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Effect of organic matter on soil enzyme activity, organic carbon and microbial activity under different land use systems

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Abstract

The microbial and enzyme activities of the soil are closely related to the organic matter content and influenced by hydrothermal regimes of the soil. Keeping this in view, the effect of organic matter was studied on dehydrogenase, urease, acid and alkaline phosphatase activity and microbial population like bacteria, fungi and actinomycetes was evaluated from four year old cultivation under different land use systems *i.e.*, mango, cashew, vegetable, rose and medicinal and aromatic crops at different depths (0-15, 15-30, 30-50, 50-100 cm). From this study it was observed that, the mango and cashew showed significantly higher enzymes activity and microbial population at the surface soil (0-15 cm) as compared to annual crops.

Keywords: effect, organic matter, organic carbon, microbial activity

1. Introduction

The term soil organic matter has been used to encompass all organic materials found in soil (Stevenson, 1994) and partial decomposed products and non-decayed plant and animal tissues. Organic matter inputs through organic amendments, in addition to supplying nutrients, stimulate microbial diversity and activity and improved soil aggregation, which had positive effects on soil water content, temperature, aeration and mechanical impedance (Ferrerias *et al.*, 2006) [3]. Enzymes are the micro organisms which catalyses the reaction without any changes. Generally, the enzyme activities in the soil are closely related to the organic matter content and strongly influenced by the hydrothermal regimes, enzymes catalyze all biochemical reactions and are an integral part of nutrient cycling in soil and these are sensitive indicators of soil ecological stress or other environmental changes (Marinari *et al.*, 2006) [8].

Microorganisms play a major role on decomposition of several organic compounds frequently used in agriculture, which directly affect the synthesis and decomposition of soil organic matter (Carney & Matson, 2005) [2]. The main microbial enzymes involved in the mineralization of soil organic matter are cellulases, dehydrogenases, acid and alkaline phosphatase activity, proteases, nitrogen fertilization is the most important management strategy for the improvement of agricultural crops. Urea is the most widely used source of organic N fertilizer in the world, which is easily hydrolyzed to ammonium and carbon dioxide by urease enzyme (Masciandaro & Ceccanti, 1999., Kunito *et al.*, 2001) [9, 6]. The main objectives of this study was to assesses the effect of organic matter on soil enzyme activity, organic carbon and microbial activity under different land use systems within the same locality of four old cultivated soil.

2. Material and Methods

The present investigation was carried out at the Regional Horticultural Research and Extension Center (RHREC), UAS Campus GKVK, Bengaluru, Karnataka during 2015. The soil of the experimental site was sandy loam and classified as fine, mixed isothermic Kandic Paleustalf of Vijayapura soil series. Cultivation of selected horticulture crops for experiment *viz.*, mango, cashew, rose, vegetables and medicinal and aromatic crops was started in the year 2010 within the same locality. The experiment plots were permanently laid out for specified crops. There is no change either in the cropping system or in the fertilizer management practices since the

planting. In each sampling site, soil samples were collected from four different depths *i.e.*, 0-15, 15-30, 30-50, and 50-100 cm. Soil samples were processed by drying under the shade, powdering with a clean wooden mallet and passing through a 2 mm sieve. The processed samples were stored in polyethylene bags for analysis in the laboratory. The statistical analysis was done by using Randomized Complete Block Design (RCBD).

2.1 Analysis of The Soil Sample

Organic carbon

A known weight (0.5g) of 0.2mm sieved soil was treated with a known excess volume chromic acid ($K_2Cr_2O_7 + H_2SO_4$). After the oxidation of organic carbon, the unreacted $K_2Cr_2O_7$ left in the contents was back titrated with standard ferrous ammonium sulphate using diphenylamine indicator (Walkley and Black, 1934) [10].

2.2 Analysis of Soil Samples For Biological Properties

Pre-incubation

Pre-incubation of soil samples was done to restore the normal biological activities. A known quantity of soil was moistened to field capacity (60% of MWHC) and incubated at 37 ± 2 °C in a BOD incubator, three days for dehydrogenase and 7 days for phosphatase. The samples incubated were adopted to bring back to the original levels of biological activity (Basavaraj, 1984) [1].

