Biological characterization of Onattukara soils under coconut based cropping system

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Biological characterization of Onattukara soils under coconut based cropping system"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

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Anila T Sasi

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LIST OF ABBREVIATIONS

%	Per cent
@	At the rate of
µg	Microgram
^{0}C	Degrees Celsius
C	Carbon
CD	Critical difference
cfu	Colony forming units
cm	Centimetre
et al.	And others
ft	Feet
FYM	Farm Yard Manure
g	Gram
hr.	Hour
ha^{-1}	Per hectare
i.e.	That is
K	Potassium
KAU	Kerala Agricultural University
kg	Kilogram
m	Metre

mg	Milligram
ml	Millilitre
N	Nitrogen
nm	Nanometre
CEC	Cation exchange capacity
Fig	Figure
P	Phosphorous
EAN	Enzyme activity number
M	Molar
POP	Package of Practices
ppm	Parts per million
PSB	Phosphorous Solubizing Bacteria
s	Seconds
t	Tonnes
TPF	Triphenyl Formazone
TTC	Triphenyl tetrazolium chloride
VAM	Vesicular arbuscular micorrizhae
Viz.	Namely

Introduction

1. INTRODUCTION

The Onattukara soil tract is a unique agro ecological landscape in Kerala, its vernacular nomenclature meaning ‘onam oottum kara’ reminiscent of its past splendor and glory. Classified under Agroecological unit 3,this region extends over an area 67,447 ha distributed in the taluks of Karthikappally and Mavelikkara in Alappuzha district and Karunagapally in Kollam district. The greyish sandy soils of this region, acidic in reaction, have been formed from marine and lacustrine sediments admixed with lateritic materials under the influence of high water table. Organic matter and all plant nutrients are extremely deficient in these soils, reflected in the poor yields of prevalent crops here like rice, coconut, sesamum, banana and vegetables.

Based on crop suitability rating 13 garden land soil series have been identified in Onattukara suitable for coconut cultivation (Soil Survey Staff, 1970) and on the basis of productivity rating these series are again classified as ‘very good’, ‘good’, ‘average’ and ‘poor’(Premachandran, 1998). Besides these classifications there are other classifications for Onattukara soils like land capability classification and irrigability classification. But in none of these classifications biological properties of these soils have been considered, let alone included. The biological properties are the direct contribution of living phase of the soil and hence are more sensitive and realistic indicators of the capacity of soil to sustain crop production than physico-chemical properties. In spite of the recognition and establishment of this fact lesser importance has been given by most research workers to this critical aspect of soils. According to Rameshchandra and Singh (2009) the living phase of the soil is constituted by myriads of soil inhabiting organisms which outnumber by several folds those which are present on earth’s surface.

Being the most sensitive the biological properties fluctuate rapidly in response to agricultural practices especially nutrient application. The quantity, form and proportion of various nutrients added have profound influence on the interaction among the soil biological community and diversity; resulting in rapid fluctuations in these properties.

Though coconut is rated as the best crop suitable for 13 soil series of Onattukara, its productivity is poor. It is cultivated mainly by the medium, small and marginal farmers of these area either as a monocrop or as a mixed crop with arecanut, banana, tapioca, sesamum and vegetables in between. Besides the inherent low capacity of the soils the unscientific management practices followed by farmers is one of the primary reasons for the low productivity of the crop. The existing fertilizer recommendation of Kerala Agricultural University for this crop has also been formulated on the basis of results of physico-chemical analyses of these soils. As soil health and in turn productivity is an interaction of the measurable physical, chemical and biological properties of a particular soil any management strategy planned for improved crop production will not fetch any result if the biological properties of the soils are not given the same weightage as the physico-chemical properties.

The present study is proposed with the objective of understanding and inventorising biological properties of the Onattukara soils under coconut as influenced by the nutrient management practices followed by farmers here. It is hoped that information of this sort will supplement available information on these soils to serve as a sound basis for micro level planning for overall integrated sustainable development of the region with its potentialities and limitations.

Review of Literature

2. REVIEW OF LITERATURE

The present investigation is an attempt to build an inventory on the biological properties of the major coconut growing soils of the Onattukara tract of Kerala and studying the impact of the prevalent nutrient management practices on these properties. Though extensive research work has been done on the physico-chemical properties of these soils enabling classifications like land capability, irrigability and crop suitability, not much research work has been done on the biological properties of these soils.

2.1 EARTHWORM POPULATION

From a study on the effect of various manurial treatments on earthworm activity in a grassland soil Scullion and Ramshaw (1987) reported that the application of poultry manure increased the earthworm population.

Earthworm population, total earthworm weight and average worm weight were used as biological indicators of soil health by Reganold and Palmer (1995). According to them, ten earthworms ft^{-2} of soil surface can be considered as a good population in agricultural system.

Lundkvist (1998) conducted investigations on the effect of wood ash on earthworm abundance and found an increased abundance of earthworms in wood ash treated soil. Huhta *et al*. (1998) studied the functional implications of soil fauna diversity in boreal forests and found no earthworms in control soils and only a few in ash treated soil.

Vestberg*et al*. (2009) studied the effects of cropping history on the quality of a silt soil cropped with strawberries and reported that farming system affected earthworms positively by increasing their population. Hurrisso*et al.* (2011) reported 5.4 times increase in earthworm population by the application of composted dairy manure.

Lalthanzara*et al.* (2011) investigated on thepopulation dynamics of earthworms in relation to soil physico-chemical parameters in agroforestry systems and reported that population dynamics of earthworm was significantly correlated with rainfall and physical characters of the soil. Earthworm biomass was also significantly affected by rainfall and moisture content of the soil. The influence of chemical factors was relatively less.

Rathinamala*et al*. (2011) conducted a field study on earthworm population in grass land and chemically fertilized land and observed that the total biomass and number of earthworms in the cultivated land were less than the non-cultivated landwhich might be due to the fertilizer applications.They also stated that number of earthworms was more in all the months of the year in the non-cultivated lands than in cultivated lands.

Sierra *et al*. (2014) found that earthworm activity modified the rate of the aerobic processes but it did not affect the intrinsic biological properties of the tropical soilswhich were controlled mainly by soil organic matter quality and carbon availability.

2.2 ARTHROPOD POPULATION

Curry (1994) reported that moderate applications of cattle and pig slurry resulted in moderate increase of hemiedaphic Collembola.

Ginsberg (1993) and New (1995) suggested arthropod species as potentially valuable tools for monitoring changes in soil health.

Huhta *et al.* (1998) observed a decrease in the total abundance of microarthropods following forest wood ash fertilization during their studies on the functional implications of soil fauna diversity in boreal forests.

Gunadi*et al.* (2002) studied the changes in trophic structure of soil arthropods after the application of vermicomposts and observed that the applications of vermicomposts increased the number of trophic groups of soil arthropods.

Miyazawa *et al*.(2002) carried out investigations on the effect of cropping systems and fallow management on microarthropod population and reported that collembola population was higher with less tillage, less biocide application, and more organic matter input in their experiment, and these effects were additive; there was no specific combination of practices that had an interacting effect. Acari population was also higher under most conservational treatments, and a significant interaction effect between tillage and organic matter application was found.

Based on a study on the influence of farm yard manure and chemical fertilizers on the occurrence and abundance of soil micro-arthropods in soybean ecosystem, significantly higher soil micro arthropod abundance was recorded in plots treated with recommended dose of partially decomposed FYM alone and the least was observed in the plot treated with both farm yard manure and recommended dose of fertilizer (Chitgupekar *et al*. 2013)

Soil microarthropod population decreased with increase in the level of spent oil while addition of poultry manure significantly improved their population. The population of Collembolain particular was improved by about 48.48 per cent under the poultry manure application than the control plots (Olla *et al*. 2013).

2.3. MICROFLORA

To maintain the productivity and ecological sustainability of a soil, biofertilizers are essential which are products containing living cells of microorganisms which can mobilize plant nutrient elements from non-usable to usable form through biological processes (Rao*et al.*, 1995).

According to Rameshchandra and Singh (2009) the population and activity of different groups of microorganisms are greatly influenced by the physical, chemical and biological environment of a soil and are directly correlated with soil fertility and its productivity.

2.3.1. Bacterial population

Tiwari *et al.* (2000) studied the effect of incorporation of wheat straw and biogas slurry at different levels of nitrogen and observed that the total bacterial count showed superiority over Azotobacter, fungi and actinomycetes up to flowering stage of a crop and decreased at harvest.

Krishnakumar *et al*. (2005) investigated on the impact of organic farming on biological properties of a rice soil and reported that the population of soil bacteria significantly increased following the application of the organic nitrogen source compared to control.

Debnath *et al.* (2005) reported that the addition of rice straw, rock phosphate and pyrite brought about a significant increase in the population of non-symbiotic nitrogen fixing and ammonifying bacteria.

Bahadhur *et al*. (2012) conducted a trial on the effect of integrated nutrient management on yield and microbial population in a sodic soil and reported a significant increase in bacterial population under conjoint use of inorganic fertilizers with organic manure and dual inoculation of biofertilizers.

Based onthe study on the appraisal of biological health of the cultivated soils of Varanasi districtKumar*et al*. (2015) reported that the population of bacteria varied from 14.20 to 42.70$\times 10^6$ cfug^{-1} soil.

2.3.2 Actinomycetes population

From a study on microbial population and biomass in the rhizhosphere as influenced by continuous intensive cultivation and fertilization in an Inceptisol Selvi *et al.*(2004) recorded the highest actinomycetes count at the harvest of the crop with the addition of farm yard manure along with 100 per cent NPK.

From investigations on the impact of neem seed cake on soil microflora and some soil properties Elnasikh *et al*. (2011) reported that application of neem seed cake showed positive effect onactinomycetes population.

Study conducted by Kawaree*et al.*(2013) in cotton, showed that incorporation of farm yard manure @ 10 t ha^{-1} resulted in significantly higher population of actinomycetes (42.66×10^5 cfu g^{-1}) in the rhizosphere at 50 per cent flowering and reduced to 21.00×10^5cfu g^{-1} of soil at boll bursting stage.

Kumari*et al.* (2014) studied the effect of organic amendments on microbial population and enzyme activities in a soil and observed that sludge incorporation increasedactinomycetes population at 45 days after incorporation followed by farm yard manure.

2.3.3. Fungal population

Hackl*et al.*(2000) reported that the plant species growing on a soil has a profound influence on the population and species of fungi inhabiting that soil.

Gopalaswamy and Kannaiyan (2000)found that the fungal population was the highest in the FYM and vermicompost applied treatments.

Swer*et al.* (2007) conducted a study on fungal population and diversity in organically amended agricultural soils of Meghalaya andreported that fungal population was comparatively higher in organically amended plots as compared to control. Among all the treatments FYM showed significantly higher fungal population.

Tuyen*et al*. (2008) on the basis of the results of a long term fertilizer experiment at Cuu Long Delta Rice Research Institute revealed that fungal population was the lowest and it ranged from zero to $0.725x10^{6}$cfug^{-1}air dry soil. Prasanthrajan*et al.* (2008) studied the influence of organic amendments on soil health and the results indicated that the application of yeast sludge and poultry manure increased fungal population when compared to no manure application.

Kaware *et al.* (2013) studied the rhizosphere microbial activity in a Vertisol soil under organic cotton and observed that incorporation of farm yard manure @ 10 t ha^{-1} resulted in higher population of fungi (85.00×10^{4} cfu g^{-1}) in the rhizosphere at50 per cent flowering stage of the crop.

2.3.4. *Azotobacter* population

Jain *et al*.(2003) studied the long-term effect of nutrient sources on *Azotobacter* in a laterite soil and observed that chemical fertilizer application did not have any negative impact on their population though farm yard manure was found to be much superior in maintaining soil biological health.

Based on a study on the effect of integrated organic nutrient sources on soil nutrient status and microbial population in a strawberry field, Nazir*et al.* (2012) found that the maximum population of *Azotobacter*(1.45×10^{5}cfu g^{-1} soil) was observed in plots treated with poultry manure, wood ashand oil cake

Mehetre*et al.* (2008) studied the influence of different bio-fertilizers amended biogas manure on soil microbial population and growth of mungbeanand observed that there was significant increase in the population of Azotobacter during the entire period of crop growth in biogas manure treated plot as compared to urea treated and control plots.

Sharma *et al.*(2015) attributed the increased population of all the three microbes, namely, *Azotobacter* (5.01-7.74 per cent), *Bacillus* (3.37-6.79 per cent), and *Pseudomonas* (5.21-7.09 per cent) to the improved structure and increased organic matter in the soil when it was treated with organic manures

2.3.5. *Azospirillum* population

Ceccherini*et al*. (2001) conducted studies on the occurrence of *Azospirillum* sp in soils amended with swine manure and found their prevalence only in the control and in the organically amended plots.They also observed that treatment with urea reduced the presence of these microbes to less than threshold level.

Datt and Sharma (2006) studied the influence of incorporation of *Sesbania* green manure and mungbean residue on soil biological properties in a rice-wheat cropping system and observed that *Azospirillum* in rice had significant and positive correlation with the biological yields of the crop.

Naveen *et al.* (2009) studied the effect of organic manures on yield and quality of green chilliesand reported that the 100 per cent organic treatment (Composted coir pith 25 per cent + Vermicompost 25per cent + Biodigested slurry 25per cent + Azospirillum cum phosphorous solubilizing bacteria 25 per cent) recorded higher population of these organisms in the post harvest soil as compared to other treatments.

Nazir*et al.* (2012) studied effect of integrated organic nutrient sources on soil nutrient status and microbial population in a soil under strawberry and found that the maximum population of *Azospirillium* (1.55×10^{6}cfu g^{-1}soil) was observed in soil treated with poultry manure, wood ash, phosphorus solubilizing bacteria and oil cake.

2.3.6. Psolubilizer population

Addition of organic matter improves the physical and biological properties of soil including phosphate solubilisation (Bisoyi and Singh, 1988).

Lal*et al*. (2000) reported that the highest number of phosphate solubilising microorganisms was harboured by*Subabul*treated soils. They also reported that in the case of rice straw, lantanatops and ipomoeatops treated soils, the population of phosphate solubilizers increased up to 60 days after incorporation.

Results of long term experiments using different nutrient sources in a Vertisol over 25 years indicated no negative impact for the chemical fertilizers on the population of nitrifying and phosphate solubilizing bacteria (Jain *et al*., 2003).More population was observed after fertilizer application compared to control.

Suja and Sreekumar (2014) studied the effect of organic management on yield, tuber quality and soil health in yams in the humid tropics and observed that thepopulation of P solubilizers was increased by 22 per cent through organic nutrient applications.

2.4. SOIL ENZYME ACTIVITY

According to Skujins (1976) the level of enzyme activity can be used as an indicator of soil fertility.

Tate (1987) stated that the soil enzymes play an important role in the mineralization processes and also many other soil biological reactions.

From a study conducted by Haider *et al*. (1991) it was observed that an increased C:N ratio resulted due to the application of cow dung along with oil cakeleading to increased microbial biomass carbon and activity of enzymes.

Aparna (2000) reported that the application of vermicompost in combination with lime and fertilizers recorded higher activities of urease, protease, phosphatase, cellulase and dehydrogenase than that of farm yard manure or green leaf manure.

Mathew and Varghese (2007) reported that the application of organic sources of nutrients along with mineral sources of NPK at recommended dose, improved the physical properties and availability of macro and micronutrients, increased the microbial population and activity of enzymes in the soil compared to mineral nutrition alone.

From a study conducted by Aparna (2010) it was observed that the enzyme activity was higher under the combined application of organic manures and chemical fertilizers in soil.

2.4.1. Urease activity

Neweigy*et al.*(1987) studied the enzyme activity in some Egyptian soils under organic manuring and observed that the urease activity was most enhanced by digested cow dung followed by sewage sludge in both sandy and alluvial soils.

From a work conducted by Reddy(2002) to study the relationship between organic carbon and soil enzymes, it was observed that the organic carbon had significant influence on urease activity which might be attributed to the increased heterotrophic microbial activity concomitant with higher organic matter in soil.

Mathew and Varghese(2007) studied the effect of various nutrients on physico-chemical and biological properties of soils in sugarcane agro-ecosystem and observed that urease activity and bacterial population increased with soil inoculation of *Azospirillum* along with NPK application at different doses.

Yang *et al*. (2012) studied effects of agronomic practices on the soil maturation of the Pudong coastal beach reclamation area and reported that animal and poultry manure had the best effect on soil improvement and could significantly increase the soil invertase and urease activities, microbial biomass, organic matter and CEC.

From a study on the short-term effect of vermicompost application on biological properties of analkaline soil with high lime content in the Mediterranean region of Turkey by Uz and Tavali (2014), it was reported that a slight but statistically significant difference was detected between organic amendments in terms of urease activity

Lakshmi*et al.* (2014) studied the cumulative and residual effects of integrated nutrient management in *kharif* rice and *Rabi* green gram on soil enzyme activities and observed that urease activity at different growth stages of the crops gradually increased over the age of the crop and attained higher activity at flowering.The enzyme activity was significantly higher in the plots which received 75 per centrecommended dose of nitrogen +vermicomposted vegetable market waste @ 2.5 t ha^{-1}.

From a study by Hagavane (2014) to find influence of sources of organic manures on urease activity in an inceptisol, the activity of enzyme was found to increase significantly with increasing moisture levels up to field capacity. The moisture levels above or below the field capacity reduced the activity of soil urease. Among the sources of organic manures, vermicompost increased the activity of the enzyme in soil.

2.4.2. Phosphatase activity

Kirchner*et al.* (1993) conducted studies on the soil microbial populations and their activities in low chemical input agroecosystems and reported that phosphatase enzyme activity was greater in the fertilized than the unfertilized soil.

Cooper and Warman (1997) reported that the application of poultry manure compost significantly increased the phosphatase activity in low organic matter containing silty clay soil but had no effect in a sandy loam soil.

The integrated use of pressmud at 5 tha^{-1}along with mineral sources of NPK at recommended doses significantly enhanced the activity of phosphatase (Mathew and Varghese,2007).

