore, single strain inoculum, will be much inferior to a multistrain natural source as that of the present one through a mixture of coirpith, cowdung, municipal solid waste and KCPL sludge. The results of the present experiment therefore, strongly signal on the possibility of composting even such lignin rich material like coirpith within comparatively short span of time without going for introduced inoculum. The substantially higher content of calcium, and satisfactory level of phosphorus, available with KCPL sludge, one of the enriching materials might also have contributed to the fast multiplication of desirable forms of microbes. Same line of inference was also made by Gaur *et al.*, 1980.

In addition to the observed speedy and effective composting process as evident from the above observations, the enriched materials also significantly influenced the nutrient contents and other desirable characters of composted coirpith. Figure 3 and Tables 9 and 10 are reflective of this. Composting of bulky organic materials themselves will increase nutrient status of the composted product even with materials of inherently low nutrient contents. This is because of concentration effect due to the biodegradation of the organic matter of the material (Gloueke, 1977). As evident from the Figure 2 and Table 9 even with the ordinary coirpith compost, there was an increase of nutrients over the raw coirpith (Table 2) due to standard technique of composting. There was also a reduction of 89 per cent lignin and 66 per cent C:N ratio with this. These qualitative improvements are imparted to raw coirpith due to corresponding reduction in organic carbon content.

The influence of this concentration effect can partly be attributed to the observed increase in all the major nutrients and also the reduction in undesirable effects in all the ECCs. But this alone will not hold good for explaining a substantial 3 fold increase of major nutrient contents with majority of the ECCs. The contribution through the individual enrichers assumes importance here. Of the enrichers, the KCPL sludge is a nutrient rich material as detailed in Table 3. Similarly the other enrichers like cowdung and MSW can also influence the quality and nutrient content of the ECC corresponding to their inherent nutrient status. In all the selected 3 ECCs the proportion of KCPL sludge, the best enricher, is at unity and therefore its proportional higher content can also tell much on the observed high nutrient status of the selected study material. The decrease in organic carbon and lignin content was also more pronounced to almost half than that of the composted coirpith. This can be due to the initial low lignin content proportional to the ratio of other enriched materials in the selected ECCs. Further, the higher microbial population and faster rate of decomposition as observed in previous sections could also have effected this.

The moisture content in all the ECCs and the ordinary coirpith compost was around 46 per cent. This is a comfortable level of wetness in handling and applying the ECCs as a potential organic manure.

The uniform content of moisture, in all the ECCs and coirpith compost will further support the view that the increased nutrient content is mainly due to corresponding enrichers.

From the above observations and inferences it can be concluded that all the selected ECCs are much superior to the ordinary coirpith compost both in terms of nutrient content and other desirable characters. Among the best selected 3 ECCs, CKDM is comparatively superior to others as it contains the highest content of nitrogen (1.56 per cent), phosphorus (3.07 per cent) and magnesium (0.19 per cent) and the lowest C:N (15.76).

4.2 Pot culture studies

Rapid test to determine the suitability of the best selected ECC (CKDM) was done in pot culture study. This was an exploratory trial and therefore only the major growth characters of the test plant alone were observed and the data are provided in Table 12.

Maximum plant height at 90 DAS, the maximum number of leaves at 60 DAS and the number of pods per plant as influenced by different treatments are given in Table 12. Analysis of variance showed that plants which received ECC 36 t ha^{1} was superior in all these characters. ECC 24 t ha^{1}

Table 12. Observations on maximum plant height, maximum number of leaves and total number of pods per plant for different treatments in pot culture studies

Treatments	Plant height (cm)	Number of leaves	Number of pods per plant
ECC 6 t ha^{-1}	47.17^{cd}	7^{cd}	7^{b}
ECC 12 t ha^{-1}	50.30^{d}	11^{bc}	8^{b}
ECC 24 t ha^{-1}	121.00^{a}	13^{b}	11^{a}
ECC 36 t ha^{-1}	126.30^{a}	19^{a}	11^{a}
Control-1 (FYM 12 t ha^{-1})	70.3^{b}	10^{c}	8^{b}
Control-2 (absolute)	47.67^{c}	4^{d}	6^{c}

Treatment means in a column with the same alphabet do not differ significantly

and 36 t ha^{-1} recorded maximum yield and the lowest with absolute control. Maximum plant height and number of leaves was recorded for plants receiving ECC 36 t ha^{-1} with values 126.3 cm and 19 respectively.

Table 12 revealed that there was increase in all the major characters of plant growth with increasing doses of ECC. With the lowest level of 6 t ha^{-1} of ECC, the maximum plant height, number of leaves and total number of pods per plant were 47.71 cm, 7 and 8, respectively. But the response with regard to plant height was almost 3 times higher in pots treated with 36 t ha^{-1} of ECC. Hence the plants reached an average height of 126.3 cm. The maximum number of leaves and total number of pods were also the highest with this treatment with respective values of 19 and 11. However, with regard to number of pods, both the levels of 24 t ha^{-1} and 36 t ha^{-1} recorded the same value of 11 pods per plant. The treatment control 1 was inferior to majority of the enrichment treatments. The second control namely FYM 12 t ha^{-1} was almost comparable with that of the ECC 12 t ha^{-1} in number of leaves and pod yield.

4.3 Field studies

4.3.1 Growth parameters and yield

1. Plant height

The data on plant height at 30 DAS, 60 DAS and 90 DAS is given in Table 13. Analysis of variance on plant height showed that there was significant difference between treatments in all stages. At 30 DAS treatments T_9 (28.67 cm), T_5 (27.00 cm) ad T_4 (24.67 cm) were found to be significantly taller than all others. Maximum plant height was recorded for T_9 at 60 DAS and 90 DAS with values 99.47 and 109.33 cm, respectively. At these stages, T_7, T_5 and T_4 though slightly inferior to T_9, were significantly superior over others.