2.3 Enumeration microbial population

The enumeration of total bacteria, fungi, and actinomycetes, in the samples was carried out by following the standard dilution plate count technique. Soil extract agar for bacteria, Martin's Rose Bengal streptomycin sulphate agar for fungi, and Kuster's agar for actinomycetes, were used for enumeration. The petriplates were incubated at 30°C for six days and population was counted and expressed per unit dry weight of substrate. Kumar (2015).

3. Result and Discussions

3.1 Soil organic carbon under different land use systems

Organic carbon content at different depths as influenced by different horticulture crops is presented in figure 1.

The organic carbon content of soil was higher in the surface layer of the soil *i.e.*, 0-15 cm as compared to other subsurface soil depth in all the cropping systems. The carbon content differed significantly with different cropping systems; the mango orchard had higher organic carbon content *i.e.*, 6500.00, 6316.00, 5846.00, and 4611.00 mg kg⁻¹ at 0-15 cm, 15-30 cm, 30-50 cm and 50-100 cm depths respectively which was followed by cashew orchard. However the medicinal and aromatic block had lowest organic carbon 4300.00, 3916.00, 3834.00 and 3786.00 mg kg⁻¹ at 0-15 cm, 15-30 cm, 30-50 cm and 50-100 cm depths respectively.

This is due to the continuous addition of organic matter in perennials crops like mango and cashew orchard which leads to accumulate more organic matter to the soil and thereby it helps to increase the carbon content in the soil.

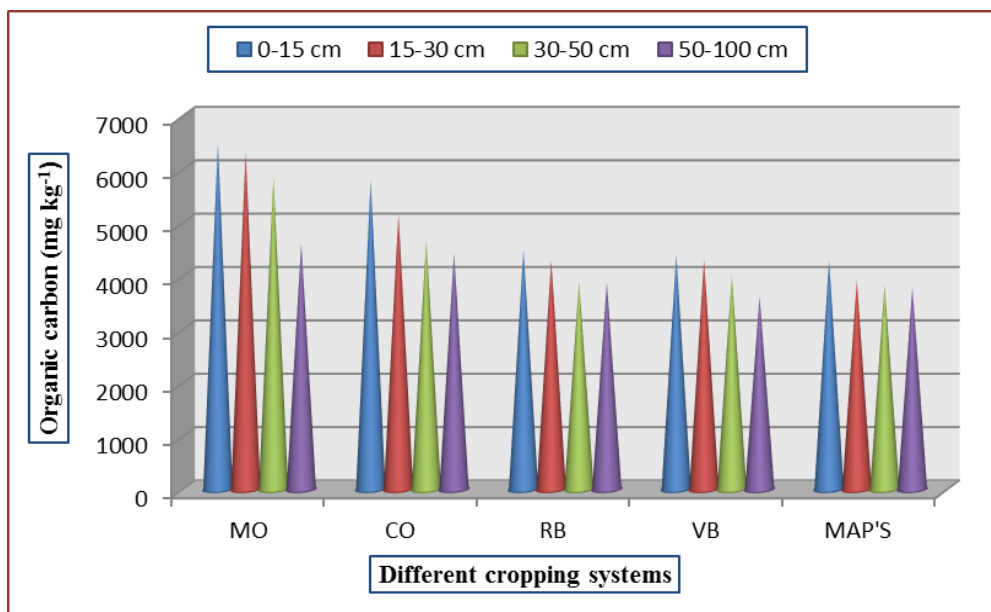


Fig 1: MO- Mango Orchard, VB- Vegetable Block, CO- Cashew Orchard, MAP's- Medicinal and Aromatic Plants, RB- Rose Block.

Since organic manures are incorporated in to the surface soil and a major portion of the left over residues of shallow rooted crops usually accumulate in the top few centimetre of the soil layers, there was possibility for a relatively greater accumulation of organic carbon in 0-15 cm soil as compared to the soils of lower layer. Similar results were obtained by Manjaiah *et al.* (2000) [7]. Increase in soil carbon due to continuous addition of bio mass through leaf and roots have been reported by Geo Jose (2006) in case of field crops and by Krishnappa Naik *et al.* (1998) [4].