Nayak and Manjappa(2010) studied the topo-sequential variations of enzyme activity in rice growing soils in hilly region and observed that the phosphataseactivity differed significantly due to rainfall conditions and it was higher in low rainfall region.

Gurumurthy*et al.* (2015) studied the effect of organic manures and fertilizers on soil enzymatic activities and observed that phosphatase activity was significantly higher with the application of 20t of farm yard manure ha^{-1} compared to recommended NPK alone.

2.4.3. Dehydrogenase activity

Dehydrogenase activity is a respiratory measurement, hence it is a more strong representative of the size and activity of viable microbial community than the activity of other soil enzymes which exist in viable cells and as enzymes stabilized in soil matrix (Bergstrom *et al.* 1998).

Pauscal *et al.* (1998) reported that the application organic amendments increased the dehydrogenase activity in arid soils.

Kunito *et al*. (2001) reported that the activity of dehydrogenase enzyme was adversely affected by the metals derived from the addition of sewage waste.

Supradip*et al*. (2008) from his study on soil enzymatic activity as affected by long term application of farm yard manure and mineral fertilizers under a rainfed soybean-wheat system opinined thatmanure application significantly increased soil dehydrogenase activity.

Suja and Sreekumar(2014) studied the effect of organic management on yield, tuber quality and soil health in yams under humid tropics and observed that the dehydrogenase enzyme activity was promoted by organic management.

Ingle *et al*.(2014) studied soil biological properties as influenced by long-term manuring and fertilization under sorghum - wheat sequence in Vertisols and observed that the activity of the dehydrogenase enzyme was significantly influenced by the application of enriched FYM @ 10 tha^{-1}.

Farm yard manure promoted maximum dehydrogenase activity (24 µg TPF g^{-1} soil day^{-1}) after 45 days of incorporation followed by fresh cow dung. (Kumari *et al*.2014)

2.4.4 Enzyme activity number

Beck (1984) proposed enzyme activity number (EAN) as an index of the biological fertility of a soil based on the activities of five different enzymes dehydrogenase, catalase, phosphatase, cellulase and protease.

Enzyme activity number tends to be decreasing with the intensive agricultural practices like tillage in a virgin soil as reported by Saviozzi *et al*. (2001).

Riffaldi *et al.* (2002) observed higher enzyme activity number in an untilled management system.

2.5SOIL RESPIRATORY ACTIVITY

Baath and Arnebrant (1994) studied the growth rate and response of bacterial communities in ash amended forest soils and observed an increased CO_2 evolution for four years after wood ash application.

Datt and Sharma (2006) in a study on the influence of incorporation of *Sesbania* green manure and mungbean residue on soil biological properties in rice-wheat cropping system reported a significant improvement in carbon dioxide evolution.

Nair (2010) on the basis of work on standardization of microbial techniques in soil, opined that a high CO_2 flux is indicative of high level microbial activity in a soil and hence better soil quality.

Oliveira and Ferreira (2014) studied the changes in soil microbial and enzyme activities in response to the addition of rock-phosphate-enriched compost and recorded that the addition of organic mineral compost significantly increasedthe microbial respiration which was dependent on the added amounts of the compost.

2. 6 NITROGEN MINERALIZATION POTENTIAL

Muthuvel*et al.* (1977) observed that the soil available N was positively influenced by the addition of organic matter under rainfed condition in a permanent manurial trial at Coimbatore.

Tiwari*et al*. (1980) studied the beneficial effects of green manuring alone and in combination with fertilizer Nin riceand observed that the interaction effect of green manuring and N mineralization was positive and significant.

Harris *et al.* (1994) found thatNmineralisation was the greatest in the manure amended soil suggesting that treatment resulted in a viable soil biomass which was either larger in size or metabolically more active.

Mondini *et al*. (2010) studied the mineralization dynamics and biochemical properties following application of organic residues to soil and observed that the there was a significant increase in the content of soil mineralisable nitrogen when treated with animal by-products, while plant residues produced immobilization of mineral N.

Mohanty*et al*. (2012) studied the carbon mineralisation kinetics of a rice soil under 41 years of rice-rice system under different nutrient management practices and reported that the potentially mineralisable N at field capacity ranged from 44.5 to 59.4 mg kg^{-1}soil and from 18.8 to 29.2 mg kg^{-1}soil in 0-15cm and 15-30 cm soil depth respectively.

Siddeswaran*et al*. (2012) conducted a study on long term effect of nutrient sources on the productivity of rice under organic farming and found that available N status steadily improved with green manuring and poultry manure applicationcompared to controland green manure alone.

2. 7 CARBON MINERALIZATION POTENTIAL

Alokkumar and Yadav (1993) found that the unfertilized soil showed reduction of about 50 per cent in organic carbon by 12 years of cropping as compared to initial value.

Study on the effect of organic amendments on biological properties of a soil under winter wheat and barley by Ross *et al*. (1995) revealed an increase in soil organic matter content and soil enzyme activities as a result of rhizo-deposition.

Selvi*et al.* (2003) observed that the highest organic carbon was recorded in plots where fertilizers were continuously incorporated with FYM. Ramesh and Chandrasekaran (2004) reported a gradual mineralisation pattern of organic carbon content under in situ incorporation of *Sesbaniarostrata* in a rice- rice cropping system.

Monaco *et al*. (2008) reported thatthe repeated application of the different organic materials, in addition to urea- N fertilizer, increased not only soil organic carbon content but also microbial biomass C as compared to no fertilizer N and urea alone.

Tomar and Das(2011) studied the influence of tree leaf green manuring on low land rice productivity in mid-altitudes of Meghalaya and reported that there was significant improvement in soil organic carbon content due to various green leaf manure applications indicating the suitability of green leaf manuring in hills as means of soil health augmentation.

Based on studies on long-term effects of nutrient management on soil health and crop productivity under rice-wheat cropping system Singh *et al*. (2012) reported that the integrated use of fertilizers with organic manures led to marked increase in the contents of various poolsof organic carbon.

Siddeswaran*et al*. (2012) conducted a study on the long term effect of nutrient sources on the productivity of rice under organic farming and found that soil organic carbon content improved with combined application of organic manures and green manuring compared to organic manure alone.

Mohanty*et al*. (2012) studied the carbon mineralization kinetics of soil under 41 years of rice-rice system under different nutrient management practices and reported that potentially mineralizablecarbon ranged from 1016 to 1855mgkg^{-1} soil.

Anan*et al*. (2015)studied the effect of application of jatropha press cake in soils of some waste land of semi arid tropics and observed thatcarbon accumulation in soil was higher per unit of applied carbon in press cake.

Saikia*et al* (2015) suggested that crop residue and FYM in combination can maintain soil organic carbon stock and can substitute 20 per cent of inorganic without compromising crop growth and development.

Materials and Methods

3.MATERIALS AND METHODS

The present study was undertaken with the objective of building an inventory on the biological properties of selected garden land soil series of Onattukara identified suitable for coconut cultivation based on crop suitability rating. Detailed investigations involving a preliminary survey of the region, collection of soil samples and their chemical analysis followed bystatistical analysis of the data generated were carried out at College of Agriculture, Vellayani during the period 2013- 15.

The details regarding the collection of soil samples, laboratory analytical methods followed and statistical techniques adopted for arriving at helpful inferences are discussed in this chapter.

3.1 DETAILS OF SOIL SAMPLE COLLECTION

On the basis of productivityrating the 13 garden land soil series of Onattukara identified suitable for coconut cultivation are further classified taking into consideration the estimated properties of these soils such as soil texture, depth, slope, drainage, coarse fragments, soil reaction, cation exchange capacity, base saturation, total soluble salts and organic carbon. For each property a weightage is given and the product of these weightages expressed as a percentage is taken as an index for calculating the productivity index of a soil series. These indices are compared against a scale and the soil series are classified into ‘very good’, ‘good’, ‘average’ and ‘poor’ (Premachandran , 1998). Two soil series from each category were selected for the collection of soil samples,Palamel and Attuva from ‘very good’ soil productivity class, Vallikunnam and Mynagappally from ‘good’, Neendakara and Kandallur from ‘average’ and Kollaka and Thrikunnappuzha from ‘poor’ productivity class.(Plate 1)

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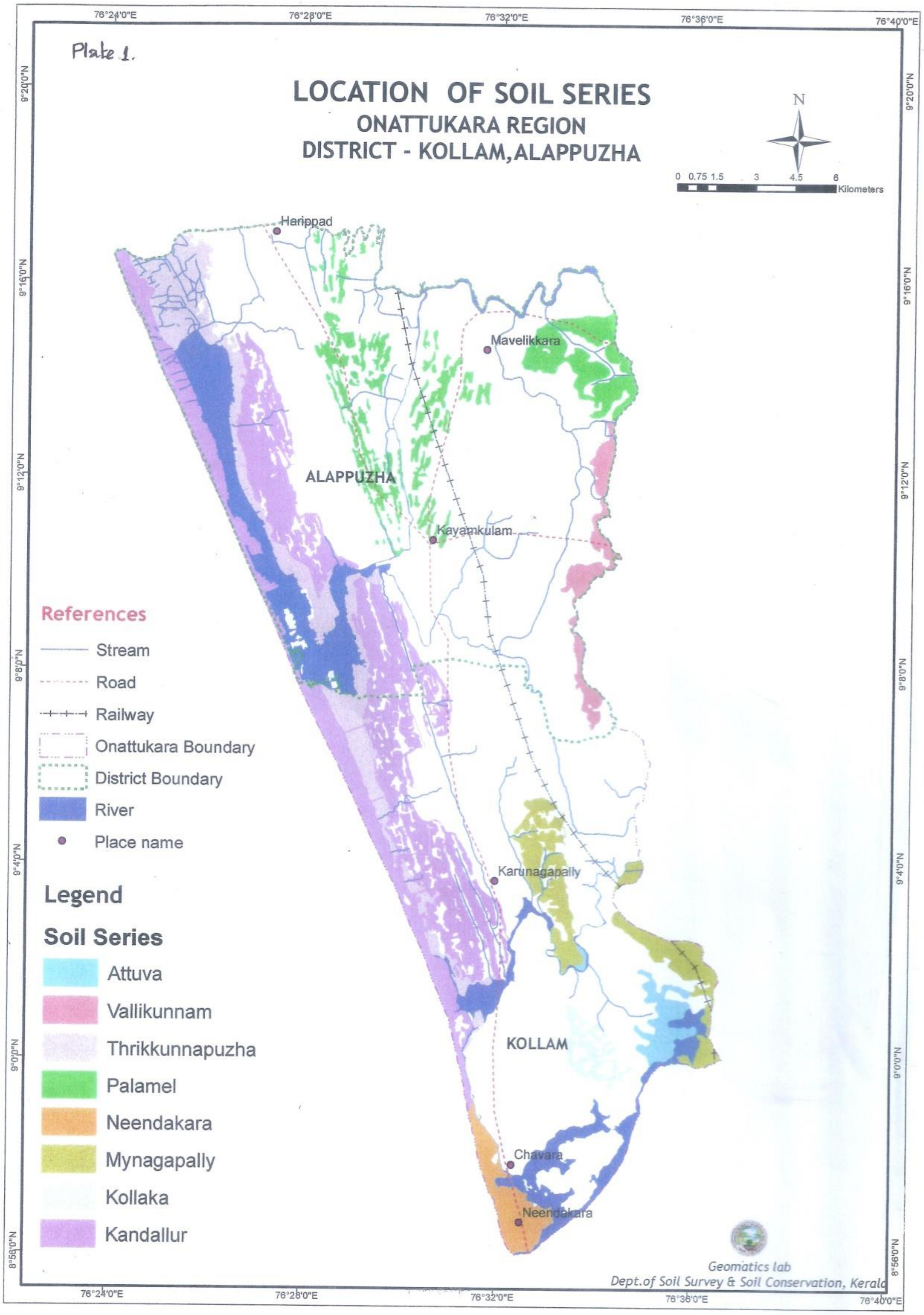


Plate 1.
LOCATION OF SOIL SERIES
ONATTUKARA REGION
DISTRICT - KOLLAM, ALAPPUZHA
N
0 0.75 1.5 3 4.5 6
Kilometers
76°24'0"E
76°28'0"E
76°32'0"E
76°36'0"E
76°40'0"E
9°20'0"N
9°16'0"N
9°12'0"N
9°8'0"N
9°4'0"N
9°0'0"N
8°56'0"N
Harippad
Mavelikkara
ALAPPUZHA
Kayamkulam
Karunagapally
KOLLAM
Chavara
Neendakara
References
Stream
Road
Railway
Onattukara Boundary
District Boundary
River
Place name
Legend
Soil Series
Attuva
Vallikunnam
Thrikkunnapuzha
Palamel
Neendakara
Mynagapally
Kollaka
Kandallur
Geomatics lab
Dept. of Soil Survey & Soil Conservation, Kerala

In each soil series, coconut growing farmers were approached and through personal interviews with them, three palms in the age group 15 to 20 years and falling in the following management categories were selected

1.Fertilized organically for the last three years.

2.Fertilized inorganically for the last three years.

3.Fertilized both organically and inorganically for the last three years.

4.Unfertilized for the last three years.

From the basins of the palms, soil samples were collected from a depth of 60cm within a lateral radius of 2m from the bases of the palms. One composite sample was collected for each palm.

3.2 PREPARATION OF SOIL SAMPLES FOR ANALYSIS

As all the soil characters studied are related to the biological activities in the soil, field fresh soil samples were used for chemical analysis in the laboratory. The soil samples were maintained at field moisture capacity under refrigeration and air dried whenever necessary.

3.3 EARTHWORM POPULATION (no. m^{-2} soil)

This estimation was done in situ. The soil sample collected as described above fromone m^2 of area was spread on sheets of paper and the number of earthworms present in this soil was counted.

3.4 ARTHROPOD POPULATION (no. kg^{-1} soil)

Arthropods like collembola and mites were counted using modified Berlesse-Tullgreen funnel method (MacFadyen, 1961). The illustration of the same is given as Plate2. One kg soil sample was taken and placed over a wire guaze in a specially

Plate 2. A view of arthropod estimation

made funnel with slanting sides. Soil was heated gently using 40 watts bulb. Heating was continued for a day. The arthropods moved down in response to the temperature gradient created and eventually got collected in a collecting vial containing ethanol-water mixture kept at the tail of the funnel. The contentsin the collecting vials were transferred directly to a counting dish and their populations were counted under a binocular microscope.

3.5 SOIL MICROFLORA

Serial dilution agar plating method outlined by Timonin (1940) was adopted for the isolation of the following microorganisms which were cultured on their specific suitable media. The details regarding the composition of each are appended as Appendix 1

	Microorganism	**Dilution factor**	**Medium**
3.5.1	**Bacteria**	x 10^6 cfu g $^{-1}$ soil	Nutrient agar
3.5.2	**Fungi**	x 10^4 cfu g $^{-1}$ soil	Martins' Rose Bengal agar
3.5.3	**Actinomycetes**	x 10^3 cfu g $^{-1}$ soil	Ken knight's agar
3.5.4	***Azospirillum*sp.**	x10^4 cfu g $^{-1}$ soil	Nitrogen free Bromothymol blue(NFB) agar
3.5.5	***Azotobacter* sp.**	x10^3 cfu g $^{-1}$ soil	Jenson's agar
3.5.6	**PSolubilizers**	x10^4cfu g $^{-1}$ soil	Pikovaskaya's agar

3.6. SOIL ENZYMES

3.6.1. Urease activity (µg urea g^{-1} soil hr^{-1})

The uresase activity was determined following the method described by Broadbent *et al.*(1964).

Twenty five gram soil was weighed into an Erlenmayer flask, to which 4 ml of urea substrate solution was added. Enough water was added to each flask to maintain a tension of 1/3 bar and incubated for 24 hours at 30^0C. Then the flasks were removed, $CaSO_4$ solution was added to make up the volume to 100 ml. About 15 ml of the supernatant solution was taken and colour was developed by adding 10ml p-dimethyl amino benzaldehyde which was then read in a spectrophotometer at a wavelength of 420 nm. Standards were also prepared using urea solutions of known concentrations(Plate3).

3.6.2 Phosphates activity (µg p- nitrophenol g^{-1} soil hr^{-1})

The procedure described by Eivazi and Tabatabai(1977)was adopted for the estimation of phosphatase activity

To one gram soil in a 50 ml Erlen Meyer flask, 0.2 ml toluene, 4 ml modified universal buffer (pH- 6.5) and 1ml p-nitrophenyl phosphate solution were added and incubated at 23^0C for one hour. After incubation, 0.5 M $CaCl_2$ (1ml) and 0.05M NaOH (1ml) were added. The contents were swirled and filtered through Whatman No.2 filter paper and the intensity of yellow colour developed was read in a spectrophotometer at a wavelength of 420 nm. One percent solution of p- nitrophenyl phosphate was used for the preparation of standards (Plate4).