2. Number of leaves

Observations on number of leaves as influenced by different treatments are presented in Table 14. At 30 DAS, plants receiving 12 t ECC with full NPK (T_9) showed significantly higher number of leaves which was closely followed by T_4 and T_5. The same trend was followed by the treatments at 60 and 90 DAS also. Average number of leaves per plant varied from 3 in control plot to 9 in T_9 by the end of crop period.

Table 13. Average height of plants (cm) under different treatments at monthly intervals

Treatment	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
T_1	26.50 ab	52.67 bc	53.83 b
T_2	22.83 cd	43.00 d	43.67 c
T_3	23.20 cd	57.83 b	57.83 bc
T_4	24.67 bc	93.50 a	103.25 a
T_5	27.00 a	95.50 a	100.00 a
T_6	21.00 def	44.33 cd	45.00 c
T_7	25.50 be	92.53 b	93.03 b
T_8	20.00 ef	60.67 b	60.67 bc
T_9	28.67 a	99.47 a	109.33 a
T_{10}	21.33 def	44.83 cd	45.17 c
T_{11}	21.50 def	55.27 b	55.33 bc
T_{12}	22.16 de	52.10 bcd	55.33 bc
T_{13}	21.58 def	51.70 bed	52.08 bc
T_{14}	19.50 f	44.17 cd	44.42 c

Treatment means in a column with the same alphabet do not differ significantly

Table 14. Number of leaves as influenced by different treatments at monthly intervals

Treatment	Number of leaves		
	30 DAS	60 DAS	90 DAS
T_1	4.00 d	10.00 bcd	5.67 cdef
T_2	4.67 cd	9.33 bcde	5.33 cdef
T_3	5.00 cd	11.66 ab	6.67 bcd
T_4	7.00 b	12.00 abc	8.00 ab
T_5	7.33 ab	12.67 ab	8.33 ab
T_6	4.67 cd	8.00 def	6.33 bcde
T_7	5.33 c	5.67 f	4.33 def
T_8	5.00 cd	9.00 cdef	5.00 def
T_9	8.00 a	13.67 a	9.00 a
T_{10}	4.33 cd	6.00 ef	7.67 abc
T_{11}	4.67 cd	7.00 def	5.33 def
T_{12}	5.00 cd	8.00 def	4.00 ef
T_{13}	5.00 cd	10.33 def	5.33 def
T_{14}	4.00 d	7.00 def	3.33 f

Treatment means in a column with the same alphabet do not differ significantly

3. Number of flowers

Total number of flowers produced by different treatments is shown in Table 15. Effect of T_7 in inducing flowers was found to be highly significant. Average number of flowers produced by this treatment was 13. This was closely followed by T_4 and T_5 which are on par with each other. The flower production in these treatments was 12.00. The control plot with the value 8 was the lowest.

4. Fruit length

The data in Table 15 show details of fruit length for different treatments at 15 days interval. Treatments T_9, T_5 and T_4 were found to be superior to others. Fruit length varied between 18.37 and 18.83 at 60 DAS and between 16.87 and 17.23 at 90 DAS. Effects of T_5 and T_4 were statistically on par in most of the stages.

5. Girth of fruit

Observations on average girth of fruit is presented in Table 16. T_4 and T_5 produced the boldest fruits with a girth of 6.83 cm at 60 DAS. Thereafter, the maximum girth was recorded with T_7.

Table 15. Number of flowers and fruit length (cm) as influenced by different treatments

Treatments	Number of flowers	Fruit length (cm)		
		60 DAS	75 DAS	90 DAS
T_1	9.97 cde	11.83 cd	15.60 abcd	11.13 ef
T_2	9.00 cde	13.43 bc	15.90 abc	10.43 f
T_3	11.00 abc	12.30 cd	15.87 abc	11.30 ef
T_4	12.00 ab	18.36 a	15.97 abc	17.07 a
T_5	12.00 ab	18.36 a	16.03 ab	17.23 a
T_6	9.33 cde	14.27 b	15.67 ef	13.80 bc
T_7	13.00 a	18.83 a	14.97 abc	16.87 a
T_8	10.00 bcde	11.67 cd	16.07 f	13.80 bc
T_9	10.33 bcd	14.27 b	16.07 a	14.40 b
T_{10}	8.33 de	11.87 cd	15.60 abcd	14.27 bc
T_{11}	9.00 cde	11.60 cd	15.47 cde	12.80 cd
T_{12}	9.00 cde	12.00 cd	15.83 abc	13.00 cd
T_{13}	9.00 cde	11.83 cd	15.87 abc	12.23 de
T_{14}	8.00 e	10.17 d	15.53 bcde	10.97 ef

Treatment means in a column with the same alphabet do not differ significantly

Table 16. Average girth (cm) of fruit as influenced by different treatments

Treatment	Average girth (cm)		
	60 DAS	75 DAS	90 DAS
T_1	3.97 def	5.60 abcd	7.33 bcd
T_2	4.27 cdef	5.30 def	4.27 bcde
T_3	4.73 c	5.77 abcd	4.47 bc
T_4	6.83 a	5.87 abc	4.10 cde
T_5	6.83 a	6.03 ab	4.53 b
T_6	4.80 c	5.07 ef	3.27 f
T_7	4.20 cdef	6.07 a	5.20 a
T_8	4.43 cde	4.97 f	4.13 cde
T_9	5.90 b	5.97 abc	4.10 cde
T_{10}	4.60 cd	5.60 abcd	4.13 cde
T_{11}	3.77 ef	5.47 cde	4.57 b
T_{12}	3.70 f	5.83 abc	4.27 bcde
T_{13}	3.91 ef	5.87 abc	3.97 de
T_{14}	5.70 b	5.53 bcde	3.93 e

Treatment means in a column with the same alphabet do not differ significantly

6. Yield

Data on yield of bhindi are presented in Table 17. Maximum yield of 4.27 kg $plot^{-1}$ (7 t ha^{-1}) was recorded in T_9. This was on par with T_7 and T_8. Treatments T_4 and T_5 were statistically on par but were inferior to T_7, T_8 and T_9. Control plot recorded the lowest yield of 0.39 kg plot (0.65 t ha^{-1}). Anova table for the field studies is presented in Appendix-2 and 3.