3.2 Dehydrogenase activity under different land use systems

The dehydrogenase activity differed from one depth to other soil depth. The higher dehydrogenase activity was observed in the 0-15 cm and lowest was observed in the 15-30 cm, 30-50 cm and 50-100 cm. The dehydrogenase activity was decreased with increase in soil depths (Table 1). Among different cropping systems, mango orchard had maximum dehydrogenase activity (650.84 $\mu\text{g TPF g}^{-1}\text{soil}$) which is on par with the cashew orchard (624.64 $\mu\text{g TPF g}^{-1}\text{soil}$) which was highly significant from rose block (426.48 $\mu\text{g TPF g}^{-1}\text{soil}$), vegetable block (421.44 $\mu\text{g TPF g}^{-1}\text{soil}$) and medicinal and aromatic block (418.14 $\mu\text{g TPF g}^{-1}\text{soil}$) with four year old cultivated soil.

Table 1: Dehydrogenase activity and Urease activity at different depths as influenced by different horticulture crops

Horticulture land use system	4 year old cultivation			
	Dehydrogenase activity ($\mu\text{g TPF g}^{-1}$ soil)			
	0-15 cm	15-30 cm	30-50 cm	50-100 cm
Mango orchard	650.84	638.78	600.14	484.78
Cashew orchard	624.64	600.18	586.78	490.11
Rose block	426.48	380.17	360.36	320.33
Vegetable block	421.44	382.54	258.78	328.78
Medicinal and aromatic block	418.14	379.13	355.18	326.38
SEm \pm	24.44	26.66	24.25	21.44
CD at 5%	84.56	79.86	73.11	65.45

3.3 Urease activity under different land use systems

The urease activity differed at different soil depths. The higher urease activity was observed in the 0-15 cm depth and lowest was observed in the deeper layer *i.e.*, 15-30 cm, 30-50 cm and 50-100 cm (Table 2). Among different cropping systems, the mango orchard had higher urease activity (1230

$\mu\text{g PNP g}^{-1}$ soil) which is on par with the cashew orchard (1246 $\mu\text{g PNP g}^{-1}$ soil) and it was highly significant from rose block (840.34 $\mu\text{g PNP g}^{-1}$ soil), vegetable block (821 $\mu\text{g PNP g}^{-1}$ soil) and medicinal and aromatic block (800 $\mu\text{g PNP g}^{-1}$ soil) in four year old cultivated soil.

Table 2: Urease activity at different depths as influenced by different horticulture crops

Horticulture land use system	4 year old cultivation			
	Urease activity ($\mu\text{g PNP g}^{-1}$ soil)			
	0-15 cm	15-30 cm	30-50 cm	50-100 cm
Mango orchard	1230.46	1200.14	1180.00	860.38
Cashew orchard	1246.53	1176.43	1118.41	870.41
Rose block	840.34	860.41	800.18	790.16
Vegetable block	821.41	853.41	818.73	792.16
Medicinal and aromatic block	800.76	824.11	800.10	786.46
SEm \pm	55.14	54.44	52.44	45.66
CD at 5%	165.45	163.24	158.44	137.45

3.4 Acid and alkaline activity under different land use systems

The acid and alkaline phosphatase activity decrease with increased in soil depths. The higher acid and alkaline phosphatase activity was observed in the 0-15 cm depth and lowest was observed in the subsurface layer of the soil *i.e.*, 15-30 cm, 30-50 cm and 50-100 cm (Table 3 and 4). Among different cropping systems, the mango orchard had the maximum acid and alkaline phosphatase activity (93.45 $\mu\text{g PNP g}^{-1}$ soil), (46.04 $\mu\text{g PNP g}^{-1}$ soil) which is on par with the cashew orchard (90.24 $\mu\text{g PNP g}^{-1}$ soil) (45.21 $\mu\text{g PNP g}^{-1}$ soil) and it is highly significant from rose block (63.23 $\mu\text{g PNP g}^{-1}$ soil), (38.11 $\mu\text{g PNP g}^{-1}$ soil), vegetable block (60.46 $\mu\text{g PNP g}^{-1}$ soil), (36.24 $\mu\text{g PNP g}^{-1}$ soil) and medicinal and aromatic block (61.53 $\mu\text{g PNP g}^{-1}$ soil), (36.11 $\mu\text{g PNP g}^{-1}$ soil) respectively in four year old cultivated soil.