Plate 3. A view of urease enzyme activity estimation

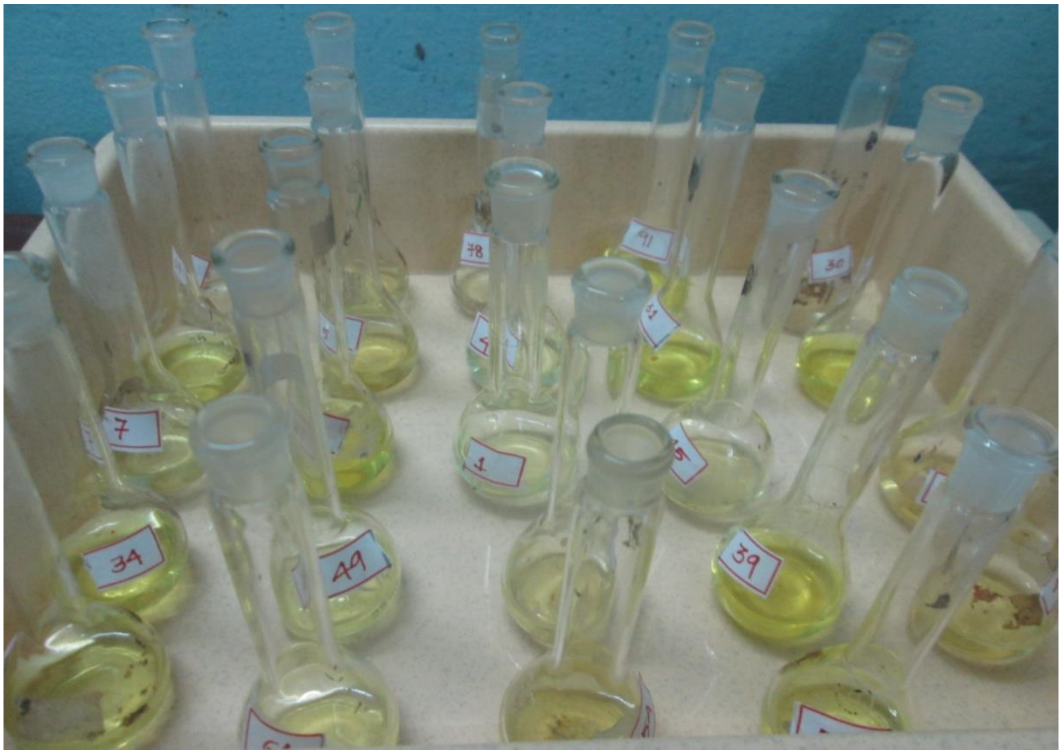


Plate 4. A view of phosphatase enzyme activity estimation

3.6.3. Dehydrogenase activity (µg TPF g $^{-1}$soil24hr^{-1})

The estimation of dehydrogenase activity in soil was done following the procedure given by Casida*et al.*,(1964)

Six gram of air dried soil was weighed to a 250 ml Erlen Meyer flask. One ml of 3 per cent triphenyltetrazolium chloride was added and incubated for 24 hours at 27°C. After incubation, the soil was quantitatively transferred to a glass funnel and was given ethanol washings consecutively till the volume reached 100 ml. The colour intensity was then read in a Spectrophotometer at 485 nm. A series of standards were used for preparing the calibration curve (Plate5).

3.6.4.Enzyme activity number

Enzyme activity number of the soil was computed based on the activity of three different enzymes as proposed by Beck (1984) adopting the following formula.

$$\text{EAN}=\frac{0.2\left(\text{dehydrogenase activity}+\frac{\text{phosphatase activity}}{40}+\frac{\text{urease activity}}{40}\right)}{2}$$

3.7. SOIL RESPIRATORY ACTIVITY (mg CO_2 100g^{-1}soil d^{-1})

The respiratory activity of the soil was estimated using the method proposed by Jenkinson and Powlson(1976)by which the CO_2 evolved from a fixed quantity of incubated soil was collected in standard alkali and titrated against standard acid.

10 g of soil sample was weighed and transferred to a sterile conical flask of 500ml capacity. The sample was moistened with water to adjust the soil moisture to 50per cent of its water holding capacity. 10 ml 0.1 N NaOH taken in an injection vial. The vial was hung inside the conical flask with the help of a string and the mouth of the conical flask was closed with cotton plug so as to make it air tight. The sample Was incubated at room temperature for a week. Carbon dioxide evolving as a

Plate 5. A view of dehydrogenase enzyme activity

result of microbial respiration got absorbed in the alkali resultingthe formation of Na_2CO_3. After the incubation period the cotton plug was removed.The alkali in the vial was transferred to a small conical flask and was titrated against standard acid using phenolphthalein as indicator (Plate 6).

3.8. CARBON MINERALIZATION POTENTIAL (%)

The chromic acid wet digestion method suggested by Walkley and Black(1934) was employed for the estimation of carbon mineralization potential of the soils.

3.9. NITROGEN MINERALIZATION POTENTIAL(kg ha^{-1})

The nitrogen mineralization potential was determined by the alkaline permanganate method of Subbiah and Asija(1956).

3.10. YIELD OF PALMS (nuts $palm^{-1}$ $year^{-1}$)

Yield of palms were computed through personal interviews held with the farmers whose palms were surveyed, based on the information they provided on the average number of nuts per harvest and the number of harvestsover an year.

3.11. OBSERVATIONS ON PEST AND DISEASES

Onattukara has been long recognized as an endemic area prone to the incidence of pest and diseases as far as coconut is considered. The symptoms manifested on the palms were observed, pest/ disease diagnosed and recorded.

Plate 6. A view of soil respiratory activity estimation

3.12. STATISTICAL ANALYSIS

The data generated from the investigations were subjected to analysis of variance applicable to factorial completely randomized design described by Cochran and Cox(1965) and their significance was tested by the F test (Snedecor and Cochran,1975)

Results

4. RESULTS

Laboratory investigations were conducted at College of Agriculture, Vellayani on the soil samples collected from the ‘very good’, ‘good’, ‘average’ and ‘poor’ soil productivity classes of Onattukara region under coconut cultivation. The samples were analyzed for their important biological properties. Information on yield and prevalence of pests and diseases on the palms were obtained through frequent field visits and personal interviews with farmers. The salient results of the effects of nutrient management practices and soil productivity classes on important biological properties were generated and presented in this chapter.

4.1 EARTHWORM POPULATION

Earthworm population (Table 1) was significantly influenced both by nutrient management practices and productivity classes of the soils. But their interaction effect was not significant on this property. The population ranged from 1.04 no m^{-2} soil in the ‘poor’ category soils receiving inorganic fertilizers only to 3.12 no m^{-2} in the ‘very good ‘soils which were under organic nutrition alone. Between management practices soil receiving organic fertilization M_1recorded the highest value of 2.55 no m^{-2}soil whereas soils receiving inorganic source of inputsM_2 recorded the lowest count of 1.64 no m^{-2}soil. Between soil productivity classes, S_1(‘very good’ productivity class) recorded the highest earthworm count of 2.72 no m^{-2}soil and S_4 (‘poor’ productivity class) recorded the lowest count of 1.77 no m^{-2}soil.

4.2 ARTHROPOD POPULATION

Nutrient management practices, soil productivity classes and their interaction caused significant variation on the arthropod populations (Table 2). The lowest value was observed in the ‘poor’ category soils which were neither organically nor inorganically fertilized (76.67 no kg^{-1}soil) and was on par with ‘average’ category

Table 1.Effect of nutrient management practices and soil productivity classes on earthworm population (no.m^{-2}soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	3.12	2.15	2.46	2.48	2.55
M_2	2.50	1.50	1.50	1.04	1.64
M_3	2.74	2.82	1.77	1.83	2.29
M_4	2.54	2.59	1.88	1.74	2.19
MEAN	2.72	2.28	1.90	1.77	
SEm(±)M	0.204				
SEm(±)S	0.204				
SE(±)S×M	0.407				
CD (0.05)M	0.573				
CD(0.05)S	0.573				
CD (0.05)M×S	NS				

S- soil productivity classes

S_1- ‘very good’ soil productivity class

S_2- ‘good’ soil productivity class

S_3- ‘average’ soil productivity class

S_4- ‘poor’ soil productivity class

M- management practices

M_1- organic only

M_2- inorganic only

M_3- both organic and inorganic

M_4- none

Table 2.Effect of nutrient management practices and soil productivity classes on arthropod population (no. kg^{-1}soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	158.33	128.33	133.33	110.00	132.50
M_2	96.67	128.33	125.00	96.67	107.50
M_3	110.00	135.00	146.67	95.00	121.67
M_4	123.33	101.67	80.00	76.67	100.42
MEAN	117.08	123.33	125.42	95.42	
SEm(±)M	5.153				
SEm(±)S	5.153				
SE(±)S×M	10.306				
CD (0.05)M	14.503				
CD(0.05)S	14.503				
CD (0.05)M×S	29.005				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

soils which were not managed by using either fertilizer or organic manure (80.00 no kg^{-1}soil) and the highest value observed in the 'very good' soils which were organically managed (158.33 no kg^{-1}soil). Among the management practices M_1 soils which were organically managed recorded the highest count of 132.50 no kg^{-1}soil and the lowest value was observed in M_4 soils which were not fertilized or manured (100.42 no kg^{-1}soil). Among the soil productivity classes, S_3('average') soil productivity class recorded the highest arthropod population (125.42 nokg^{-1}soil) where as S_4 ('poor') soil productivity class recorded the lowest count of arthropod population (95.42 no kg^{-1}soil).

4.3SOIL MICROFLORA

4.3.1 Bacterial population

The effect of nutrient management practices and soil productivity classes on bacterial population varied from the lowest value of 27.00×10^6cfu g^{-1} soil in the 'poor' soils which were under neither organically nor inorganic nutrition to 67.00×10^6cfu g^{-1} soil in the 'very good' soils which were receiving organic inputs alone (Table 3). Between management practices, M_1(soils managed with organic inputs) recorded the highest value of 54.54×10^6cfu g^{-1} soil andM_2 (soils inorganically managed) recorded the lowest value of 38.71×10^6cfu g^{-1} soil. Among soil classes, S_1 ('very good') soil productivity class recorded the highest value of 55.79×10^6cfu g^{-1} soil and S_4('poor') soil productivity class recorded the lowest value of 35.58×10^6cfu g^{-1} soil.

4.3.2Actinomycetes population

There was significant effects for the factors, nutrient management, soil productivity class and their interactions on actinomycetes population (Table 4). The 'poor' soils receiving no organic and inorganic nutrition recorded the lowest value of actinomycetes population of 4.33 x 10^3 cfu g^{-1}soil. The highest value of 11.67 x 10^3

Table 3.Effect of nutrient management practices and soil productivity classes on bacterial population (×10^6cfu g^{-1}soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	67.00	53.67	62.67	34.83	54.54
M_2	35.33	32.50	43.83	43.17	38.71
M_3	65.67	41.67	57.00	37.33	50.42
M_4	55.17	36.17	38.17	27.00	39.13
MEAN	55.79	41.00	50.42	35.58	
SEm(±)M	3.346				
SEm(±)S	3.346				
SE(±)S×M	6.693				
CD (0.05)M	9.418				
CD(0.05)S	9.418				
CD (0.05)M×S	NS				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

Table 4.Effect of nutrient management practices and soil productivity classes on actinomycetes population (x 10^3 cfu g^{-1}soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	11.67	9.67	6.50	9.33	9.29
M_2	6.67	8.50	7.50	7.50	7.54
M_3	8.83	8.67	7.50	7.00	8.00
M_4	7.00	6.50	5.17	4.33	5.75
MEAN	8.54	8.33	6.67	7.04	
SEm(±)M	0.382				
SEm(±)S	0.382				
SE(±)S×M	0.764				
CD (0.05)M	1.076				
CD(0.05)S	1.076				
CD (0.05)M×S	2.152				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

cfu g^{-1}soil was recorded in the 'very good' soils which were receiving organic inputsalone. Among the nutrient management practices, M_1under organic nutrition alone recorded the highest value of 9.29 x 10^3 cfu g^{-1}soil while M_4 with no nutrition recorded the lowest value of 5.75 x 10^3 cfu g^{-1}soil. Between soil classes S_1 ('very good' category) recorded the highest value of 8.54 x 10^3 cfu g^{-1}soil and S_3 ('average'category) had the lowest value of 6.67 x 10^3 cfu g^{-1}soil.

4.3.3 Fungal population

There was statistical significance for influence of management practices, productivity classes and their interaction on fungal population in these soils (Table 5). The population of fungi ranged from 17.00 x 10^4 cfu g^{-1} soil in the 'poor' soils with no nutritionat all to the highest value of 32.17 x 10^4 cfu g^{-1} soil in the 'very good' soils which received nutrition from both organic and inorganic sources. On comparison between management practices, M_3(which was managed both organically and inorganically) recorded the highest value of 26.71x 10^4 cfu g^{-1} soil and M_4(soil in which no nutrient applications were done organically or inorganically) recorded the lowest value of 18.75 x 10^4cfu g^{-1}soil. Among soil productivity classes S_1(very good category) recorded the highest value of 26.83 x 10^4 cfu g^{-1} soil and S_4(poor category) recorded the lowest value of 19.54x 10^4 cfu g^{-1} soil.

4.3.4 *Azotobacter* population

The result of enumeration of *Azotobacter*population in Onattukara soils under coconut cultivation is presented in Table 6. The population of these organisms was influenced significantly only by the nutrient management methods practiced by farmers. The population ranged from 12.50x 10^3 cfu g^{-1} soil in the 'average'soils devoid of any nutrition .to 18.17 x 10^3 cfu g^{-1} soil in the 'good' soils which wereput under organic nutrition. The management practice M_1 (organically managed) recorded the highest population of 16.58 x 10^3 cfu g^{-1} soil and M_4 soils which had neither organic nor inorganic nutrient addition recorded the lowest value of 13.79 x

Table 5. Effect of nutrient management practices and soil productivity classes on fungal population (x 10^4 cfu g^{-1} soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	29.50	25.83	23.67	21.00	25.00
M_2	24.67	22.67	20.67	18.67	21.67
M_3	32.17	28.17	25.00	21.50	26.71
M_4	21.00	18.83	18.17	17.00	18.75
MEAN	26.83	23.88	21.88	19.54	
SEm(±)M	0.429				
SEm(±)S	0.429				
SE(±)S×M	0.858				
CD (0.05)M	1.208				
CD(0.05)S	1.208				
CD (0.05)M×S	2.416				

S- soil productivity classes — M- management practices

S_1- 'very good' soil productivity class — M_1- organic only

S_2- 'good' soil productivity class — M_2- inorganic only

S_3- 'average' soil productivity class — M_3- both organic and inorganic

S_4- 'poor' soil productivity class — M_4- none

Table 6.Effect of nutrient management practices and soil productivity classes on *Azotobacter* population (x 10^3 cfu g^{-1} soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	15.33	18.17	15.83	17.00	16.58
M_2	15.50	16.50	15.83	15.83	15.92
M_3	15.17	17.00	16.67	15.33	16.04
M_4	15.00	14.00	13.67	12.50	13.79
MEAN	15.25	16.42	15.21	15.46	
SEm(±)M	0.489				
SEm(±)S	0.489				
SE(±)S×M	0.978				
CD (0.05)M	1.377				
CD(0.05)S	NS				
CD (0.05)M×S	NS				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

10^3 cfu g^{-1} soil. When the soil productivity classes are compared S_2('good') category soils recorded the highest value of 16.42x 10^3 cfu g^{-1} soil while S_3('average' category soils) recorded the lowest of 15.21x 10^3 cfu g^{-1} soil.

4.3.5 *Azospirillum* population

Table 7 shows the effect of nutrient management practices and soil productivity classes on *Azospirillum* population. While the former had significant effect on these populations the latter did not significantly exert any influence. However the interaction was significant. The population ranged from 13.17×10^4 cfu g^{-1} soil in the 'average' soils managed neither organically nor inorganically to 25.00×10^4 cfu g^{-1} soil in the 'average' soils which were managed organically. Between management practices organically managed soilsM_1 recorded the highest value of 23.33×10^4 cfu g^{-1} soil and M_4 managed neither organically nor inorganically recorded the lowest value of 16.17×10^4 cfu g^{-1} soil. Between soil classes S_1 very good category had the highest value of 21.50×10^4 cfu g^{-1} soil and S_4 had the lowest value of 18.92×10^4 cfu g^{-1} soil.

4.3.6 P solubilizers population

The data on the effect of nutrient management practices, soil productivity classes and their interactions on the population of P solubilizers are presented in Table.8. The effects were significant for both main factors but not for their interaction. The population ranged from 1.50 x 10^4 cfu g^{-1} soil in the 'poor' soils without any nutrition to 5.50 x 10^4 cfu g^{-1}soil in the 'very good' soils under organic management alone. Between the management practices soils managed both organically and inorganicallyM_3 recorded the highest value of 4.33 x 10^4 cfu g^{-1} soil and M_4 managed neither organically nor inorganically had the lowest value of 2.42 x 10^4 cfu g^{-1} soil. Between soil classes S_1 'very good' category recorded the highest

Table 7. Effect of nutrient management practices and soil productivity classes on *Azospirillum* population (×10^4cfu g^{-1}soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	23.83	21.67	25.00	22.83	23.33
M_2	20.00	19.83	23.67	17.50	20.25
M_3	24.00	23.83	20.67	19.50	22.00
M_4	18.17	17.50	13.17	15.83	16.17
MEAN	21.50	20.71	20.63	18.92	
SEm(±)M	0.701				
SEm(±)S	0.701				
SE(±)S×M	1.402				
CD (0.05)M	1.973				
CD(0.05)S	NS				
CD (0.05)M×S	3.833				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

Table 8.Effect of nutrient management practices and soil productivity classes on P solubilizers population (x 10^4 cfu g^{-1} soil)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	5.50	4.17	3.17	3.67	4.13
M_2	4.00	2.33	5.33	2.00	3.42
M_3	5.50	4.50	4.50	2.83	4.33
M_4	2.83	2.33	3.00	1.50	2.42
MEAN	4.46	3.33	4.00	2.50	
SEm(±)M	0.214				
SEm(±)S	0.214				
SE(±)S×M	0.428				
CD (0.05)M	0.603				
CD(0.05)S	0.603				
CD (0.05)M×S	NS				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

value of 4.46 x 10^4 cfu g^{-1} soil and the S_4 'poor' category had the lowest value of 2.50 x 10^4 cfu g^{-1} soil.

4.4 ENZYME ACTIVITY

4.4.1 Urease activity (ppm urea hydrolysed g^{-1} soil hr^{-1})

Irrespective of the nutrient management practices followed by farmers or the productivity classes of the soils or even their interaction, urease activity did not vary significantly in the soils(Table9). However the values ranged from 90.37 ppm urea hydrolysed g^{-1} soil hr^{-1} in the 'very good' soils which were receiving inorganic nutrition only to 116.88 ppm urea hydrolysed g^{-1} soil hr^{-1} in the average soils which had both organic and inorganic nutrition. Between management practices $M_4$with no nutrition at all registered the highest value of 109.64 ppm urea hydrolysed g^{-1} soil hr^{-1} and $M_2$with inorganic nutrition had the lowest value of 100.65 ppm urea hydrolysed g^{-1} soil hr^{-1}. Between the soil classes S_2, 'good' category recorded the highest value of 110.55 ppm urea hydrolysed g^{-1} soil hr^{-1} and S_4, 'poor' category had the lowest value of 99.26 ppm urea hydrolysed g^{-1} soil hr^{-1}.