The biological expressions of the test crop, bhindi, both in the pot culture as well as in the field experiment are conformatory to the fact that the enriched coirpith compost is a good organic source of nutrients. The highest plant height of (126.36 cm) and maximum number of leaves (19) with the highest dose of ECC namely 36 t ha^{-1} in the pot culture studies reflect that this can support plant growth even at higher dose. Though a nutrient rich material, at comparable levels of 12 t ha^{-1}, ECC was pot tested inferior to farmyard manure. This is evident from the comparatively high values both for plant height (70.63 cm) and maximum number of leaves (10) observed in FYM treated plots. However, the number of pods assumed the same value of 8 at this level with both materials. The observed variations in vegetative characters and the uniformity in yield records, with these two materials at same level however, remains difficult to interpret.

Table 17. Yield of the crop as influenced by different treatments

Treatment	Yield	
	kg/plot	t ha^{-1}
T_1	1.07 cd	1.78 cd
T_2	1.12 cd	1.87 cd
T_3	1.31 c	2.18 c
T_4	3.58 b	5.97 b
T_5	3.62 b	6.03 b
T_6	2.49 c	4.15 c
T_7	4.20 a	7.00 a
T_8	4.21 a	7.01 a
T_9	4.27 a	7.12 a
T_{10}	2.67 c	4.45 c
T_{11}	2.96 c	4.93 c
T_{12}	3.00 c	5.00 c
T_{13}	3.24 c	5.40 c
T_{14}	0.39 c	0.65 e

Treatment means in a column with the same alphabet do not differ significantly

The results of field investigation with lower medium and higher levels of ECC alone, along with low and medium levels of ECC in conjunction with inorganic forms of nutrients are narrated under section 4.3.1. These results are also in general, in agreement with that of the major trend of results of the pot culture studies. With increased amount of ECC, both at 24 and 36 t ha^{-1} crop performance was comparatively better than at lower levels. However, the best growth and yield was observed in T_9 where ECC 12 t ha^{-1} + NPK full dose was applied. This was evident from all the characters studied, namely plant height, number of leaves, total number of flowers, length of fruit, diameter of fruit and yield. The performance of T_7 (ECC 12 t ha^{-1} + half dose of NPK) and T_8 (ECC 12 t ha^{-1} + 3/4 dose of NPK) were also in close comparison with that of T_9.

As the harvestable produce is the end result of effective sinking of photosynthetic assimilates (Bidwell, 1974 and Devlin and Witham, 1986) yield is influenced by vegetative as well as yield attributing characters. Since these characters assumes superior values in T_9, the highest yield of 4.27 kg per plot is explainable. However, even at this rate, yield is equivalent to 7.1 t ha^{-1} which is just near to the average yield of 7.2 t ha^{-1} of the locality. The overall decline in yield is not attributable to treatment influences since comparatively poor yield is usually reported during rabi season in this locality. The general incidence of yellow vein mosaic observed at the fag end of the crop might also have contributed to the general yield decline.

Taking yield as the best criterion in judging the agronomic suitability of a manure, treatments T_9 followed by T_8 and T_7 assumes significance here. In T_8 and T_7 ECC was applied at 12 t ha^{-1} in combination with three-fourth and half dose of NPK, respectively. But the yield did not vary significantly as revealed from the Table 17 and it varied around 4 kg per plot (71 t ha^{-1}). The economic produce need not always increase linearly with the addition of nutrients especially beyond a critical limit and this may be the reason for the observed insensitiveness in yield with increased NPK addition. Similar results were also reported by many workers (Savithri *et al.*, 1991 and Lavanya and Manickam, 1993). Therefore, after a critical limit, any addition of fertilisers become waste and tend to inflate the cultivation expenditure and associated environmental consequences (Tisdale *et al.*, 1995). Viewing the yield data and related aspects on this background it can be concluded that T_7 (ECC at 12 t with half of recommended level of NPK) is the best for economic yield return. The confirmatory field evidence of these treatments in comparison with other related treatments are provided through plates 3a to 3c.

Plate 3 Evidences on field trials

Plate 3a General view of the field

Plate 3b Plants treated with ECC 12 t ha^{-1} with half NPK


R_2 T_7
ECC12t/ha
+½ NPK

Plate 3c Plants treated with ECC 12 t ha^{-1} with full NPK

The observations in plots which received ECC alone at higher levels i.e. at the rate of 36 and 24 t ha^{-1} also merit consideration here. As observed in pot culture studies, these treatments in field too promoted better crop growth. But the observations were on par with each other in majority of the cases. Their influence especially on yield was significantly inferior to the best set of treatments as mentioned above and it was around 3.6 kg per plot (6.0 t ha^{-1}). This relatively poor performance despite the heavy dose of ECC, remains difficult to explain fully. However, a possible explanation can be offered through the trend in nutrient absorption observed with these treatments. As revealed from Table 18 and Figure 4 the plot which received ECC at 36 t ha^{-1} was contributing to a total addition of 561.6, 1105 and 224 kg ha^{-1} respectively of nitrogen, phosphorus and potash. The corresponding figure with ECC 24 t ha^{-1} where 374.4, 737 and 216 kg ha^{-1}. But with the best treatment of ECC 12 t ha^{-1} with half dose NPK as evident from the above discussion, the total input of nutrients into the system was to the tune of 212, 372 and 120 kg ha^{-1} of NPK, respectively. With the FYM treated plots also, corresponding figures were 100, 60, 120 kg ha^{-1} NPK, respectively.