$\mu\text{g PNP g}^{-1}$ soil), (46.04 $\mu\text{g PNP g}^{-1}$ soil) which is on par with the cashew orchard (90.24 $\mu\text{g PNP g}^{-1}$ soil) (45.21 $\mu\text{g PNP g}^{-1}$ soil) and it is highly significant from rose block (63.23 $\mu\text{g PNP g}^{-1}$ soil), (38.11 $\mu\text{g PNP g}^{-1}$ soil), vegetable block (60.46 $\mu\text{g PNP g}^{-1}$ soil), (36.24 $\mu\text{g PNP g}^{-1}$ soil) and medicinal and aromatic block (61.53 $\mu\text{g PNP g}^{-1}$ soil), (36.11 $\mu\text{g PNP g}^{-1}$ soil) respectively in four year old cultivated soil.

Table 3: Acid phosphatase activity at different depths as influenced by different horticulture crops

Horticulture land use system	4 year old cultivation			
	Acid phosphatase activity ($\mu\text{g PNP g}^{-1}$ soil)			
	0-15 cm	15-30 cm	30-50 cm	50-100 cm
Mango orchard	93.45	90.11	84.53	78.78
Cashew orchard	90.24	87.33	82.56	75.74
Rose block	63.23	58.17	54.33	48.16
Vegetable block	60.46	57.28	55.11	47.28
Medicinal and aromatic block	61.53	56.13	54.01	46.24
SEm \pm	4.21	3.86	3.76	3.31
CD at 5%	12.56	11.74	11.21	9.91

Table 4: Alkaline phosphatase activity at different depths as influenced by different horticulture crops

Horticulture land use system	4 year old cultivation			
	Alkaline phosphatase activity ($\mu\text{g PNP g}^{-1}$ soil)			
	0-15 cm	15-30 cm	30-50 cm	50-100 cm
Mango orchard	46.04	42.43	37.51	33.28
Cashew orchard	45.21	40.23	33.78	28.21
Rose block	38.11	33.74	29.56	26.31
Vegetable block	36.24	32.98	28.31	25.22
Medicinal and aromatic block	36.11	33.21	29.33	26.16
SEm \pm	2.26	2.09	1.78	1.59
CD at 5%	6.82	6.08	5.36	4.68

This may be due to the fact that soil enzymatic activity was generally higher at the surface soil owing to higher organic matter and availability of more nutrients by continuous addition of organic matter with minimum tillage treatments which has a synergizing effect on enzymatic activity in upper layer of the soil than in deeper depths. However in the subsurface layers of the soil, as the depth increases the compaction of soil will be more which has less organic matter and nutrients which recorded the lowest enzymatic activity.

3.5 Soil microbial population

3.5.1 Bacterial population under different land use systems

In four year old cultivated soil, the bacterial population was differed at different depth of the soil (fig. 2). 0-15 cm soil depth showed higher bacterial population and lowest was observed in the subsurface layer of the soil *i.e.*, 15-30 cm, 30-50 cm and 50-100 cm. The bacterial population decreased with increased in soil depth. Among different cropping systems, the mango orchard (4.43 CFU X 10⁶ g⁻¹soil) showed maximum bacterial population which is on par with the cashew orchard (4.32 CFU X 10⁶ g⁻¹soil) and it is highly significant from rose block (3.31 CFU X 10⁶ g⁻¹soil), vegetable block (3.27 CFU X 10⁶ g⁻¹soil) and medicinal and aromatic block (3.23 CFU X 10⁶ g⁻¹soil).