4.4.2 Phosphatase activity(µg p- nitrophenol released g^{-1} soil hr^{-1})

Scrutiny of the data on phosphatase activity in the soils presented in Table 10 shows that this property of the soil was significantly altered by the nutrient management practices, the productivity classes of the soils as well as their interaction. The activity ranged from 41.99 µg of p- nitrophenol released g^{-1} soil hr^{-1} in the 'poor 'soils which hadorganic source of nutrition to 109.74 µg of p- nitrophenol released g^{-1} soil hr^{-1} in the 'very good' soils which were receiving organic inputs. Between management practices M_4devoid of any nutrition at all recorded the highest value of 93.49 µg of p- nitrophenol released g^{-1} soil hr^{-1} and M_3receiving nutrients through organic as well as inorganic sources registered the lowest value of 74.22 µg of p- nitrophenol released g^{-1} soil hr^{-1}. Between soil classes S_4'very good' category

Table 9.Effect of nutrient management practices and soil productivity classes on urease enzymeactivity (ppm urea hydrolysed g^{-1} soil hr^{-1})

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	106.12	108.14	95.64	100.01	102.48
M_2	90.37	113.88	101.51	96.84	100.65
M_3	109.27	104.33	116.88	93.27	105.93
M_4	112.32	115.85	103.49	106.93	109.64
MEAN	104.52	110.55	104.39	99.26	
SEm(±)M	2.919				
SEm(±)S	2.919				
SE(±)S×M	5.838				
CD (0.05)M	NS				
CD(0.05)S	NS				
CD (0.05)M×S	NS				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

Table 10.Effect of nutrient management practices and soil productivity classes on phosphatase enzyme activity(µg p- nitrophenol released g^{-1} soil hr^{-1})

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	109.74	53.17	102.14	41.99	76.23
M_2	101.83	54.56	100.28	60.82	79.37
M_3	100.99	51.66	98.41	45.79	74.22
M_4	107.59	88.53	103.94	71.78	93.49
MEAN	105.04	61.98	101.19	55.09	
SEm(±)M	2.381				
SEm(±)S	2.381				
SE(±)S×M	4.763				
CD (0.05)M	6.702				
CD(0.05)S	6.702				
CD (0.05)M×S	13.405				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

had the highest value of 105.04 µg of p- nitrophenol released g^{-1} soil $hr^{-1}$and S_1‘poor’category had the lowest value of 55.09 µg of p- nitrophenol released g^{-1} soil hr^{-1}. All the nutrient management practices under ‘very good’ and ‘average’ soil productivity classes were on par with each other.

4.4.3 Dehydrogenase activity(µg TPF hydrolysed g^{-1} soil 24 hr^{-1})

Dehydrogenase activity recognized as the most sensitive indicator of soil biological health, varied significantly as a result of nutrient management practices, soil productivity classes and their interaction (Table 11). The values ranged from 216.66 µg TPF hydrolysed g^{-1} soil 24 hr^{-1} in poor category soils which were neither organically nor inorganically fertilized to 403.49 µg TPF hydrolysed g^{-1} soil 24 hr^{-1}in very good category soils which were solely organically fertilized. Between the management practices, M_1managed organically recorded the highest value of 344.44 µg TPF hydrolysed g^{-1} soil 24 hr^{-1} and M_4 (managed neither organically nor inorganically) recorded the lowest value of 270.92 µg TPF hydrolysed g^{-1} soil 24 hr^{-1}. Between soil classes S_1(very good category) recorded the highest value of 345.56 µg TPF hydrolysed g^{-1} soil 24 hr^{-1} and S_4(poor category) recorded the lowest value of 246.06 µg TPF hydrolysed g^{-1} soil 24 hr^{-1}.

4.4.4 Enzyme activity number

The data on enzyme activity number of the soils are given in Table 12. The values ranged from 22.21 recorded by the ‘poor’ soils with no nutrition to 40.72 which was registered by ‘very good’ soils under organic nutrition. No statistical analysis of the data was done as an arbitrary value of 35 has been accepted as the standard for judging a soil for its biological health based on this value. On this basis ‘very good’ and ‘good’ soils with only organic and both organic and inorganic nutrition recording values above 35 come under biologically healthy or fertile soil group.

Table 11.Effect of nutrient management practices and soil productivity classes on dehydrogenase enzyme activity (µg TPF hydrolysed g^{-1} soil 24 hr^{-1})

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	403.49	382.26	324.39	267.59	344.44
M_2	300.35	293.02	261.73	235.99	272.76
M_3	353.23	371.27	314.33	264.01	325.71
M_4	325.19	287.85	253.98	216.66	270.92
MEAN	345.56	333.60	288.60	246.06	
SEm(±)M	5.674				
SEm(±)S	5.674				
SE(±)S×M	11.349				
CD (0.05)M	15.970				
CD(0.05)S	15.970				
CD (0.05)M×S	31.941				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

Table 12. Effect of nutrient management practices and soil productivity classes on Enzyme Activity Number

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	40.72*	38.62*	32.93	27.27	34.89
M_2	30.41	29.72	26.67	24.09	27.73
M_3	35.71*	37.51*	31.98	26.88	33.02
M_4	32.98	29.29	25.92	22.21	27.59
MEAN	34.95	33.79	29.37	25.12	

*Number above 35 indicates that the soil is biologically fertile

S- soil productivity classes — M- management practices

S_1- 'very good' soil productivity class — M_1- organic only

S_2- 'good' soil productivity class — M_2- inorganic only

S_3- 'average' soil productivity class — M_3- both organic and inorganic

S_4- 'poor' soil productivity class — M_4- none

4.5 SOIL RESPIRATORY ACTIVITY

Result of the assay of the soils for respiratory activity depicted in Table 13 shows that nutrient management practices and soil productivity classes individually and in combination exerted significant effects. At the interaction level, the lowest value was observed in the ‘poor’ category soils which were neither organically nor inorganically fertilized (8.79 µg CO_2 evolved g^{-1}soil hr^{-1}) and the highest valuewas observed (11.37 µg CO_2 evolved g^{-1}soil hr^{-1}) in ‘very good’ soils which received organic source of nutrition. Between management practices M_1 (managed organically) recorded the highest value of 10.85 µg CO_2 evolved g^{-1}soil hr^{-1} and M_4 (not at all receiving any nutrient) recorded the lowest value of 9.67 µg CO_2 evolved g^{-1}soil hr^{-1}. Organic management practices in all the soil productivity classes were on par with each other. Between soil productivity classes S_1 (‘very good’ category) recorded the highest value of 11.09 µg CO_2 evolved g^{-1}soil hr^{-1} and S_4 (‘poor’ category) recorded the lowest value of 9.43 µg CO_2 evolved g^{-1}soil hr^{-1}.

4.6 NITROGEN MINERALIZATION POTENTIAL

Nitrogen mineralization potential which was estimated as available nitrogen content in the soil differed significantly as a result of nutrient management practices, soil productivity classes and their interaction (Table14). The values ranged from 219.69 kg ha^{-1} in the ‘poor’ category soils receiving neither organically nor inorganic inputs to 471.72 kg ha^{-1} in the ‘very good’ soils fertilized both organically and inorganically. Among the management practices M_3(both organically and inorganically fertilized) recorded the highest value of 392.23 kg ha^{-1} whereas M_4(no organic or inorganic inputs) recorded the lowest content of 291.91 kg ha^{-1}. Between soil classes S_1(‘very good’) category hadthe highest value of 402.99 kg ha^{-1} and S_4 (’poor’ category) had the lowest value of 288.77kg ha^{-1}.

Table 13.Effect of nutrient management practices and soil productivity classes on soil respiratory activity (µg CO_2 evolved g^{-1}soil hr^{-1})

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	11.37	11.11	10.76	10.16	10.85
M_2	11.11	10.45	8.81	8.81	9.79
M_3	11.29	9.81	9.78	9.99	10.22
M_4	10.61	10.34	8.92	8.79	9.67
MEAN	11.09	10.43	9.56	9.43	
SEm(±)M	0.215				
SEm(±)S	0.215				
SE(±)S×M	0.430				
CD (0.05)M	0.606				
CD(0.05)S	0.606				
CD (0.05)M×S	1.212				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

Table 14.Effect of nutrient management practices and soil productivity classes onnitrogen mineralization potential (kg ha^{-1})

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	341.94	417.49	354.72	304.25	354.59
M_2	366.39	346.12	346.56	299.55	339.66
M_3	471.72	436.37	329.23	331.59	392.23
M_4	431.89	237.40	278.64	219.69	291.91
MEAN	402.99	359.35	327.28	288.77	
SEm(±)M	14.402				
SEm(±)S	14.402				
SE(±)S×M	28.804				
CD (0.05)M	40.533				
CD(0.05)S	40.533				
CD (0.05)M×S	81.006				

S- soil productivity classesM- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

4.7 SOIL CARBON MINERALIZATION POTENTIAL

Nutrient management practices, soil productivity classes and their interaction significantly differed carbon mineralization potential of the soils, which was estimated as organic carbon content in the soilsand the values are presented in Table 15. The range was from 0.61 per cent in the ‘poor’ soils receiving neither organic nor inorganic nutrient inputs to 1.75 per cent in ‘very good’ soils which were both organically and inorganically fertilized. Between management practices M_3 both organically and inorganically managed recorded the highest value of 1.25 per cent while M_4 soils which were nourished neither organically nor inorganically recorded the lowest value of 0.92 per cent.Between soil classes S_1(‘very good’ category) had the highest value of 1.42 per cent and S_4(‘poor’ category) had the lowest value of 0.90 per cent.

4.8. COCONUT YIELD

The yield of the palms (Table. 16) differed significantly as a consequence of nutrient management practices, soil productivity classes and their interaction effect. The range was from 17.50 nuts palm^{-1} year^{-1} in the ‘poor’ category soils which were neither organically nor inorganically nurtured to 56.33 nuts palm^{-1} year^{-1}in the ‘very good’ soils which were both organically and inorganically nourished. Between the management practices, M_3 (supplied with both organic and inorganic nutrient inputs) recorded the highest value of 48.13 nuts palm^{-1} year^{-1} and M_4 (deprived of nutrition of any kind) recorded the lowest value of 24.55 nutspalm^{-1} year^{-1}. Between the soil productivity classes S_1(‘very good’) recorded the highest value of 42.25 nuts palm^{-1} year^{-1} and S_4(‘poor’) recorded the lowest value of 27.92 nutspalm^{-1} year^{-1}.

Table 15.Effect of nutrient management practices and soil productivity classes on soil carbon mineralization potential (%)

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	1.13	1.13	1.41	1.23	1.23
M_2	1.15	1.01	0.99	0.82	0.99
M_3	1.75	1.47	0.82	0.93	1.25
M_4	1.64	0.80	0.62	0.61	0.92
MEAN	1.42	1.06	1.02	0.90	
SEm(±)M	0.091				
SEm(±)S	0.091				
SE(±)S×M	0.182				
CD (0.05)M	0.256				
CD(0.05)S	0.256				
CD (0.05)M×S	0.513				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

Table 16.Effect of nutrient management practices and soil productivity classes on coconut yield (nuts palm^{-1} year^{-1})

Treatments	S_1	S_2	S_3	S_4	MEAN
M_1	43.00	43.00	37.00	28.00	37.75
M_2	41.00	39.83	32.50	26.00	34.83
M_3	56.33	52.50	43.50	40.17	48.13
M_4	28.67	27.00	25.00	17.50	24.55
MEAN	42.25	40.58	34.50	27.92	
SEm(±)M	1.605				
SEm(±)S	1.605				
SE(±)S×M	3.210				
CD (0.05)M	4.517				
CD(0.05)S	4.517				
CD (0.05)M×S	NS				

S- soil productivity classes M- management practices

S_1- 'very good' soil productivity class M_1- organic only

S_2- 'good' soil productivity class M_2- inorganic only

S_3- 'average' soil productivity class M_3- both organic and inorganic

S_4- 'poor' soil productivity class M_4- none

4.9 OBSERVATIONS ON PEST AND DISEASES

Coconut cultivation in Onattukara soils has always been under threat from most of the major pests and diseases reported in Kerala for this crop. Through personal inspection of the palms and information gathered from the growers the prevalence of the following pests and diseases in almost equal intensities could be detected on all the palms surveyed irrespective of the nutrient management practices followed and the soil productivity classes.

Pests

1. Rhinocerous beetle (*Oryctes rhinoceros*)
2. Red palm weevil (*Rhyncophoruferrugineus*)
3. Leaf eating caterpillar (*Opisinaarenosella*)
4. Eriophid mites (*Aceria [Eriophyes] guerreronis*)

Diseases

1 Root(wilt) disease

2 Leaf rot

Discussion

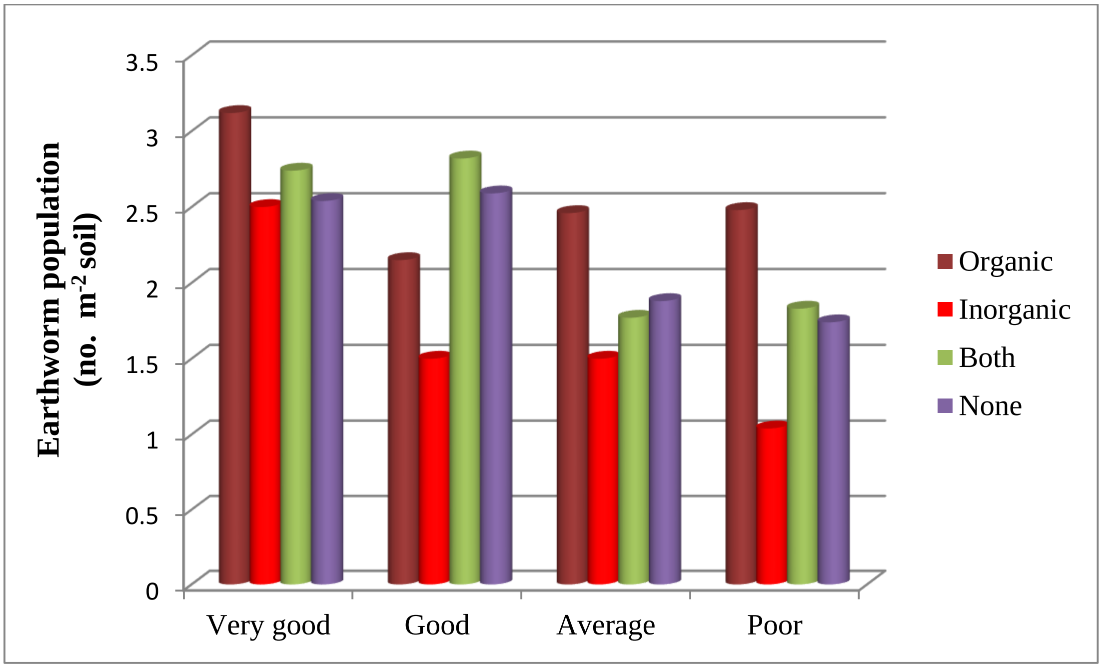
5. DISCUSSION

The salient results generated out oflaboratory investigations carried out at College of Agriculture, Vellayani with the objective of building an inventory on the important biological properties of major coconut growing soils of Onattukaratract of Kerala are briefly discussed in this chapter. The soil samples analyzed were collected from eight soil series of Onattukara which have been identified suitable for coconut cultivation based on crop suitability classification. Each two of these belong to the 'very good', 'good', 'average' and 'poor' productivity class of soil as decided by their productivity indices which had been worked out taking into consideration soil properties, viz. soil texture, depth, slope, drainage, coarse fragments, soil reaction, cation exchange capacity, base saturation, total soluble salts and organic carbon.

5.1 EARTHWORM POPULATION

Among the soil macrofauna, earthworms known as the 'friend of farmer' are considered extremely important for the maintenance of soil fertility. Through their castings they increase the fertility of the soil and through their pedoturbation activity they help in nutrient cycling as well as increasing the aeration of the soil. Table 1 shows the effect of nutrient management practices and soil productivity classes on earthworm population. The illustration is given in Figure1. Eventhough there was no significance for earthworm count by the interaction between the soil productivity classes and nutrient management practices, both main factors exerted significant effect individually on the count. At the interaction level the maximum count was recorded in the 'very good' productivity class with organic management. Among the management practices, organically managed soils and among the productivity classes 'very good' category soils recorded the highest values. Similar results were reported by Mekha (2013) who found that maximum earthworm count was obtained for soil treated with organic source of inputs viz. vermicompost and poultry manure. Edwards

Figure 1.Effect of nutrient management practices and soil productivity classes on earthworm population (no.m^{-2}soil)

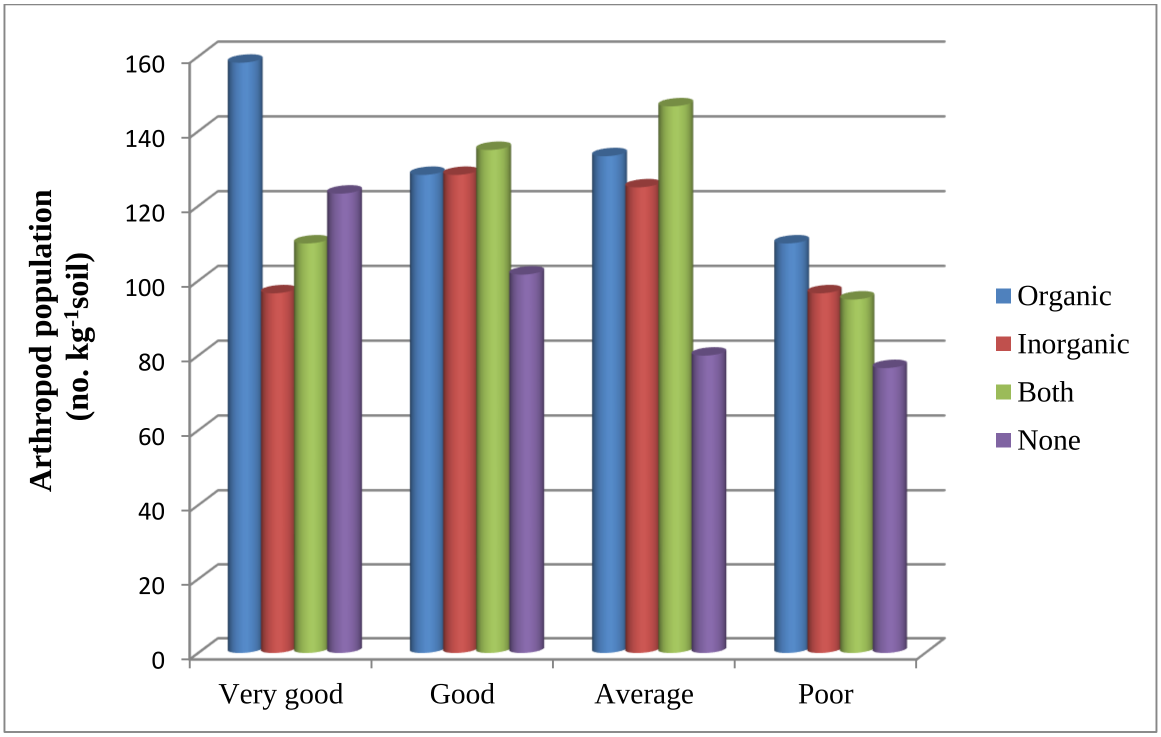


et al. (1995) reported that the addition of animal manure, sewage wastes, and spent malt from breweries, paper pulp, and wastes from potato processing showed positive effect on the earthworm population.