Irrespective of the abundant input of nutrients into the system as observed above, the plant uptake was not in proportion to the quantity applied. Figure 4, tells that the

Table 18. Plant uptake of NPK as influenced by different treatments

Treatment	N	P	K
T_1	88.973 d	13.363 g	80.117 hi
T_2	71.460 i	14.173 f	80.043 i
T_3	71.960 g	14.537 e	81.200 d
T_4	92.137 c	18.333 b	85.123 b
T_5	92.453 b	17.800 c	85.687 a
T_6	72.041 fg	14.623 e	82.160 hi
T_7	72.133 fg	14.520 e	80.130 c
T_8	71.673 h	14.937 d	80.267 ghi
T_9	92.747 a	19.177 a	85.600 a
T_{10}	70.087 j	14.087 f	80.347 fgh
T_{11}	71.327 i	14.073 f	80.457 fg
T_{12}	72.143 f	14.360 ef	80.937 e
T_{13}	73.240 e	14.470 e	80.523 f
T_{14}	63.173 k	12.140 h	75.313 j

Treatment means in a column with the same alphabet do not differ significantly

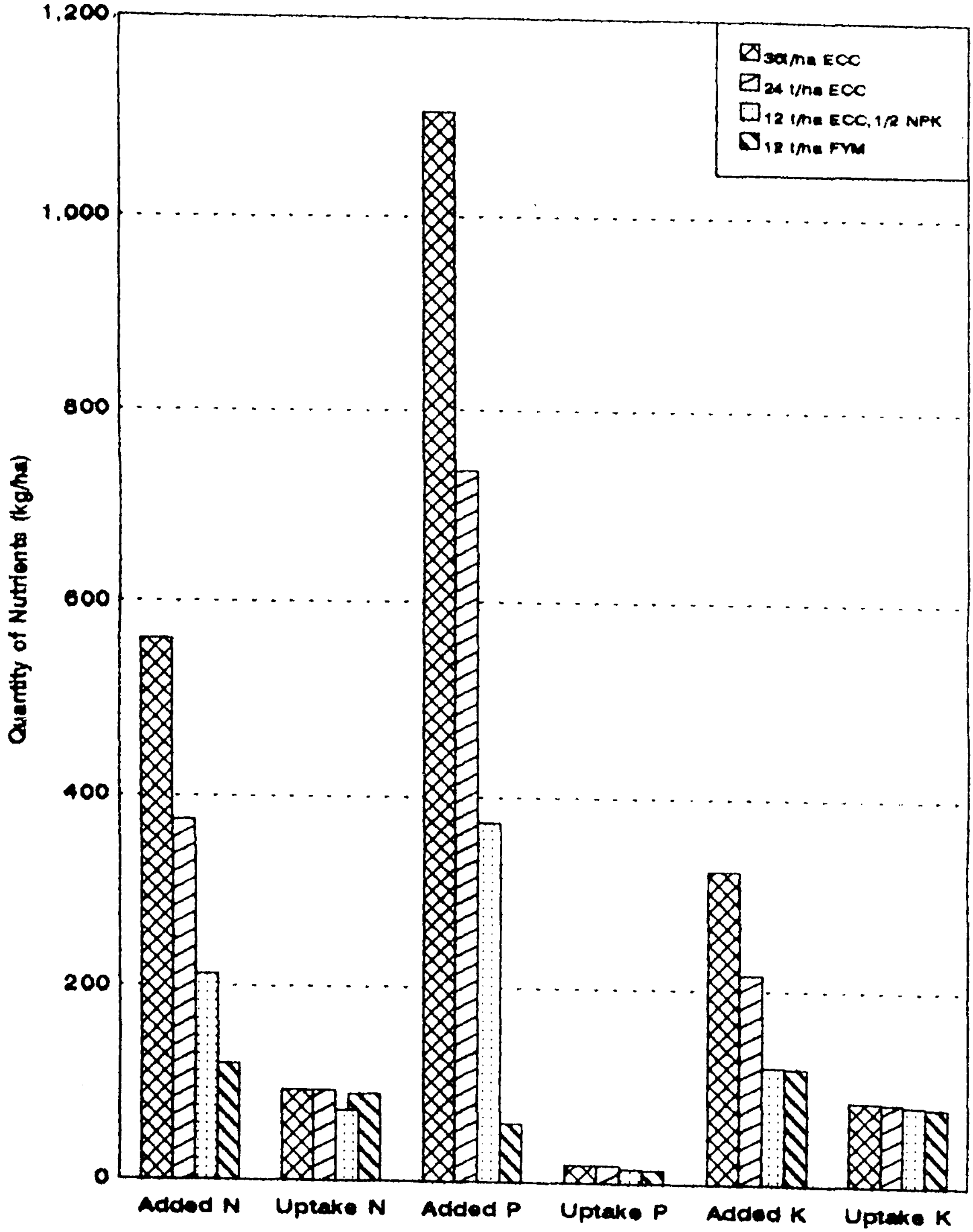


Fig.4 Added and absorbed quantities of nitrogen, phosphorus and potassium in selected treatments

total uptake of nitrogen varied around 92 kg ha^{-1} in all the best 3 sets of treatments. The corresponding response for P and K were 18 and 85 kg ha^{-1}, respectively. Even in the FYM alone treated plot, the total uptake of N, P and K was not much lower to the above treatments. It was around 89, 12 and 80 kg ha^{-1}, respectively. These observations are indicative to the fact that crop growth and yield are also controlled by the biological limit and environmental stress, especially when nutrients are not in limited supply. Such reports are available with other crops and situations (Tisdale *et al.*, 1995).