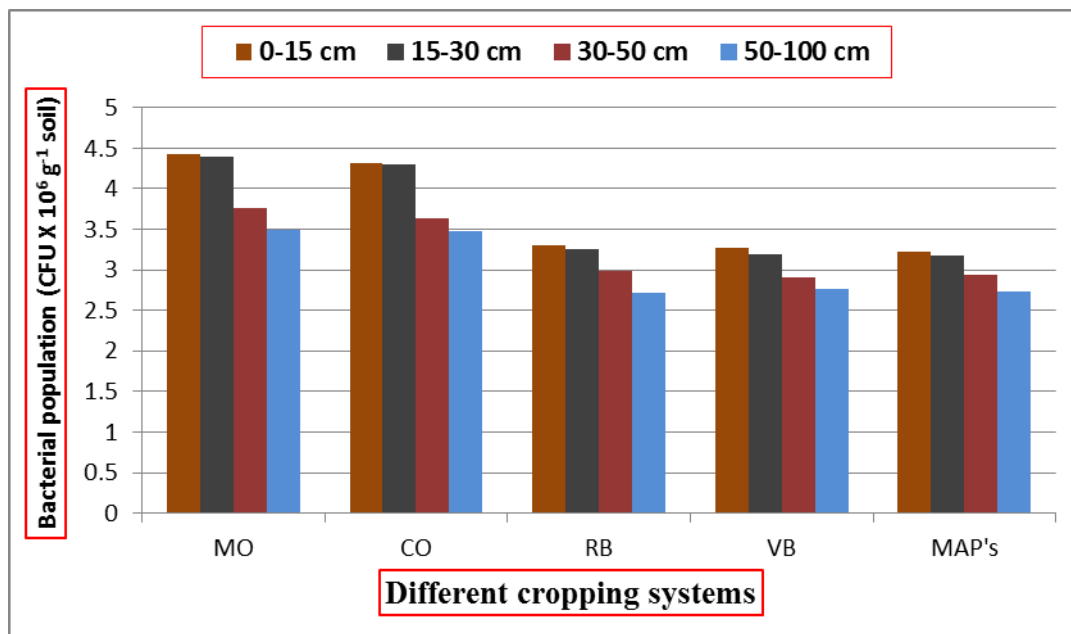


Fig 2: Organic carbon content at different depth as influenced by different horticulture crops.

MO- Mango Orchard, VB- Vegetable Block, CO- Cashew Orchard, MAP's- Medicinal and Aromatic Plants, RB- Rose Block.

3.5.2 Actinomycetes population under different land use systems

The actinomycetes population decreased with increase in soil depths. 0-15 cm soil depth showed highest actinomycetes

population and lowest was observed in the subsurface layer of the soil *i.e.*, 15-30 cm, 30-50 cm and 50-100 cm (Table 5). Among different cropping systems, the maximum actinomycetes population was recorded under the mango orchard (0.90 CFU X 10³ g⁻¹soil) which is on par with the cashew orchard (0.85 CFU X 10³ g⁻¹soil) followed by rose block (0.56 CFU X 10³ g⁻¹soil), vegetable block (0.54 CFU X 10³ g⁻¹soil) with four old cultivation.

Table 5: Actinomycetes population at different depths as influenced by different horticulture crops

Horticulture land use system	4 year old cultivation			
	Actinomycetes population (CFU X 10 ³ g ⁻¹ soil)			
	0-15 cm	15-30 cm	30-50 cm	50-100 cm
Mango orchard	0.90	0.85	0.39	0.26
Cashew orchard	0.85	0.78	0.40	0.25
Rose block	0.56	0.38	0.25	0.16
Vegetable block	0.54	0.37	0.26	0.18
Medicinal and aromatic block	0.54	0.39	0.28	0.15
SEM ±	0.24	0.03	0.02	0.02
CD at 5%	0.73	0.09	0.06	0.04

The bacteria and actinomycetes populations were maximum in the upper layer of the soil and lowest was recorded in the deeper layers, the populations of bacteria and actinomycetes were decreased with increase soil depths. This may be due to the fact that soil bacteria and actinomycetes populations is generally higher at the surface soil owing to higher organic

matter and availability of more nutrients which act as a source for their food for their survival by continuous addition of organic matter with minimum tillage treatments than in deeper depths. However, in the subsurface layers of the soil, as the depth increase the compaction of soil will be more which has less organic matter and less nutrients which

recorded the lowest microbial populations. Velmourougane *et al.* (2014) reported that the microbial population declined with depth and maximum activity was recorded within 0–30 cm soil depth.

The fungal populations were slightly higher in the surface layers as compared to the subsurface layers. In this study, the fungal population showed non-significant results in all the cropping systems and in all the depths. This is due to the, the soil pH under the selected horticulture crops in RHREC, UAS campus, Bengaluru was neutral *i.e.*, 6.5-7.5. However, the fungal growth will be more in the acidic soil which is having soil pH less than 5.5 showed non-significant results in all the cropping systems.

4. Conclusion

The mango and cashew orchard had higher soil carbon content, enzymes activity and microbial population at 0-15 cm as compared to the annual crops. Because the surface soil had higher carbon content and availability of more nutrients which act as a source for their food for their survival by continuous accumulation of organic matter with minimum tillage treatments under the perennial crops than in deeper depths. However, in the subsurface layers as the depth increase the compaction of soil will be more which has less organic matter, carbon content and less nutrients.

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