5. 2 ARTHROPOD POPULATION

The data presented in Table 2 and depicted in Figure2 show the effect of soil productivity classes and nutrient management practices on arthropod population. Soil arthropods include mainly the collembolas and mites and their presence in the soil indicates the redistribution of organic matter, humification, organic matter break down and comprehensive ecological restoration. The arthropod population was significantly influenced by both the factors, soil productivity class and nutrient management practices and their interaction. The maximum count was observed in 'very good' productivity class which received nutrients through organic sources. Miyazawa *et al.* (2002) opined that organic manure application increased the number of micro arthropods. According to study conducted by Nikhil (2014) maximum arthropod count was observed for the treatments which had the combination of both organic manures and inorganic fertilizers. The results are in agreement with Olla *et al*. (2013) who observed significant improvement in the arthropod population, particularly collembola by about 48.48 per centwith the addition of poultry manure. Gunadi *et al*. (2002) reported the effect of vermicompost and inorganic fertilizers on tomato and pepper and the tendency for inorganic fertilizers to decrease the number of soil arthropods where as vermicompost increased their number. Axelsen and Kristensen (2000) reported that the application of organic matter in various forms, such as green manures and crop residues increased the populations of micro arthropods. Among the nutrient management practices, the highest count was observed in soils receiving organic inputs as sources of nutrition.

Figure 2.Effect of nutrient management practices and soil productivity classes on arthropod population (no. kg^{-1}soil)



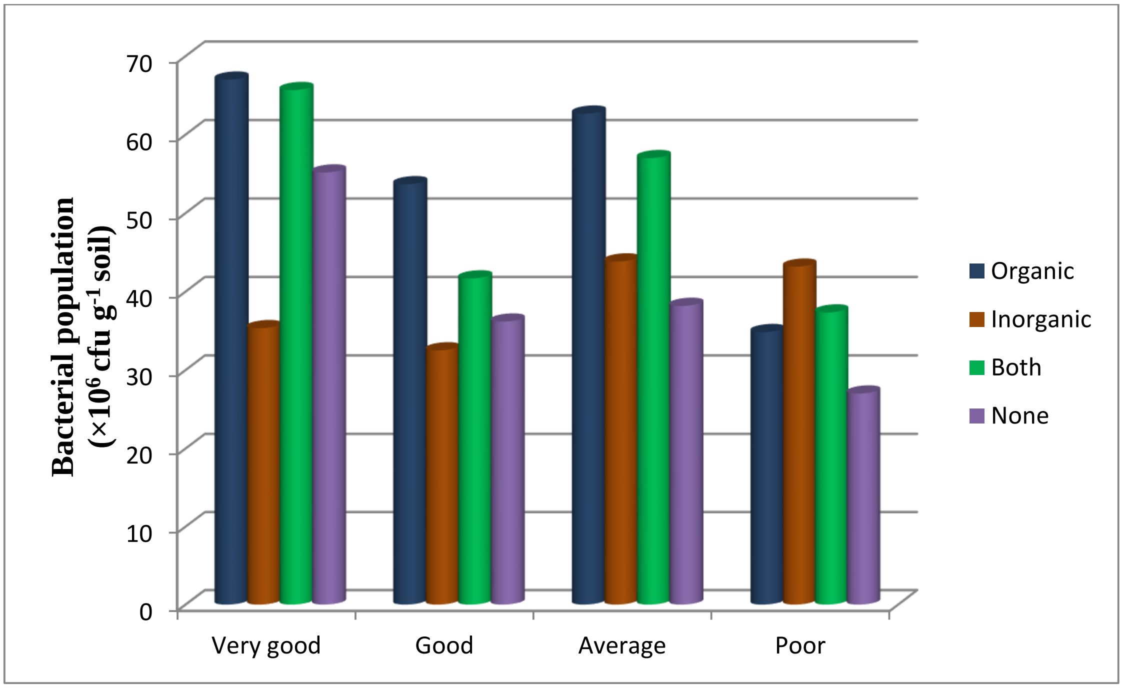
5.3 SOIL MICROFLORA

Soil microbial populations and their activities function as excellent indicators of soil health (Kennady and Papendick, 1995). They are essential for the healthy growth and development of plants and also play important role in decomposition of organic matter, nitrogen transformation, humification of organic residue and several other biochemical soil reactions.

5.3.1 Bacterial population

Effect of nutrient management practices and productivity classes on bacterial population significant at both their individual levels is illustrated in Table 3 (Figure 3). The highest population was observed in organically managed ‘very good’ category soil. As bacteria are the most abundant microorganisms in soil, it is evident in results also, bacterial population observed was higher than that of fungi and actinomycetes. Observations are in agreement with Mekha (2013), who observed the maximum bacterial population in the treatment with a combination of oil cake, rock phosphate and wood ash as organic sources of manuring. Similarly it is reported that combined application of FYM and neem cake increased the bacterial population. Fraser *et al.* (1998) expressed that the addition of organic manures favoured a significantly higher input of organic carbon which enhanced the bacterial population. The highest count was on par with ‘very good’ soils with both organic and inorganic sources of fertilizers. The result is in agreement with Selvi *et al.* (2004) who found out that in a continuous intensive cultivation in an inceptisol, FYM along with 100 per cent NPK increased the soil bacterial population.Similar result was observed by Tiwari *et al.* (2000),who reported that the total bacterial count showed superiority over *Azotobacter*, fungi and actinomycetes up to flowering stage of a crop and decreased at harvest due to incorporation of wheat straw and biogas slurry to supply different levels of nitrogen.

Figure 3.Effect of nutrient management practices and soil productivity classes on bacterial population ($\times 10^6$cfu g^{-1}soil)



5.3.2*Actinomycetes* population

Actinomycetes population showed significance for both the factors at their individual levels and also their interaction level (Table 4, Figure 4). Thehighest value was observed in the soils under 'very good' category which received organic inputs only. Similar results were observed in investigations on the impact of neem seed cake on soil microflora and soil properties conducted by Elnasikh *et al*. (2011). Swarup (2000) also found that continuous application of farm yard manure resulted in greater counts of actinomycetes.

5.3.3 Fungal population

Thehighest value for fungal population was observed in the 'very good' soils which received nutrients in both organic and inorganic forms (Table 5, Figure 5). The fungal population was significant for soil productivity class, nutrient management and their interaction. Results are in agreement with Nikhil (2014) who found that the green leaf, cattle manure and NPK application recorded the highest fungal population. Similarly increase in the fungal population was reported for the addition of organic manures, green manures and vermicompost along with chemical fertilizers (Venkateswarlu 2000, Sharma *et al*. 1983). On personal interviews with farmers, it was known that green manures like sunhemp and glyricidia were being used by them as organic sources of nutrients. The narrow carbon nitrogen ratio of the green manures might have resulted in greater availability of soil nitrogen for this organism to flourish.

5.3.4 *Azotobacter* population

The highest *Azotobacter* population was observed for 'good' soils which were under organic nutrition only (Table 6, Figure 6). The results of the present study go hand in hand with the report of Jain *et al.* (2003) that regular addition of farm yard manure increased the population of *Azotobacter* in a Vertisol. Nazir *et al.* (2012)

Figure 4.Figure 4.Effect of nutrient management practices and soil productivity classes on actinomycetes population (x 10^3 cfu g^{-1}soil)

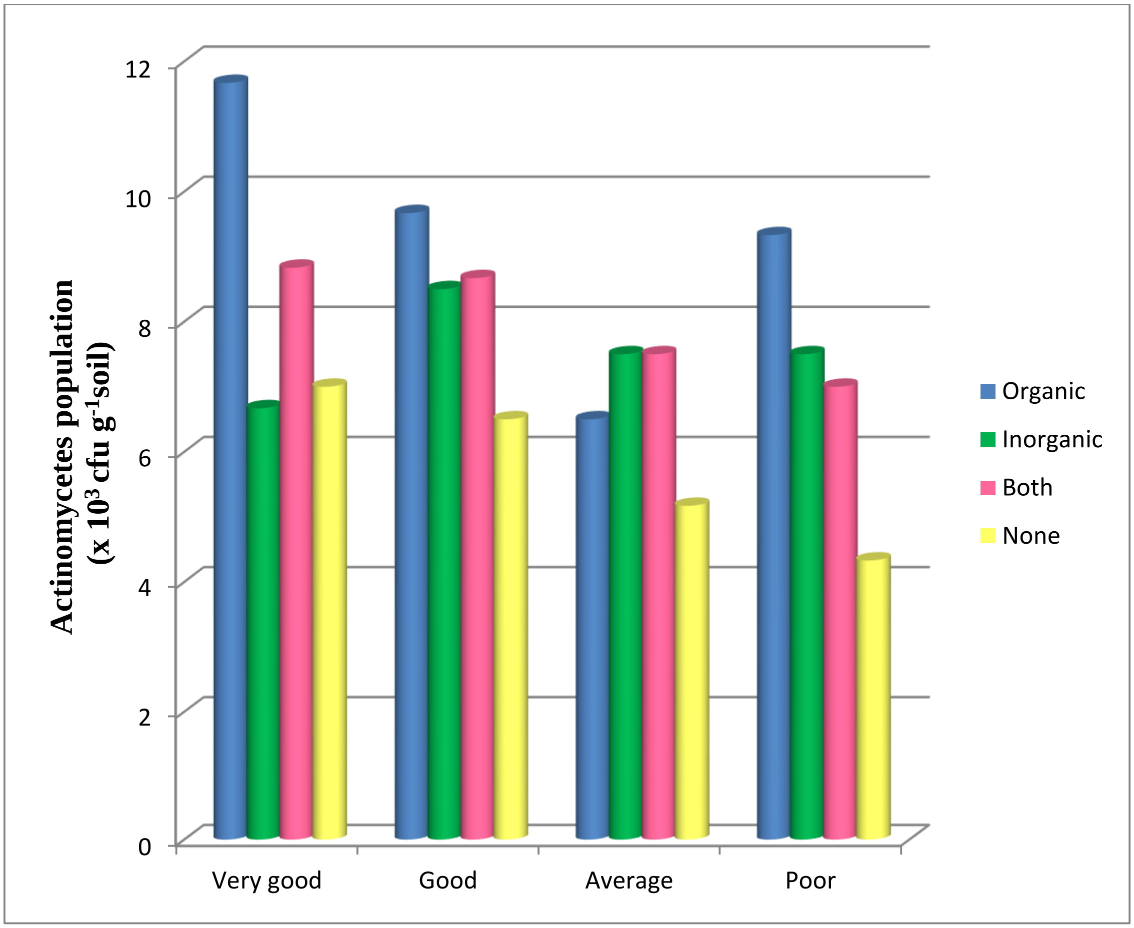


Figure 5.Effect of nutrient management practices and soil productivity classes on fungal population (x 10^4 cfu g^{-1} soil)

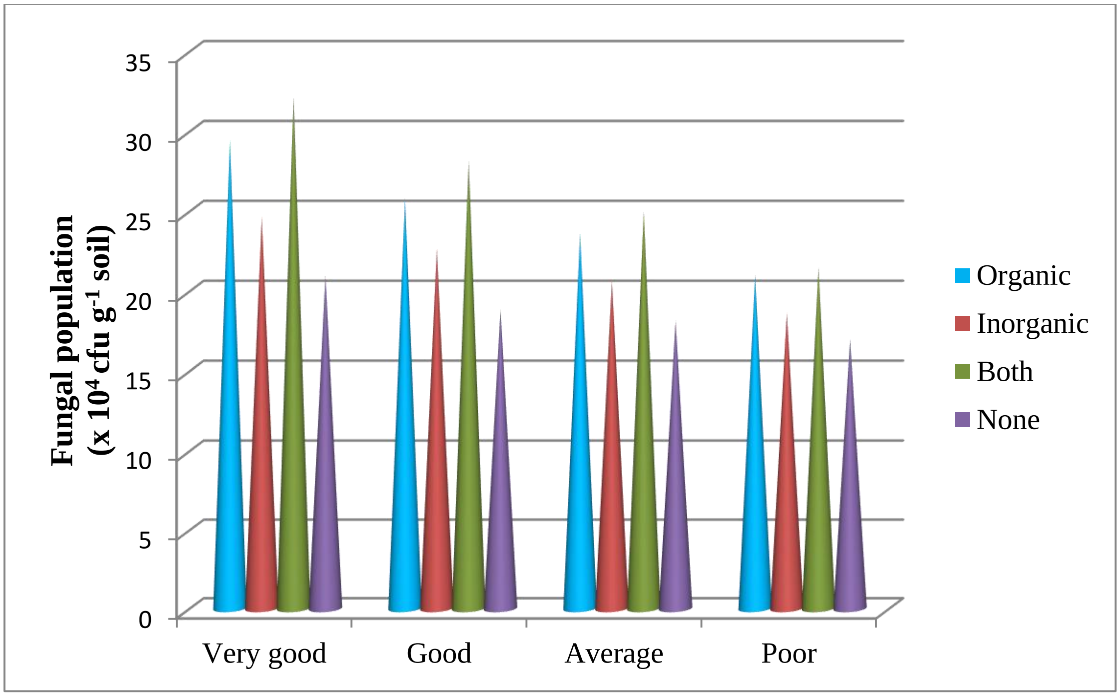
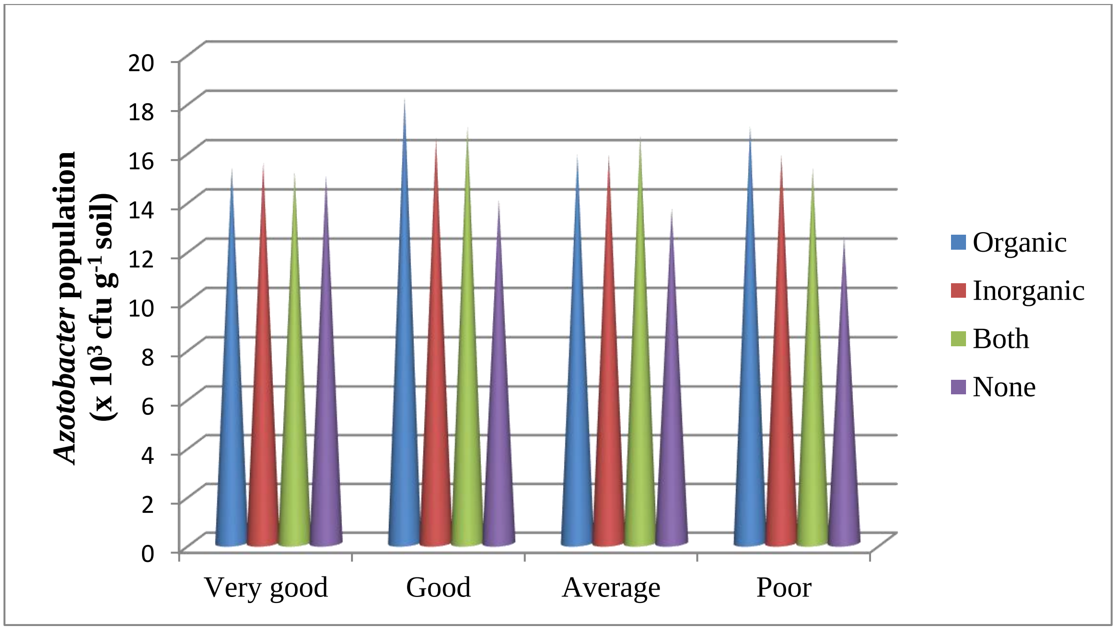


Figure 6.Effect of nutrient management practices and soil productivity classes on *Azotobacter* population (x 10^3 cfu g^{-1} soil)



recorded a same trend on application of organic nutrient sources like poultry manure, wood ash and oil cake.

5.3.5 *Azospirillum*population

The management practices followed by farmers exerted significance on the population of *Azospirillum* while the other factor soil productivity class failed to do the so (Table 7, Figure 7). However their interaction effect was significant. The population was observed to be the highest in the 'average' class soils which were under organic nutrition alone. The results are in agreement with the findings of Veeraputhran (2000) and Nikhil (2014). Nazir *et al*. (2012) based on his work on the effect of integrated organic nutrient sources on microbial populations in a soil under strawberry came to the conclusion that population of this organism was the highest in plots treated with poultry manure, wood ash and oil cake.