The best performance of the treatment with 12 t ha^{-1} ECC along with added fertiliser, further signifies that the absorption of nutrients and the consequent expressions in terms of growth and yield is not only determined by the abundance of respective nutrients, but also on their forms and nature of materials through which they are supplied. The ECC when combined with half NPK becomes a favourable combination to ensure all the major and minor nutrients to the extent required for crop growth than when it is applied in isolation and in abundance. Many research reports are also in support of this comfortable blending of organic as well as inorganic form of fertiliser for proper plant growth (De, 1989 and Tisdale *et al.*, 1995).

4.3.2 Soil characters

1. Organic carbon

The values presented in Table 19 shows the organic carbon in the soil at the end of crop period. Initial value is provided is Appendix-1. There was significant difference among the treatments by the end of crop season. Plots which received ECC 36 t ha^{-1} (T_5) showed the highest organic carbon content (1.05 per cent) followed by T_9 (1.047 per cent) and T_8 (1.033 per cent). Control plot (T_{14}) recorded the lowest content of 0.733 per cent.

2. Available nitrogen

Available nitrogen status in the soil at the initial and final stage is provided in Appendix-1 and Table 19 respectively. Nitrogen availability differed significantly by the end of crop season. Treatment T_9 recorded the maximum value of 248.1 kg ha^{-1} and T_{14} the lowest 200 kg ha^{-1}.

3. Available phosphorus

Value of available phosphorus is also shown in Appendix-1 and Table 19. There was significant difference between treatments by the end of crop season. Here also, the treatment T_9 ranked first with a value of 19 kg ha^{-1} T_{14} came last with 10 kg ha^{-1}.

Table 19. Data on organic carbon (%) available nitrogen, available phosphorous available potassium (kg ha^{-1}) in the soil

Treatment	Organic (per cent) carbon	Available nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})
T_1	1.02 de	239 abc	16 e	209 f
T_2	0.98 fg	226 def	18 d	211 ef
T_3	1.02 c	223 ef	19 abcd	212 def
T_4	1.03 bc	234 bcde	19 abc	214 bcde
T_5	1.05 a	240 abc	19 ab	216 abcd
T_6	1.03 b	233 bcde	18 bcd	214 bcde
T_7	1.03 bc	243 ab	19 abc	215 abcde
T_8	1.03 b	245 ab	18 abcd	217 ab
T_9	1.05 ab	248 a	19 a	219 a
T_{10}	1.00 f	229 cde	18 cd	214 bcde
T_{11}	0.99 gh	238 abcd	19 abcd	212 cdef
T_{12}	1.01 e	240 abc	19 abcd	214 bcde
T_{13}	1.01 d	241 ab	19 ab	216 abc
T_{14}	0.73	200 f	10 f	164 g

Treatment means in a column with the same alphabet do not differ significantly

4. Available potassium

Available potassium in soil at 90 DAS is given in Table 19. Initial values are furnished in Appendix-I. As in the case of N and P, here also treatment T_9 came first compared to other treatments with a value of 219 kg ha^{-1}. Control plot had the lowest value of 164 kg ha^{-1} potassium.

5. Cation exchange capacity (CEC)

CEC was centered around 10 C mole (+) kg^{-1} before and after the crop season. The data are given in Appendix-1.

6. Water holding capacity (WHC)

Water holding capacity (WHC) at 30 k Pa and 500 k Pa is shown in Table 20. Treatment T_9 had the highest value (19.76 per cent) at 30 k Pa. But at higher suction of 500 k Pa T_5 and T_4 over took T_9. Anova table for the soil characters is given in Appendix-4.

The influence on organic carbon, available nitrogen, phosphorus, potassium, CEC and water holding capacity of the soil also indicate, on the suitability of the enriched coirpith compost as soil enrichers. Despite with the above positive influence of the material, availability of major nutrients was always more with treatments having medium level of ECC with fertiliser NPK additions. This increased availability of nutrients (Table 19) was also reflected on the

Table 20. Waterholding capacity of the soil at 30 and 500 k Pa at the end of the experiment

Treatment	30 k Pa	500 k Pa
T_1	17.06 i	14.93 c
T_2	17.27 hi	13.97 fg
T_3	17.75 def	14.02 fg
T_4	19.35 b	16.78 a
T_5	19.21 b	16.89 a
T_6	17.86 de	14.21 de
T_7	17.96 d	14.12 ef
T_8	18.41 c	14.05 ef
T_9	19.75 a	16.52 b
T_{10}	17.84 de	14.29 d
T_{11}	17.57 fg	14.03 fg
T_{12}	17.64 efg	13.89 g
T_{13}	17.46 gh	13.70 h
T_{14}	15.22 j	12.91 i

Treatment means in a column with the same alphabet do not differ significantly

crop growth as observed under section 4.3.1. This can be explained due to the increased content of easily available nutrients, in fertilisers than in organic enrichers.

The organic carbon content, one of the important characters which determine the productivity of soil is significantly influenced by the addition of ECC. It is evident from the highest content of 1.053 per cent with the ECC 36 t ha^{-1}. The positive influence of the new material on soil health and on crop supporting function is further established by the increased water holding capacity especially at higher suction. As derived from Appendix-1 and Table 20 the material is potential enough to boost up the carbon content upto 43 per cent over the initial value and a corresponding 30 per cent increase in WHC at 500 k Pa. These responses are more or less same even with the treatment of g ECC at 24 t ha^{-1}. Though a three months study with a short duration crop the results are indicative of the positive effects of the new material on soil health. Detailed investigations and long term experiments are, however necessary to substantiate the influence of ECC on fertility build up.