5.3.6 P Solubilizers population

For P solubilzers, effects were significant for both the factors but not for their interaction (Table 8, Figure 8). The highest count was observed in 'very good' soil with either organic nutrient management and INM practices. The resultscorroborate with the report by Suja and Sreekumar (2014) who studied the effect of organic nutrient management on the yield, tuber quality and soil health in a humid tropic soil under yamsand found that the population was increased by 22 percent by organic management practices. The highest value was on par with soils under 'very good' category managed with organic and inorganic sources of fertilization. The result is in agreement with that of Nikhil (2014) who recorded the highest P solubilizers population for such an integrated treatment in Pattambi soils under long term fertility experiments.

Figure 7.Effect of nutrient management practices and soil productivity classes on *Azospirillum* population (×10^4cfu g^{-1}soil)

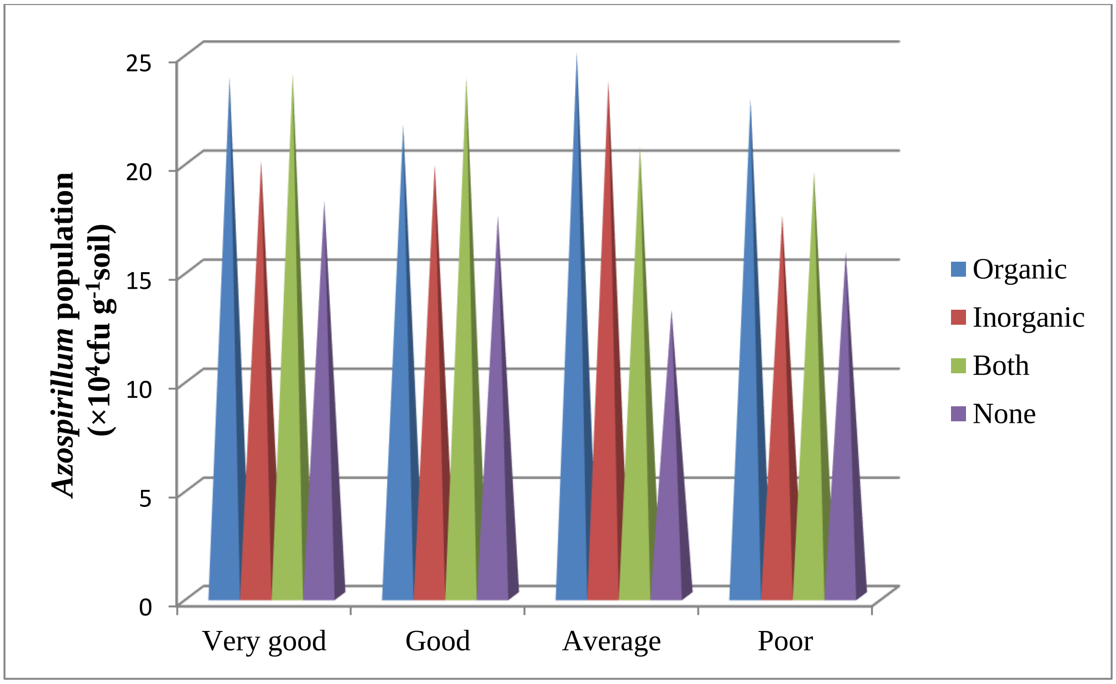
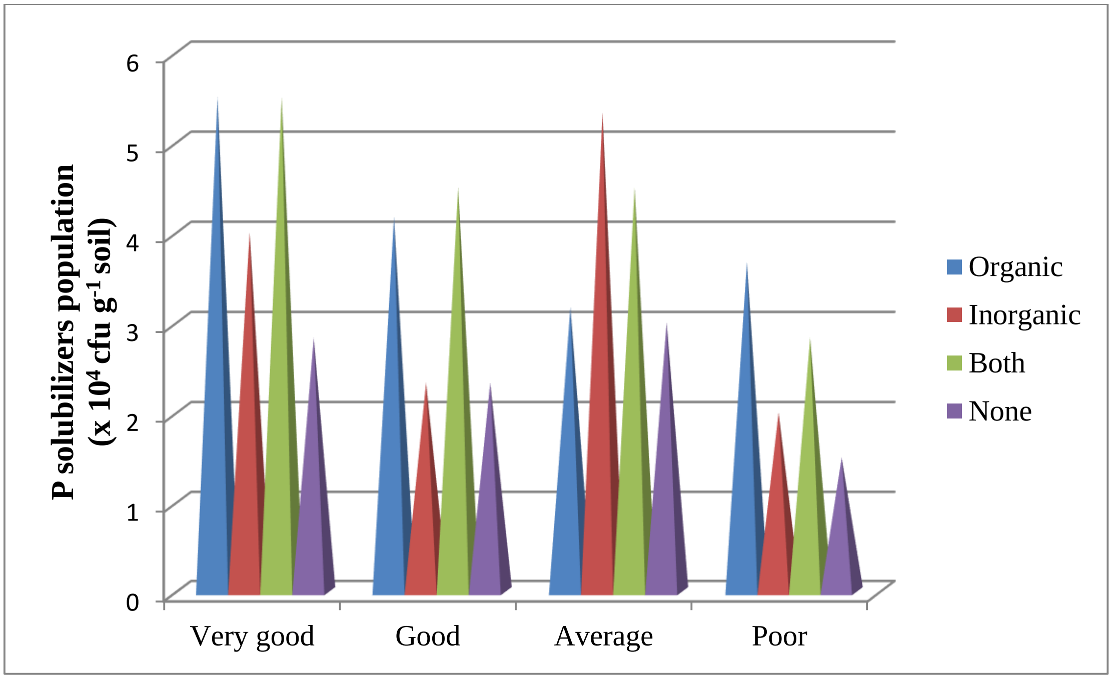


Figure 8.Effect of nutrient management practices and soil productivity classes on P solubilizers population (x 10^4 cfu g^{-1} soil)



5.4 SOIL ENZYMES

Soil enzymes are the integral part of soil biochemical processes and therefore used as functional indicators of microbial communities. Quantitative measurement of these enzyme activities can contribute to understanding of transformations by facilitating the evaluation of microbes present in the soil. Soil enzymatic assays being operationally practical and integratively sensitive are described as ‘biological finger prints’ of past and present soil management.

5.4.1 Urease activity

The effect of soil productivity classes and nutrient management practices on urease activity is given in Table 9 and depicted in Figure 9. Irrespective of the nutrient management practices followed by farmers or the productivity classes of the soils or even their interaction urease activity did not vary significantly in the soils. However the ‘average’ soils which were receiving nutrition in inorganic form only recorded the highest value of urease activity. This is in agreement with the findings of Frankenberger and Dick (1983) that inorganic sources of nitrogen are essential for stimulating the activity of ureolytic bacteria for the secretion of this extracellular enzyme. Mekha (2013) from her work in amaranthus observed that the treatment which supplied nitrogen to the crop in an organic form alone recorded the maximum value for urease activity

5.4.2 Phosphatase activity

Data on phosphatase activity are given in Table 10 and depicted in Figure 10. The influence of nutrient management practices, soil productivity classes as well as their interaction were significant. The highest value of phosphatase enzyme was recorded in ‘very good’ soils which were receiving organic inputs alone which was

9. Effect of nutrient management practices and soil productivity classes on urease enzymeactivity (ppm urea hydrolysed g^{-1} soil hr^{-1})

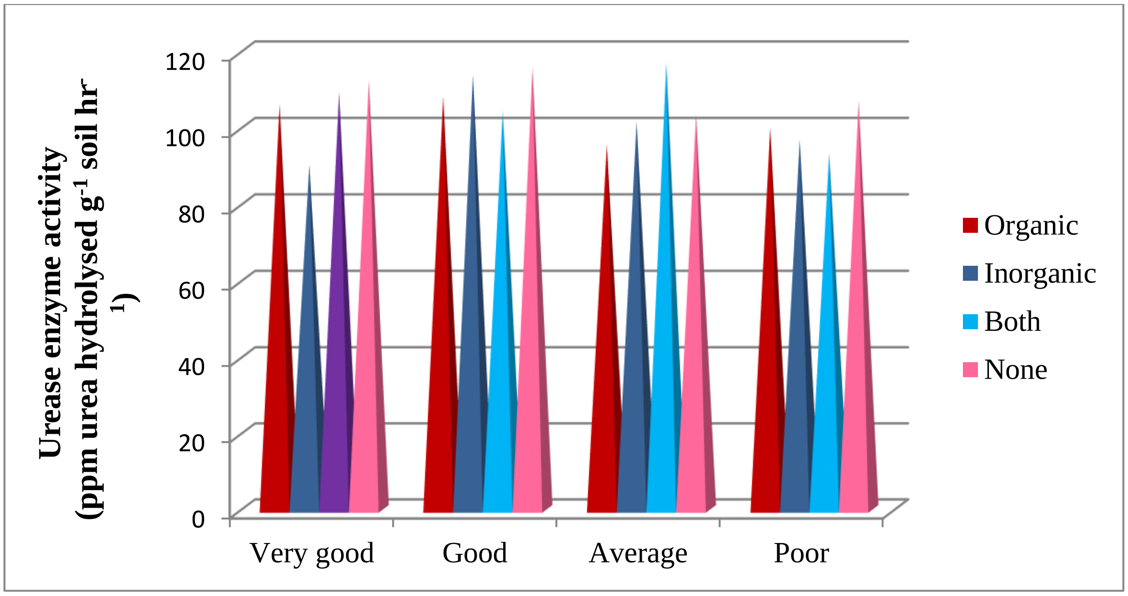
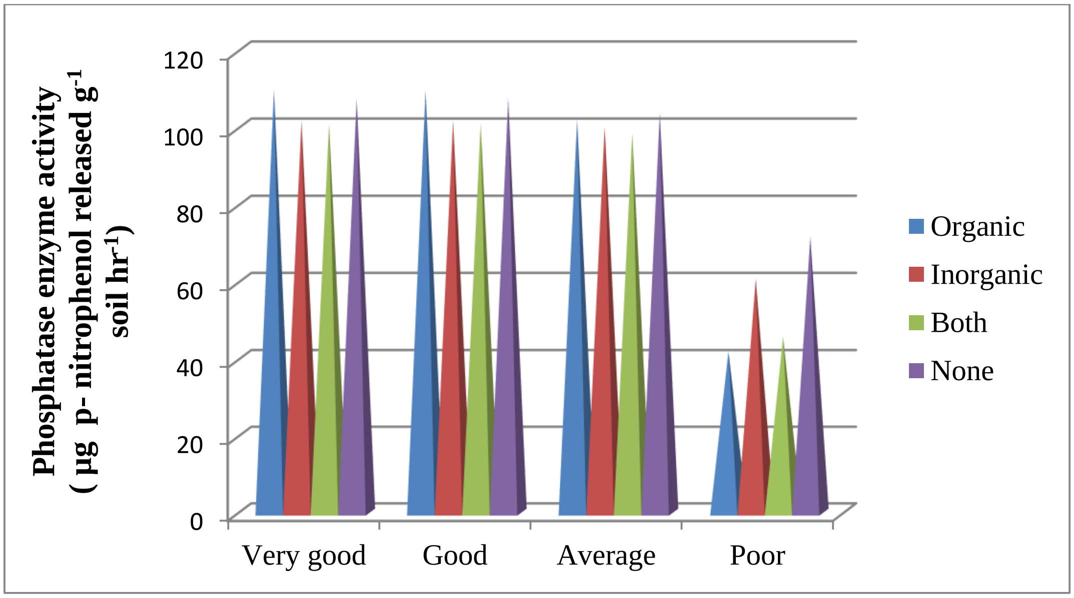


Figure 10.Effect of nutrient management practices and soil productivity classes on phosphatase enzyme activity (µg p- nitrophenol released g^{-1} soil hr^{-1})

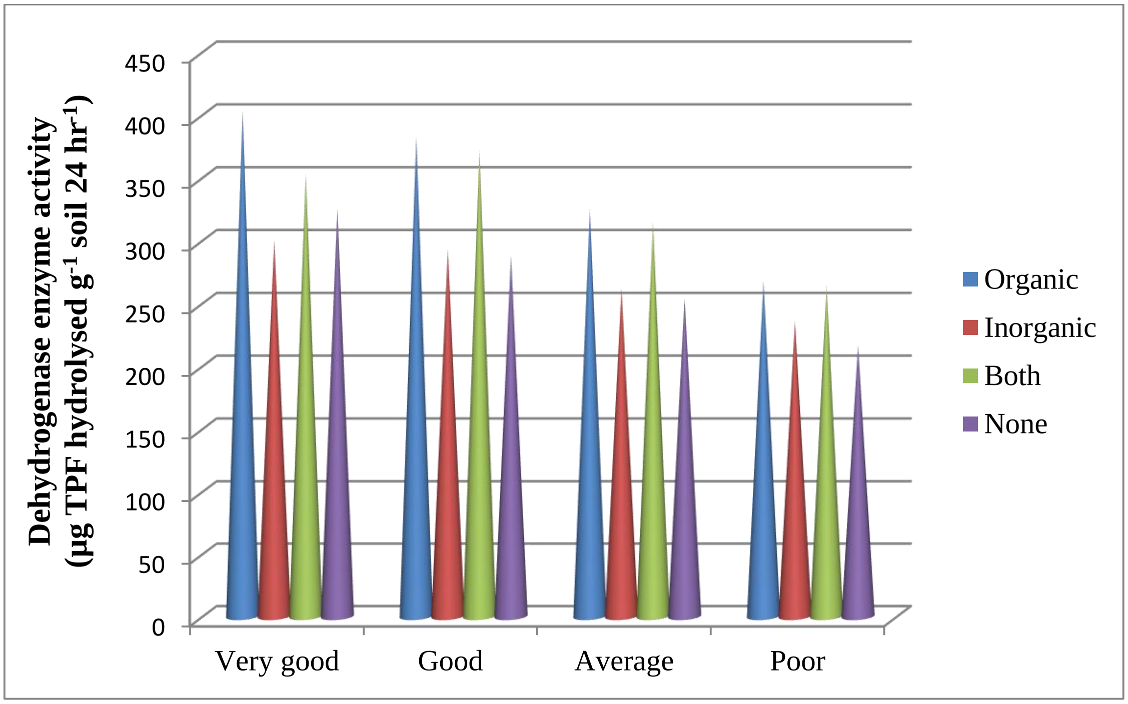


on par with all the nutrient management practices under 'very good' and 'good' soil productivity classes. As phosphatase activity has been established to be highly Figure correlated with both microbial respiration and total microbial biomass, it is only natural that the activity of this enzyme is maximum in soils receiving organic sources of nutrients only (Frankenber and Dick, 1983). As the enzyme is often seen bound to humic protein complex a positive relationship between phosphatase activity and organic matter content in the soil has been suggested by Harrison (1983). Organic fertilization of soils resulting in significant increase in the actitvity of phoasphatase has been reported by Kalembasa and Kuzienska (2010). Mekha (2013) observed that the highest value for phophatse activity was recorded for treatment with organic sources, oil cake, bone meal and wood ash and opinioned that it may be due to the high organic P content in the manures, which might have triggered the microorganisms to produce more phosphatase enzyme. Cooper and Warman (1997) reported that the application of poultry manure compost significantly increased the phosphatase activity in a low organic matter silty clay soil.

5.4.3 Dehydrogenase activity

As dehydrogenase is an endocellular enzyme existing as integral parts of intact cells its activity is considered to reflect the oxidative activities of soil microflora and for these reasons it is considered to be the most sensitive tool for evaluating biological health of a soil. Table 11 gives the result of effect of nutrient management practices and soil productivity classes on the dehydrogenase activity. Illustration of the same is given in Figure 11. Enzyme activity varied significantly as a result of nutrient management practices and soil productivity classes and the interaction between these two factors. Maximum activity was observed in the 'very good' soil category which were solely organically fertilized. Higher dehydrogenase activities in soils receiving organic sources of nutrients have been reported by Haider *et al.* (1991), Dinesh *et al.* (2000), Krishnakumar*et al.* (2005). Eiland (1980)

Figure 11. Effect of nutrient management practices and soil productivity classes on dehydrogenase enzyme activity (µg TPF hydrolysed g^{-1} soil 24 hr^{-1})



observed higher dehydrogenase activity in organically fertilized soils which he attributed to the nutrient rich environment coupled with high carbon and energy sources which are mandatory for the activity of this enzyme. Similar result was observed by Mekha (2013) in amaranthus under treatment combination of oil cake, rock phosphate and wood ash recorded the maximum activity of urease enzyme.

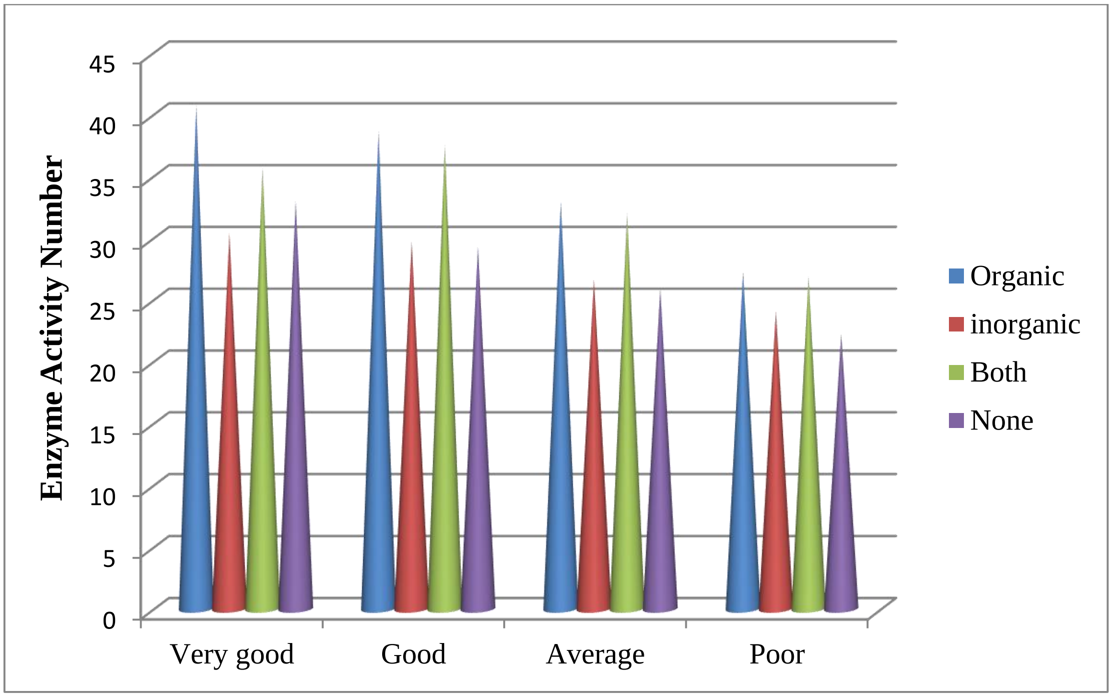
Supradip *et al*. (2008) in his study on soil enzymatic activity as affected by long term application of farm yard manure in a rainfed soybean-wheat system in N-W Himalaya observed that manure application increased dehydrogenase activity significantly. Suja and Sreekumar (2014) studied the effect of organic management on yield, tuber quality and soil health in yams in the humid tropics and observed that the dehydrogenase enzyme activity was promoted by organic management.

5.4.4 Enzyme activity number

Enzyme activity number is an index of the biological fertility or health of a soil and is computed based on the activity of the three enzymes viz. urease, phosphatase and dehydrogenase. According to Beck (1984) a value above 35 for this parameter for a soil indicates that it is a biologically fertile soil. As a discriminatory standard is there for judging a soil for its biological health based on this parameter no statistical analysis of the data on this parameter was done. (Table 12, Figure 12)

As per the above criterion soils receiving nutrients through organic sources alone or through both organic and inorganic sources under the 'very good' and 'good' productivity classes can be considered as biologically healthy. The importance of organic matter in sustaining soil health which has been universally accepted is highlighted by this finding. Soil enzymes are microbial in origin and microorganisms are the driving forces of fundamental metabolic processes involving specific enzyme activities (Nannipieri *et al*., 1972). Incorporation of organic amendments in soil promotes microbial growth and activity by providing nutrients and carbon and

Figure 12. Effect of nutrient management practices and soil productivity classes on Enzyme Activity Number



thereby improve activity of enzymes like dehydrogenase, phosphatase and urease (Balasubramanian *et al.*, 1972)

5. 5 SOIL RESPIRATORY ACTIVITY

Soil respiration, a strong indicator of soil metabolism and ecological functions is assessed by measuring the CO_2 evolved from the soil as a result of microbial respiration. Effect of nutrient management practices and soil productivity classes on soil respiratory rate is given in Table 13. It is also depicted in Figure 13. All the soil productivity classes under organic management practices recorded the maximum respiration rate. Raupp and Lockretz (1997) reported that an increased organic matter turn over and accumulation enhanced respiratory activity in soils. Dattand Sharma (2006) studied the influence of incorporation of *Sesbania* green manure and mungbean residue on soil biological properties in rice-wheat cropping system and reported a significant improvement in carbon dioxide evolution after their addition and incorporation.

The maximum value recorded by ‘very good’ soils under organic manuring was on par with the value recorded by ‘very good’ soils which were receiving both organic and inorganic nutrition. The result is in agreement with Wheatley *et al*. (1990) who reported that the combined application of manures and fertilizers provide a balanced supply of carbon, energy and mineral nutrients which increase the microbial activity and substrate induced respiratory activity. Thus even with moderately high organic sources, supplementary addition of chemical fertilizers could improve the activity of soil microflora substantially and produce high respiratory activity.

5.6 NITROGEN MINERALIZATION POTENTIAL

The nitrogen mineralization potential of the soils was estimated by alkaline permanganate oxidisable organic nitrogen method. The highest value was obtained by

Figure 13.Effect of nutrient management practices and soil productivity classes on soil respiration (µg CO_2 evolved g^{-1}soil hr^{-1})

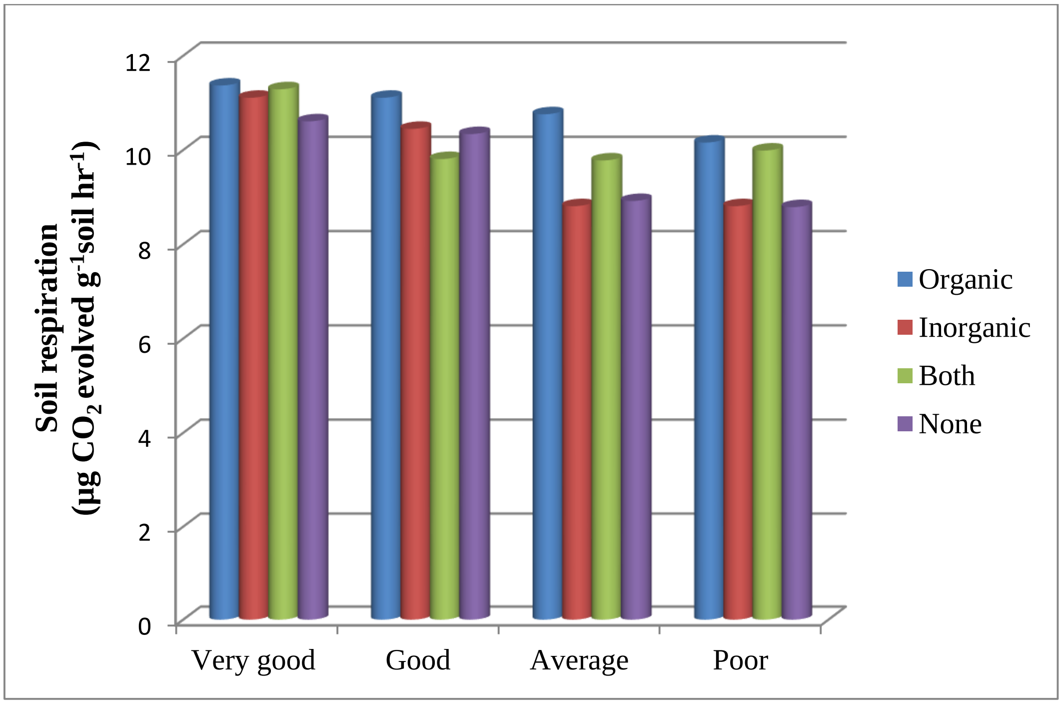
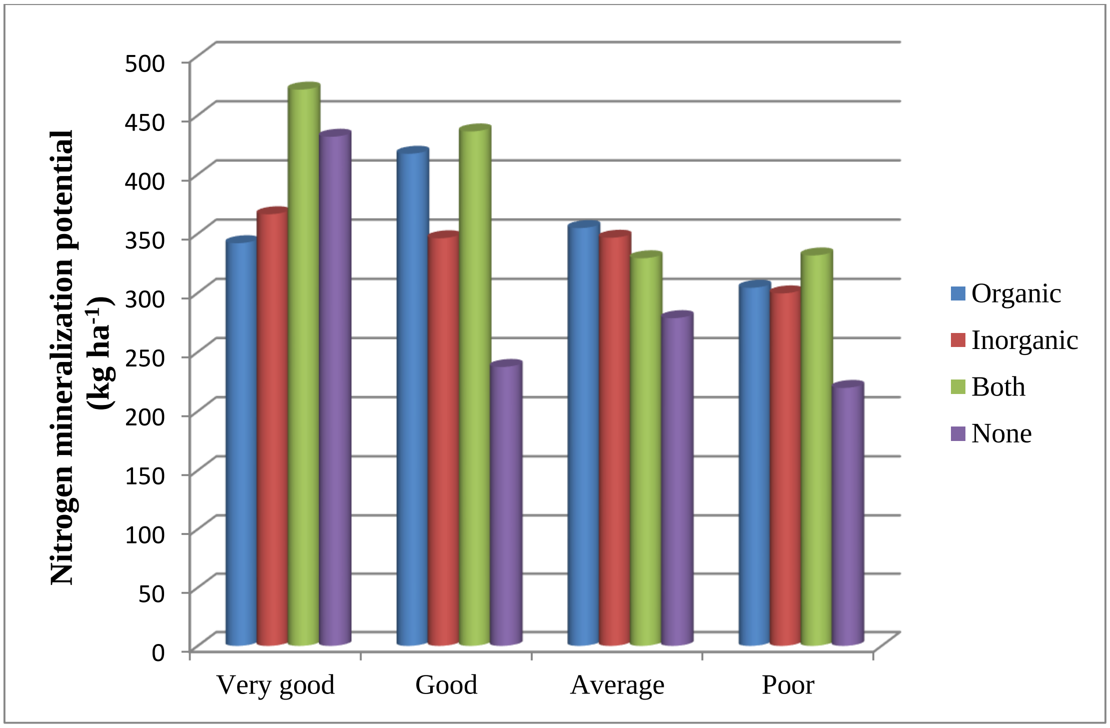


Figure 14.Effect of nutrient management practices and soil productivity classes onnitrogen mineralization potential (kg ha^{-1})



the ‘very good’ soils which were under both organic and inorganic fertilization. The organically bound form of nitrogen becomes available in soil after decomposition, followed by mineralization into inorganic form (Tusneem and Patrick, 1971). The results are given in Table 14 and illustrated in Figure 14. Tiwari *et al*. (1980) observed the beneficial effects of green manuring alone and in combination with fertilizer N in rice and reported the positive effect of green manuring on N mineralisation.

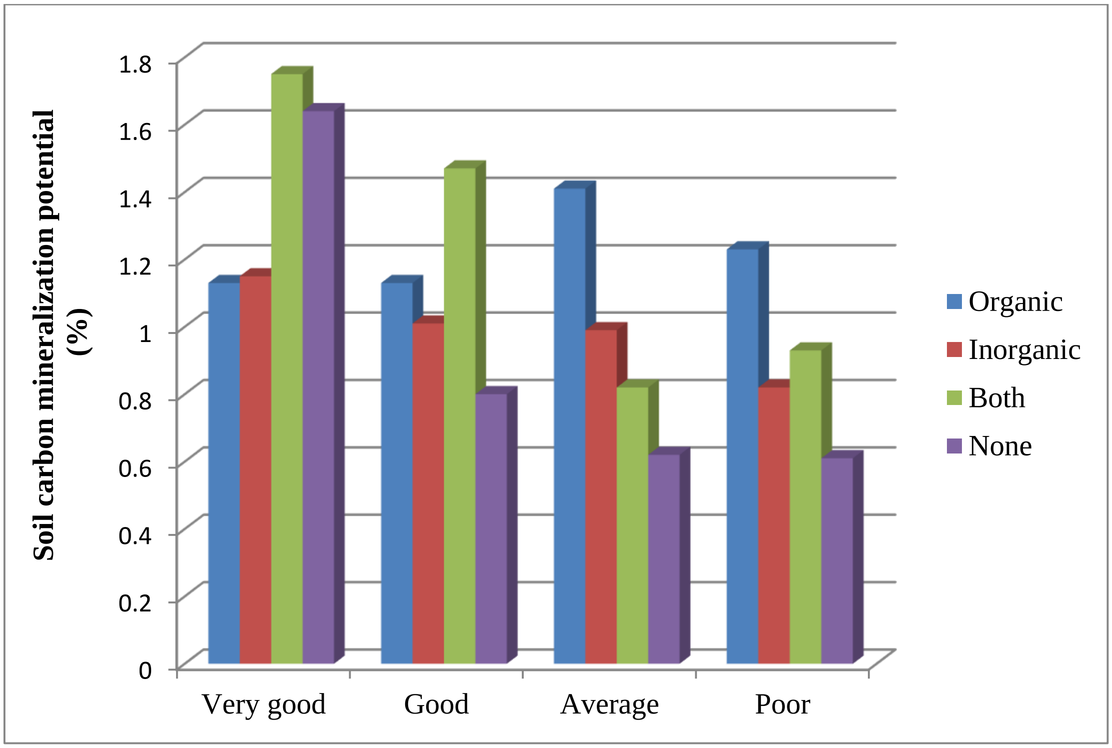
Bitzer and Sims (1988) studied the effect of combination of organic and inorganic sources of nutrients on soil available N and reported that the process of aminisation, ammonification and oxidative deamination all brought about by microbially mediated pathways are active under such a combination thus contributing more of soluble N to soil. Organic amendments are known to stimulate biological nitrogen fixation in the soil which may also be responsible for the increase in soil available N.

5.7 CARBON MINERALIZATION POTENTIAL

The carbon mineralisation potential of the soil was estimated as the oxidisable organic carbon content of the soil (Table 15, Figure 15). It has been widely observed that C mineralization rates are higher in soils receiving organic manures compared to unfertilized soils and soils receiving inorganic fertilizers alone. For carbon mineralization potential both the factors and interaction showed significance. Maximum organic carbon content was observed in ‘very good’ and ‘good’ soils which were receiving organic as well as inorganic nutrients.

Higher organic carbon levels in soils as a result of application of organic and inorganic nutrients have been reported by workers like Rabindra and Honnegowda (1986), Brar *et al*. (2000), Beena *et al*. (2002), Moossa *et al*. (2002), Mekha (2013) and Nikhil (2014). Anand *et al*. (2015) who studied the effect of jatropha press cake

Figure 15.Effect of nutrient management practices and soil productivity classes on soil carbon mineralization potential (%)



on carbon dynamics in the soil and opined that carbon accumulation in soil was higher per unit of applied carbon.

5.8 OBSERVATIONS ON YIELD AND INCIDENCE OF PESTS AND DISEASES

As yield is the ultimate reflection of the culmination of several inter dependant vital metabolic processes taking place within a plant which are dependant on the physico-chemical and biological properties of the soil environment of which it is a part, the same trend as shown for the biological properties of the soils was observed in the case of yield of the palms also (Table 16). The management practices and soil productivity classes were significant and the highest values were for dual nutrition (both organic and inorganic) and 'very good' soil productivity class respectively. Though not significant at the interaction level the maximum palm yield was observed under the combination 'very good' productivity soils receiving both organic and inorganic nutrition.

Coconut responding to integrated nutrient management in terms of yield has been reported by several workers like Reddy *et al*. (2002), Ghosh and Bandopadhyay (2009) and Krishnakumar and Maheswarappa (2010). The yield in Onattukara soil is poor compared to that in other soil types of Kerala and even the state average. Coconut is often found as a neglected crop growing on its own in the homesteads of marginal and subsistence farmers, receiving not much attention in the case of nutrient management as well as crop protection aspects. Onattukara has long been accepted as a high disease / pest endemic area as far as coconut cultivation is concerned. In the present study also the same observations could be noticed. Irrespective of the nutrient management practices followed and soil productivity classes, there was prevalence of diseases like root (wilt) and leaf rot and pests like rhinocerous beetle, red palm weevil, leaf eating caterpillar and eriophid mites.

The meagre plant protection measures adopted by the farmers were not adequate enough and the genetic potential of the palms was also an inhibitory factor. Most of the palms surveyed were of the low yielding local variety, West Coast Tall. Lack of labour for harvesting nuts and plant protection operations like cleaning up of the crowns of palms and applying plant protection chemicals and fertilizers were also the factors observed during the study as reasons for the prevalence of pest and diseases in the major coconut growing soils of Onattukara which coupled with improper nutrient management was finally reflected as poor yield of the crop.

APPRAISAL OF THE PRESENT SCENARIO WITH SUGGESTIONS FOR THE FUTURE

As almost all the tangible biological properties of a soil are the result of an intrinsic network of biochemical reactions brought about by myriads of macro and micro organisms inhabiting the soilthe quantification of these through laboratory investigations results in values which when higher in magnitude are considered better and more desirable.

A critical scrutiny of the statistically analyzed data provided in the tables shows that for most of the biological parameters of these soils the maximum values or the most desirable values were recorded by soils of the ‘very good’ productivity class mostly under organic nutrition and in one or two cases under both organic and inorganic nutrition. But the interesting feature that can be noticed is that even soils of ‘poor’ and ‘average’ productivity classes receiving organic nutrition alone or both organic and inorganic nutrition recorded values which were statistically on par with highest values of the ‘very good’ productivity class (Table 17). This implies that the practice of organic input additions as sources of nutrients which the farmers are unscientifically following are benefitting these soils in building up their biological health.

Most of the farmers approached in this study for taking soil samples and collecting information on yield and other information related to the palms were mainly marginal and subsistence farmers falling in the low to medium education category. No judicious or systematic organic practices were being followed by them except occasional incorporation of some bone meal and dumping of kitchen and farm wastes according to availability. But still the added organic inputs had manifested their benefits through improving the biological health of the soils.

Table 17.Paritybetween soils in biological properties

Sl.no	Biological parameter	Soils which recorded the highest value	Soil / soils which recorded value on par with the highest value
1	Arthropod population	‘very good’ soils with organic nutritiononly (S_1M_1)	‘average’ soils with both organic and inorganic nutrition (S_3M_3)
2	Bacterial population	‘very good’ soils with organic nutrition only (S_1M_1)	‘average’ soils with organic nutrition only (S_3M_1)
3	Actinomycetes population	‘very good’ soils with organic nutrition only (S_1M_1)	‘poor’ soils with organic nutrition only (S_4M_1)
4	Azotobacter population	‘very good’ soils with organic nutrition only (S_1M_1)	‘poor’ soils with organic nutrition only (S_4M_1)
5	Soil respiratory activity	‘very good’ soils with organic nutrition only (S_1M_1)	‘average’ and ‘poor’ soils with organic nutrition only (S_3M_1 , S_4M_1)

6	Organic carbon	'very good' soils with both organic and inorganic nutrition (S_1M_3)	'average' soils with organic nutrition only (S_3M_1)
7	Coconut yield	'very good' soils with both organic and inorganic nutrition (S_1M_3)	'average' and 'poor' soils with both organic and inorganic nutrition (S_3M_3)

Through creating awareness among farmers on the importance of soil test based nutrient applications through a combination of organic and inorganic sources and imparting skills in the production and application of value added manures like enriched and fortified composts, efforts can be taken for improving the biological health of these soils.