4.4 Economics

The expenditure, yield and income of bhindi crop using the best treatment (T_7-12 t ha^{-1} ECC with half NPK) in comparison with those of the recommended practice (12 t ha^{-1} FYM with full NPK) is narrated in Table 21 and Figure 5. The cost component for the nutrient input alone is considered, as the other cost factors are same to both of the treatments. Further, average yield with the recommended practice for rabi crop of bhindi is considered as 7.2 t ha^{-1} (as noticed) by the Department of Olericulture, College of Horticulture, Vellanikara

The expenditure was Rs.9140 per hectare in the case of recommended practice while it was Rs.5070 in the best practice. The yield and income for the best practice were 7.2 t ha^{-1} and Rs.28,800 while those for the recommened practice were 7.1 t ha^{-1} and 28,400 respectively.

Almost 45 per cent reduction in the cost factor was observed together with comparable yield and income with the best practice over the recommended practice of bhindi cultivation. The cost reduction can be attributed mainly to the comparatively cheap source of organic forms of nutrients through ECC, an enriching material prepared from materials which are considered as wastes and of no value. similarly, due to the increased nutrient content of ECC, the NPK requirements through fertiliser could also be reduced to half of the recommended dose. The cost reduction can further be augmented if labour component for the preparation of ECC is reduced through suitable mechanisation and family labour employment. Even without this, a comparable yield with that

Table 21. Expenditure and income of bhindi crop on per hectare basis - recommended fertiliser level versus the best treatment

	Recommended practice		Best practice	
	12 t ha^{-1} FYM with 50:8:25 NPK		12 t ha^{-1} ECC with 25:4:12.5 NPK	
	Quantity	Amount (Rs.)	Quantity	Amount (Rs.)
I. Input costs				
1. FYM	12 t	6000*	12 t(ECC)	3000
2. NPK	83 kg	1140*	41.5	570
II Application charges	20 men	2000***	15 men	1500
Expenditure		9140		5070
III Yield & income	7.2	28800***	7.1	28400

* Farm yard manure was bought @ Rs.500 t^{-1}

Cost of ECC is not fixed for the time being as the ingredients for preparation of ECC are considered as waste material of no value. However, to compensate the labour component for formulation of ECC, an amount of Rs.250 t^{-1} is provided.

** Unit cost of nutrient is estimated at Rs.13.7 considering the market price of urea at Rs.4 kg^{-1}, rock phosphate at Rs.2.2 kg^{-1} and that of muriate of potash at 3.8 kg^{-1}.