Summary

6. SUMMARY

The present study was an attempt to assess the biological soil health of the Onattukara soils of Kerala, principally supporting coconut by building an inventory on the important biological properties of the soils. On the basis of productivityrating the 13 garden land soil series of Onattukara identified suitable for coconut cultivation are further classified taking into consideration the estimated properties of these soils such as soil texture, depth, slope, drainage, coarse fragments, soil reaction, cation exchange capacity, base saturation, total soluble salts and organic carbon. For each property a weightage is assigned and the product of these weitages expressed as a percentage is taken as an index for calculating the productivity index of a soil series. These indices are compared against a standard scale and the soil series are classified into ‘very good’, ‘good’, ‘average’ and ‘poor’. Two soil series from each category were selected for the collection of soil samples. Palamel and Attuva from ‘very good’ soil productivity class, Vallikunnam and Mynagappally from ‘good’, Neendakara and Kandallur from ‘average’ and Kollaka and Thrikunnappuzha from ‘poor’ productivity class. From each series three mature bearing palms under four levels of nutrient management practices (‘organically’, ‘inorganically’, ‘both organically and inorganically’ and ‘none’) for the last three years were selected on the basis of personal interviews. Soil samples were collected from the basins of palms and assessed for various biological parameters.

The salient findings of the study generated through personal interviews, field observations and laboratory investigations are summarized below.

❖ Earthworm population was significantly influenced by both nutrient management practices and productivity classes of the soils. But their interaction effect was not significant on this property. The highest value (3.12 no m^{-2}soil) was observedin the ‘very good’ soils under organic nutrition alone. Between management practices M_1(organic alone) had highest value of 2.55 no m^{-2}soil and M_2 (inorganic alone) recorded the lowest value of 1.64 no m^{-2}soil. Among the soil productivity classes S_1 ('very good') had the highest value of 2.72 no m^{-2}soil while S_4 ('poor') had the lowest value of 1.77 no m^{-2}soil.

❖ Nutrient management practices, soil productivity classes and their interaction caused significant variation on the arthropod populations. The highest value was observed in the 'very good' soils which were organically managed (158.33 no kg^{-1}soil). Among the management practices M_1 (only organic inputs) recorded the highest count of 132.50 no kg^{-1}soil and the lowest value (100.42 no's kg^{-1}soil) was observed in M_4 (not fertilized or manured). Between the soil productivity classes, S_3 ('average') productivity class recorded the highest arthropod population (125.42no kg^{-1}soil) where as S_4 ('poor') productivity class recorded the lowest count of arthropod population (95.42 no's kg^{-1}soil).

❖ Though the bacterial population was not significant at the interaction level,the maximum (67.00×10^6 cfu g^{-1} soil) was observed in the 'very good' soils receiving organic inputs alone. Between management practices M_1 (organic inputs only) recorded the highest value of 54.54×10^6 cfu g^{-1} soil and M_2 (inorganic sources alone) recorded the lowest value of 38.71×10^6 cfu g^{-1} soil. Among soil classes S_1 ('very good') recorded the highest value of 55.79×10^6 cfu g^{-1} soil and S_4 ('poor') recorded the lowest value of 35.58 $\times10^6$ cfu g^{-1}soil.

❖ Actinomycete population showed significance for the individual facors, nutrient management and soil productivity class and their interactions. The highest value of 11.67 x 10^3 cfu g^{-1}soil was in the 'very good' soils which were receiving organic inputs alone. Among the nutrient management practices M_1 (organic nutrition alone) recorded the highest value of 9.29 x 10^3 cfu g^{-1}soil while M_4 (no nutrition) recorded the lowest value of 5.75 x 10^3 cfu g^{-1}soil. Between soil classes S_1 ('very good') recorded the highest value of 8.54 x 10^3 cfu g^{-1}soil and S_3 ('average') had the lowest value of 6.67 x 10^3 cfu g^{-1}soil.

❖ Statistical significance was observed for the effect of management practices, productivity classes and their interaction on fungal population. The highest value of 32.17 x 10^4 cfu g^{-1} soil was recorded for the 'very good' soils receiving nutrition from both organic and inorganic sources. Between management practices M_3 (both organic and inorganic inputs) recorded the highest value of 26.71x 10^4 cfu g^{-1} soil and M_4 (no nutrient application) recorded the lowest value of 18.75 x 10^4 cfu g^{-1}soil. Among soil productivity classes S_1 ('very good') recorded the highest value of 26.83 x 10^4 cfu g^{-1} soil and S_4 ('poor') recorded the lowest value of 19.54x 10^4 cfu g^{-1} soil.

❖ The population of *Azotobacer* was influenced significantly by the nutrient management practices only. Maximum population (18.17 x 10^3 cfu g^{-1}soil) was observed in the 'good' soils which were put under organic nutrition. Between management practices M_1 (organic management) recorded the highest value of 16.58 x 10^3 cfu g^{-1} soil and M_4 (nor organic or inorganic nutrient addition) recorded the lowest value (13.79 x 10^3 cfu g^{-1} soil). Soil productivity class S_2 ('good') had the highest value 16.42 x 10^3 cfu g^{-1} soil while S_3 ('average') recorded the lowest count of 15.21 x 10^3 cfu g^{-1} soil.

❖ Management practices had the significant influence on the *Azospirillum* population but productivity class did not significantly exert any influence. However the interaction was significant. The highest value recorded was 25.00×10^4 cfu g^{-1} soil in the 'average' soils which were managed organically. Between management practices M_1 (organic only) recorded the highest value of 23.33×10^4 cfu g^{-1} soil and M_4 (no nutrition) recorded the lowest value of 16.17×10^4 cfu g^{-1} soil. Between soil classes S_1 ('very good') had the highest value of 21.50×10^4 cfu g^{-1} soil and S_4 ('poor') had the lowest value of 18.92×10^4 cfu g^{-1} soil.

❖ Both the factors had significant effects on the population of P solubilizer but not their interaction. The highest value of 5.50 x 10^4 cfu g^{-1} soil was in the 'very good' soils under organic management alone. Between the management practices M_3 (both organic and inorganic inputs) recorded the highest value of 4.33 x 10^4 cfu g^{-1} soil and M_4 (no nutrition) had the lowest value of 2.42 x 10^4 cfu g^{-1} soil. Between soil classes S_1 ('very good') recorded the highest value of 4.46 x 10^4 cfu g^{-1} soil and the S_4 ('poor') had the lowest value of 2.50 x 10^4 cfu g^{-1} soil.

❖ The urease enzyme activity was observed to be non significantly influenced by all the levelsof factors and their interaction. However the highest value (116.88 ppm urea hydrolysed g^{-1} soil hr^{-1}) was noticedin the average soils which had both organic and inorganic nutrition. Between management practices M_4 with no nutrition at all registered the highest value of 109.64 ppm urea hydrolysed g^{-1} soil hr^{-1} and M_2 with inorganic nutrition alone had the lowest value of 100.65 ppm urea hydrolysed g^{-1} soil hr^{-1}. Between the soil classes S_1 ('very good') recorded the highest value of 104.52 ppm urea hydrolysed g^{-1} soil hr^{-1} and S_4 ('poor') had the lowest value of 99.26 ppm urea hydrolysed g^{-1} soil hr^{-1}.

❖ Considering the phosphatase activity, the highest value (109.74 µg of p-nitrophenol released g^{-1} soil hr^{-1}) was observed in the 'very good' soils receiving organic inputs. Between management practices M_4 (no nutrition at all) recorded the highest value of 93.49 µg of p-nitrophenol released g^{-1} soil hr^{-1} and M_3 (both organic and inorganic) recorded the lowest value of 74.22 µg of p-nitrophenol released g^{-1} soil hr^{-1}. Between soil classes S_4 ('very good') had the highest value of 105.04 µg of p-nitrophenol released g^{-1} soil $hr^{-1}$and S_1 ('poor') had the lowest value of 55.09 µg of p-nitrophenol released g^{-1} soil hr^{-1}.

❖ For dehydrogenase activity the highest value 403.49µg TPF hydrolysed g^{-1} soil 24 hr^{-1} was recorded in 'very good' category soils which were solely organically fertilized. Between the management practices M_1 (organically managed) recorded the highest value of 344.44µg TPF hydrolysed g^{-1} soil 24 hr^{-1} and M_4 (no nutrition at all) recorded the lowest value of 270.92µg TPF hydrolysed g^{-1} soil 24 hr^{-1}. Between soil classes S_1 ('very good') recorded the highest value of 345.56µg TPF hydrolysed g^{-1} soil 24 hr^{-1} and S_4 ('poor') recorded the lowest value of 246.06µg TPF hydrolysed g^{-1} soil 24 hr^{-1}.

❖ Based on the enzyme activity number, soils with EAN > 35 of the M_1(organic management only) and M_3 (both organic and inorganic management) categories under both 'very good' and 'good' productivity classes can be adjusted to be biologically fertile or healthy.

❖ Nutrient management practices and soil productivity classes individually and in combination exerted significant effects on soil respiratory activity. The highest value (11.37 µg CO_2 evolved g^{-1}soil hr^{-1}) was observed in 'very good' soils which received organic input only. Between management practices M_1 (managed organically) recorded the highest value of 10.85µg CO_2 evolved g^{-1}soil hr^{-1} and M_4 (not at all receiving any nutrient) recorded the lowest value of 9.67µg CO_2 evolved g^{-1}soil hr^{-1}. Between soil productivity classesS_1 ('very good') recorded the highest value of 11.09µg CO_2 evolved g^{-1}soil hr^{-1} and S_4 ('poor') recorded the lowest value of 9.43µg CO_2 evolved g^{-1}soil hr^{-1}.

❖ Nitrogen mineralization potential differed significantly by the nutrient management practices, soil productivity classes and their interaction. The highest value (471.72 kg ha^{-1}) was recorded in the 'very good' soils fertilized both organically and inorganically. Among the management practices M_3 (both organic and inorganic nutrition) recorded the highest value of 392.23 kg ha^{-1} whereas M_4 (no nutrition) recorded the lowest content of 291.91 kg ha^{-1}. Between soil classes S_1 ('very good') had the highest value of 402.99 kg ha^{-1} and S_4 ('poor') had the lowest value of 288.77kg ha^{-1}.

❖ Nutrient management practices, soil productivity classes and their interaction significantly differed the carbon mineralization potentials of these soils. The highest value (1.75per cent) was observed in 'very good' soils which were both organically and inorganically fertilized. Between management practices M_3 (both organic and inorganic inputs) recorded the highest value of 1.25 per cent while M_4 (no nutrition) recorded the lowest value of 0.92 per cent. Between soil classes S_1 '(very good') had the highest value of 1.42 per cent and S_4 ('poor') category had the lowest value of 0.90 per cent.

❖ Coconut yield differed significantly for nutrient management practices, soil productivity classes and their interaction effect. Maximum yield (56.33 nuts palm^{-1} year^{-}1) was recorded in the 'very good' soils which were both organically and inorganically nourished. Between the management practices M_3 (both organic and inorganic nutrient inputs) recorded the highest yield of 48.13 nuts palm^{-1} year^{-1} and M_4 (deprived of nutrition of any kind) recorded the lowest yield of 24.55 nutspalm^{-1} year^{-1}. Between the soil productivity classes S_1 ('very good') recorded the highest value of 42.25 nuts palm^{-1} year^{-1} and S_4 ('poor') recorded the lowest yield of 27.92 nutspalm^{-1} year^{-1}.

❖ Irrespective of the nutrient management practices followed and soil productivity classes there was prevalence of diseases like root (wilt) and leaf rot and pests like rhinocerous beetle, red palm weevil, leaf eating caterpillar and eriophid mites.

The maximum values or the most desirable valuesof the biological properties were recorded by soils under ‘very good’ productivity class managed with organic nutrition. Evensoils of the ‘poor’ and ‘average’ productivity classes receiving organic nutrition in some biological parameters were on par with the values of the ‘very good’ productivity class highlighting the importance of organic input additions as sources of nutrients in building up the biological health of the soils.

FUTURE LINE OF WORK

For completing the inventory on biological properties of these soils the following properties may be attempted in future.

1. Soil microbial biomass carbon
2. Soil microbial biomass nitrogen
3. Soil microbial biomass phosphorous
4. Soil microbial biomass sulphur
5. Hot water soluble carbohydrates

It is hoped that thefindings at this study will serve as a small, but definite ‘step’ in the ‘giant leap’of the nation towards sustainable agricultural development.

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Biological characterization of Onattukara soils under coconut based cropping system

by

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ABSTRACT

The present investigation titled 'Biological characterization of Onattukara soils under coconut based cropping system' was undertaken during 2013-15 with the objectives of building an inventory on the biological properties of the major coconut growing soils in Onattukara tract of Kerala and studying the impact of the prevalent nutrient management practices followed by farmers on these properties.

Eight soil series of Onattukara viz. Palamel and Attuva (under 'very good' productivity class) Vallikunnam and Mynagappally ('good') Neendakara and Kandallur ('average') Kollaka and Thrikkunnappuzha ('poor') were selected (Premachandran,1998). In each series three mature bearing palms in the age group of 15 to 20 years under four levels of nutrient management practices for the last three years (organically, inorganically, both organically and inorganically and none) were selected on the basis of personal interviews and soil samples were collected from a depth of 60 cm within a lateral distance of 2 m from the base of coconut palm. The data generated were subjected to statistical analysis applicable to factorial CRD, the factors being four productivity classes and four levels of nutrient management.

The soil faunal populations, earthworms (1.04 – 3.12 no m^{-2} soil) and arthropods (76.67 - 158.33 no kg^{-1}soil) were significantly influenced by the nutrient application practices in different productivity classes. The interaction effect was significant for the arthropod population only. All the microbial populations studied differed significantly as a result of nutrient management. The productivity of the soil exerted significant influence only on the bacterial, actinomycetes, fungal and P solubilizer populations while the interaction effects were significant for actinomycetes, fungi, Azospirillum and P solubilizers.

Result of enzyme assay showed that urease activity was not influenced by any of the factors where as Phosphatase and dehydrogenase were significantly altered by both the factors and their interactions. Soil respiratory activity showing significance

at all levels was maximum in the ‘very good’ soils under organic fertilization only and minimum in the ‘poor’ soils not receiving any nutrition. Carbon as well as Nitrogen mineralization potentials of the soils showed significant variations in response to management, productivity and their interaction. ‘Very good’ soils under dual nutrition registered the highest values (1.75% organic C and 471.72 kg ha^{-1}available N). The lowest values of 0.61% organic C and 219.69 kg ha^{-1}available N were for the ‘poor’ soils with no nutrition at all.

Details on yield of the palms and management practices (nutrient application as well as plant protection measures) were gathered through personal interviews with farmers whose palms were surveyed. Irrespective of the production and nutrient management and soil productivity classes, there was prevalence of rhinocerous beetle, red palm weevil, leaf eating caterpillar, eriophid mites, root (wilt) disease and leaf rot on all palms.

The results clearly indicate that all the biological properties studied are sensitive indicators of soil health and are highly expressed in ‘very good’ soils receiving nutrients, organically and inorganically and minimum in ‘poor’ soils with no nutrition. But even the ‘poor’ and ‘average’ soils can be made biologically more healthy through systemic and judicious nutrient application through organic or inorganic or a combination of these two sources.

Appendix

APPENDIX – 1

COMPOSITION OF MEDIA FOR MICROBIAL ENUMERATION

1. Enumeration of Bacteria

Media: Nutrient Agar

Composition

1.	Peptone	-	5g
2.	NaCl	-	5g
3.	Beef extract	-	3g
4.	Agar	-	20g
5.	pH	-	7.0
6.	Distilled water	-	1000ml

2. Enumeration of Fungi

Media: Rose Bengal agar

Composition

1.	Glucose	-	3g
2.	$MgSO_4$	-	0.2g
3.	KH_2PO_4	-	0.9g
4.	Rose Bengal	-	0.5g
5.	Streptomycin	-	0.25g
6.	Agar	-	20g
7.	Distilled water	-	1000ml

3. Enumeration of Actinomycetes

Media: Kenknight's Agar

Composition

1.	Dextrose	-	1g
2.	KH_2PO_4	-	0.1g
3.	$NaNO_3$	-	0.1g
4.	KCl	-	0.1g
5.	$MgSO_4$	-	0.1g
6.	Agar	-	15g
7.	Distilled water	-	1000ml

4. Enumeration of Azospirillum

Media: Nitrogen free bromothymol blue

Composition

1.	Mallic acid	-	5g
2.	KH_2PO_4	-	0.5g
3.	$MgSO_4. 7H_2O$	-	0.2g
4.	NaCl	-	0.1g
5.	$CaCl_2$	-	0.1g
6.	Trace elements	-	2ml
7.	BTB	-	2ml
8.	$FeSO_4$	-	pinch
9.	Yeast extraxt	-	pinch
10.	KOH	-	40g
11.	Agar	-	32g
12.	Distilled water	-	1000ml

5. **Enumeration of Azotobacter**

Media: Jensen's Agar

Composition

1.	Sucrose	-	20g
2.	KH_2PO_4	-	1g
3.	$MgSO_4$	-	0.5g
4.	NaCl	-	0.5g
5.	$FeSO_4$	-	0.1g
6.	Na_2MoO_4		0.005g
7.	$CaCO_3$		2g
8.	Agar	-	15g
9.	Distilled water	-	1000ml

6. **Enumeration of P- solubilizer**

Media: Pikovaskaya's Agar

Composition

1.	Glucose	-	10g
2.	Ca(PO4)2	-	5g
3.	(NH4)2SO4	-	0.5g
4.	KCl	-	2g
5.	$MgSO_4$	-	0.1g
6.	MnSO4	-	0.1g
7.	FeSO4	-	pinch
8.	Yiest extract	-	0.5g
9.	Agar	-	30g
10.	Distilled water	-	1000ml