*** Labour charge is Rs.100 per man

**** Selling price of bhindi is Rs.4 per kg

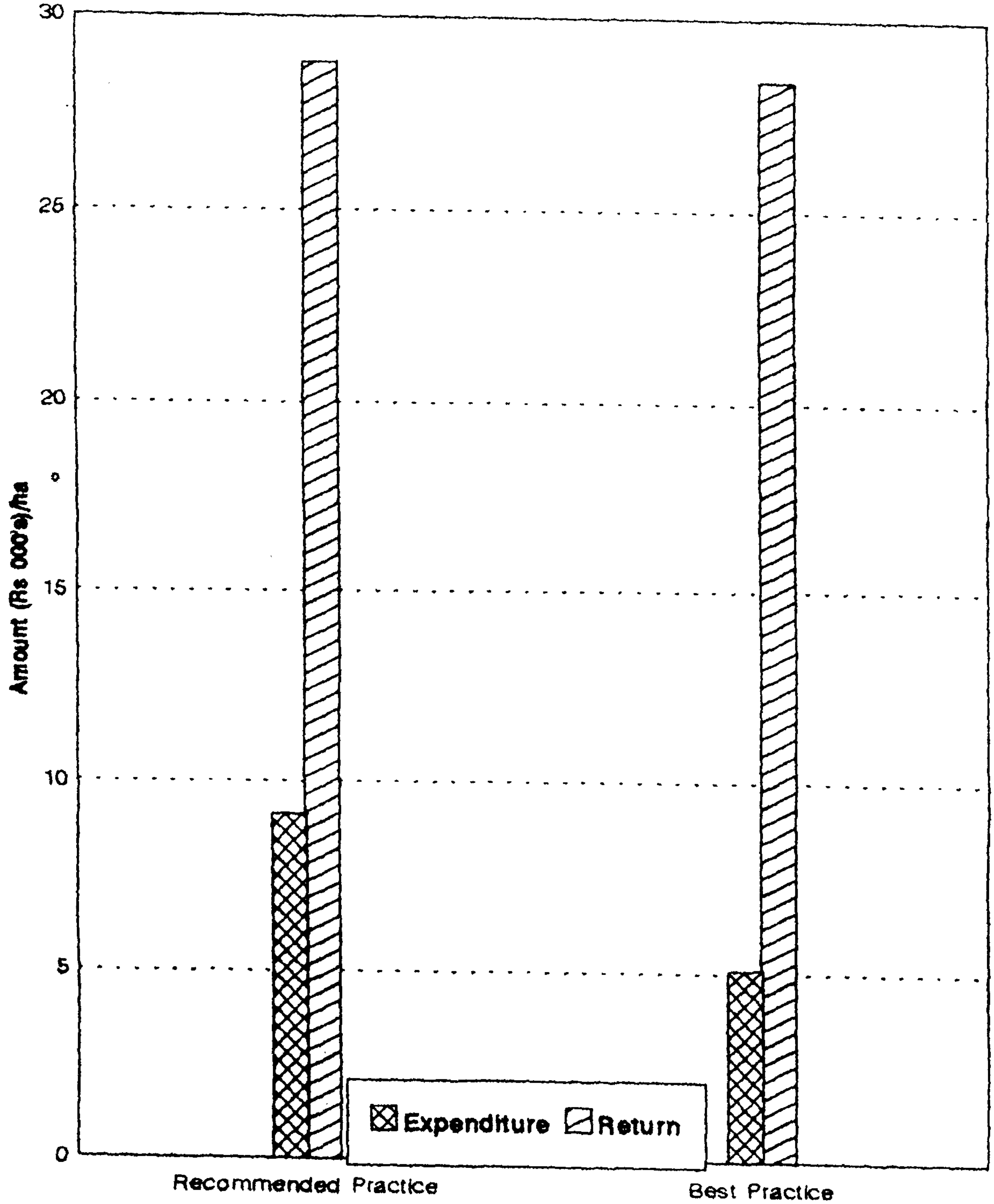


Fig.5 Expenditure and income of bhindi crop on per hectare basis - recommended fertiliser level versus the best treatment

of the recommended dose at 45 per cent cost reduction makes ECC a prómising option of organic source of nutrients.

Further, the possible residual effect of sizeable quantities of unused nutrients as derived from Fig.4 and Table 18 again reduce the cost of cultivation on subsequent crops. But this needs to be confirmed through detailed field experiments.

4.5 Future line of work

Being a new material, the long term influence of ECC on crop and soil need to be investigated thoroughly. Further, the carry over effect of ECC may influence the subsequent crops positively and reduce the cost of cultivation. As the present investigation was basically for standardising the enrichment technique of coirpith compost, these carry over effects were not studied. Detailed agronomic trials on a variety of crops are essential for this.

Summary

SUMMARY

The salient results of the present study entitled "enrichment of coirpith compost through organic amendments" are summarised below:

1. The raw coirpith on proper enrichment with KCPL sludge, cowdung and municipal solid waste (MSW) by employing the principle of aerobic composting was found superior to ordinary coirpith compost. The enriched coirpith compost (ECC) thus produced was superior in all the major nutrients, to the ordinary coirpith compost.

2. Among the enrichment techniques, ECC with 1:1:1:1 coirpith, KCPL sludge, cowdung and municipal solid waste (CKDM) was adjudged to be the best. This was closely followed by 3/4:1:1:1 (3/4CKDM) and 1:1:3/4:1 (CD3/4DM). The best ECC contained 1.56, 3.07, 0.90, 3.43, 0.19 per cent N, P, K, Ca and Mg, respectively. It also had the lowest C:N ratio (15.76) coupled with 53 per cent reduction in lignin content over the ordinary coirpith compost.

3. The study revealed that enriched coirpith compost can be obtained within 84 days of composting without resorting to any external inoculum. There was practically no

significance for introduced inoculum in hastening the process of composting.Cowdung and top soil slurry mixed to a ratio of 10:1 could harbour and help flourish a host of native organisms which could impart speedy composting of coirpith than the introduced inoculum (*Pleurotus sajor-caju*).

4. The study revealed that the maximum microbial population of bacteria, ($358.7x10^5$) actinomycetes ($163.3x10^5$) and fungi ($62x10^4$) were in the thermophilic stage. Temperature (66.3°C and pH (7.4) also attained the maximum values at the thermophilic stage.

5. Rapid pot culture trials with the best selected ECC (CKDM) showed, in general, a corresponding increase in growth characters and yield with the increased dose of ECC. At lower levels, though ECC was inferior in vegetative characters of the plant growth, they assumed comparable values of yield with that of farmyard manure.

6. Field investigations also proved a positive influence of ECC at higher levels on plant growth. But their influence on yield was inferior to those treatments with medium level of ECC + NPK fertilizers. ECC at 12 t ha^{-1} mixed with full dose of NPK produced the highest yield of 7.1 t ha^{-1}. ECC at 12 t ha^{-1} with lower levels of NPK also produced comparable yield to this.

7. Through the addition of ECC at the rate of 36 t ha^{-1} it was found that 562, 1105 and 324 kg ha^{-1} N, P and K was added, respectively into the system. But the uptake was only 72, 15 and 80 kg ha^{-1} N, P and K respectively.

8. Uptake of nutrients and the corresponding increase in yield was not proportional to the quantity of nutrients added to the soil which proved that there was a biological limit for unit conversion of nutrients to harvestable produce.

9. The soil productivity status was improved by the addition of ECC. It also resulted in the increased water holding capacity, organic carbon, available nitrogen, available phosphorus and available potassium in the soil.

10. The cost on nutrient input could be reduced substantially and thereby the expenditure for raising of crop was reduced to 45 per cent by resorting to ECC at 12 t ha^{-1} with half NPK. The yield of 7.1 t ha^{-1} recorded with this treatment was comparable to those which received the highest rates of ECC and also with the recommended practices of cultivation.

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* Originals not seen

Appendices

Appendix - I

Soil characteristics at the initial and final stages of experiment

Character of soil	Quantity	
	Initial	Final
Organic carbon (per cent)	0.73	0.73-1.05
Available nitrogen (kg ha^{-1})	198	200-223
Available phosphorus (kg ha^{-1})	10.8	10-19
Available potassium (kg ha^{-1})	166	164-219
Cation exchange capacity (cmol(+)kg^{-1})	10-10.3	10.20-10.25
Water holding capacity at 0.3 atm (per cent)	18	15.22-20
Water holding capacity at 5 atm (per cent)	13	13.00-16

APPENDIX-2

ABSCTACT OF ANOVA

Plant height, number of leaves, number of flowers, fruit length

Source	d.f.	Mean squares									
		Plant height			Number of leaves			Number of flowers	Fruit length		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS
Replication	2	1.736	25.721	37.711	0.929	3.167	0.167	0.452	0.078	0.061	0.232
Treatment	13	22.711	1192.65	1599.109	4.659	19.152	9.326	6.793	24.572	0.366	15.747
		**	**	**	*	**	**	**	**	NS	**
Control Vs Treatment	1	13.350	3320.55	1163.21	5.34	17.24	22.15	12.62	36.98	0.05	20.27
Error	26	1.744	25.432	58.626	0.313	3.141	1.551	1.222	1.236	0.072	0.643

** Significant at 1% level
* Significant at 5% level
NS Non-significant

APPENDIX-3

ABSCTACT OF ANOVA

Diameter of fruit, yield and uptake of NPK

Source	d.f.	Mean squares						
		Diameter of fruit			Yield	Uptake nitrogen	Phosphorus	Potassium
		30 DAS	60 DAS	90 DAS				
Replication	2	0.106	0.112	0.005	0.463	0.001	0.022	0.04
Treatment	13	3.398	0.356	0.543	4.623	300.103	11.760	22.317
Control Vs Treatment	1	102.44**	0.030NS	0.280NS	4.680	602.090**	27.23**	114.97**
Error	26	0.125	0.072	0.042	0.064	0.01	0.025	0.019

** Significant at 1% level
* Significant at 5% level
NS Non-significant

APPENDIX-4

ABSCTACT OF ANOVA

Organic carbon, nitrogen phosphorus, potassium and water holding capacity

Source	d.f.	Mean squares					
		Organic carbon	Nitrogen	Phosphorus	Potassium	WHC 90 DAS 0.3 atm	WHC 90 DAS 5 atm
Replication	2	0.039	8.95	0.600	14.699	0.002	0.003
Treatment	13	0.019	242.561	17.606	551.908	3.74	4.57
Control Vs Treatment	1	0.23NS	1174.16**	199.61**	6925.77**	22.93**	9.21**
Error	26	0.0001	37.853	0.332	4.778	0.018	0.009

** Significant at 1% level
* Significant at 5% level
NS Non-significant

APPENDIX-5

Weather data at monthly intervals during the experimental period

Months	Rainfall (mm)	Temperature °C		Relative humidity (%)	Sunshine (hrs)	Wind speed (km/h)
		Maximum	Minimum			
November 1996	22.1	31.5	23.6	71.5	7.1	3.7
December	60.4	30.5	21.8	67.5	6.8	6.4
January 1997	0.0	32.0	22.9	61.5	9.6	6.9
February	0.0	33.9	21.8	60.5	9.3	3.9
March	0.0	35.7	24.0	59.5	9.6	4.0
April	8.2	35.2	24.5	66.5	9.6	3.3
May	63.0	34.4	24.5	72.0	6.7	3.3
June	720.5	31.2	23.0	82.0	5.9	2.7
July	979.2	28.6	21.8	90.0	1.9	4.6

ENRICHMENT OF COIRPITH COMPOST THROUGH ORGANIC AMENDMENTS

By
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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

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1997

ABSTRACT

The study on enrichment of coirpith compost through organic amendments was conducted at College of Horticulture, Vellanikkara during the period 1995-97, to investigate into the methodologies and standardisation of enrichment of coirpith compost through organic amendments and to determine the effect on plant and soil of the best enriched coirpith compost.

The standardisation of enrichment of coirpith compost was in accordance with the principle of aerobic composting. Three adjuctants were utilised namely KCPL slurry, cowdung and municipal solid waste in various proportions with the coirpith. These treatments were compared with the control where fungal inoculum (*Pleurotus sajor-caju*) was used as the ameliorant. The study involved aerobic composting in pits of size $2x1x1m^3$.

Temperature, pH and bacterial population at weekly interval were monitored throughout the composting period. The end phase of the bioprocessing was arrived at through indications on stabilisation of temperature, pH and the quality of material. Nutrient quality of composted coirpith was arrived at by analysing major nutrients (N, P, K, Ca and Mg), organic

carbon, lignin and moisture content. C:N ratio was also calculated to find out the acceptability of the manure.

The best selected ECC was used to study the effect on plant and soil. At first it was used in pot culture studies to know whether the newly selected ECC was safer at higher levels. The selected ECC was also field tested in bhindi crop in rabi season. The ECC at 6 and 12 t ha^{-1} with and without 4 levels of recommended NPK were tried besides at higher levels of 24 and 36 t ha^{-1}. Growth parameters, yield and soil characters were observed. Economics of the best selected treatment in comparison with the recommended fertiliser dose was worked out.

The study revealed that ECC was superior in nutrient contents compared to ordinary coirpith compost. The best ECC contained 1.56, 3.07, 0.90, 3.43, 0.19, 24.59, 3.55 and 46.23 per cent N, P, K, Ca, Mg, organic carbon, lignin and moisture content. C:N was 15.76. External source of inoculum was not found necessary for composting coirpith especially with the enriching materials. Both the inoculated and non-inoculated treatments matured within around 90 days. Further the microbial population build up between treatments was higher in thermophilic stage increasing the rate of decompostion.

From the pot culture study it was inferred that ECC, even at higher levels of 36 t ha^{-1} was not harmful to the crop.

Field results were also almost in confirmation with that of the pot culture experiment. With higher doses of ECC, there corresponding increase in growth and yield was observed. However, ECC 12 t ha^{-1} with half NPK emerged as the best treatment for economic yield return. This treatment could bring down the cost of nutrient input and thus expenditure for raising the crop to about 45 per cent without affecting the yield. The ECC application also resulted in increased nutrient availability and water holding capacity of the soil.