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Studies on the impact of organic farming on physico-chemical and microbial properties of soil

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Abstract

Soil health was a key founding principle for the development and practice of organic farming. Such farming practices, combined with the proper management of the farm and concurrently available renewable resources, can result in the rejuvenation of the soils and sustainable, improved crop productivity. Effective use of farmyard manure, vermicompost and organic liquids are a key to nutrient cycling on organic farms. These organic fertilizers enhance the soil physical, chemical and microbial properties, so that it can become a potential alternative to conventional farming systems. The present study assesses the impacts on soil macro and micronutrients of organic farming. It also identifies and assesses soil processes regulated by microbes under organic and conventional management practices. Our findings supports the view that organically treated soil (OS) activates the growth of microorganisms as compared with conventionally used synthetic chemical fertilizers. This enrichment of microbes possibly leads to the enhanced level of soil organic carbon, soil organic nitrogen, and microbial biomass in OS.

Keywords: Soil health; vermicompost; organic liquids

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1. Intruduction

Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. The influence of organic and conventional management practices on soil chemistry, microbial activity, and biomass has been extensively studied (García-Ruiz *et al.*, 2009; Ge *et al.*, 2011). Such farming practices, combined with the proper management of the farm and concurrently available renewable resources, can result in the rejuvenation of the soils and sustainable, improved crop productivity. The application of organic matter from such resources as animal manures, crop residues and green manuring has been shown to replenish organic C and improve soil structure and fertility (Guisquiani *et al.*,1995; Parham *et al.*, 2002; Saviozzi *et al.*, 2002).

Organic farmers manage for high soil organic matter (SOM) and net N mineralization rates. Furthermore, use of synthetic pesticides, which can negatively impact soil biota (e.g., Miller and Jackson, 1997; Sukarno *et al.*, 1993), is also prohibited (USDA National Organic Program Standards). As a consequence, microbial activity is often higher in organic than conventionally-managed soils (Carpenter-Boggs *et al.*, 2000; Drinkwater et al., 1995; Lundquist *et al.*, 1999), community composition can be more complex (Ma¨ der et al., 2002), and in some instances, invertebrate density and biodiversity increases (Hole et al., 2005). Abundance of arbuscular mycorrhizal (AM) fungi may also increase under organic management (Ma¨ der *et al.*, 2002).

Soil is a complex mixture of minerals, oxides, organic matter, microorganisms, and other compounds that have been produced during the soil formation process, which provides an extremely large variety of soils. In particular, the topmost layers of agricultural soil are very delicate and dynamic in their behavior. Therefore, soil analysis has been a routine practice for the evaluation of soil fertility (Du *et al.*, 2009). Soils under organic farming (compost and green manure) have better quality and microbial activity (Nautiyal *et al.*, 2010) due to crop rotation and reduced application of synthetic nutrients and pesticides in organically managed soil (Shannon et al.2002; Wu *et al.*, 2008). Soil health was a key founding principle for the development and practice of organic farming, as evident in one of its original precepts (here in the words of Lady Eve Balfour, 1943) that “the health of soil, plant, animal and man is one and indivisible”. Briefly, the early organic movement focused strongly on issues of human nutrition and health, as well as the promotion of soil fertility through the use of composts and other organic fertilizers.

A large percentage of the Earth’s active carbon (C) is deposited in soil organic matter (SOM), and its cycling rate is tightly linked to nitrogen (N) availability in natural and managed ecosystems (Gärdenäs *et al.*, 2011). SOM turnover, the formation of dissolved organic N (DON), and its subsequent turnover to inorganic N play a key role in soil fertility and available nutrient supply to both vegetation and soil microorganisms. Additional ON molecular components are derived from dry and wet deposition, rainfall, litter fall, animal residues (urine and feces), and soil organic fertilizer applications (Kalbitz *et al.*, 2000). Due to soil degradation processes such as wind and water erosion, organic matter decline, soil compaction, and soil fertility loss occur rapidly in these areas because of high temperatures and low and irregular precipitation. This study is a part of a comprehensive investigation to monitor the soil fertility and to assess the status of macro and micronutrients in three different soil types.

2. Materials and Methods

Soil samples were collected from three different fields: (1) soil treated with organic fertilizers (OS); (2) soil treated with chemical fertilizers (CS) and (3) untreated control soil of Reddiyapatti village of Viruthunagar District. OS received of composted Farm yard manure (FYM), vermicompost (VC) and organic liquid manures like Beejamurth and Jeevamurth. In OS, no tillage and crop residue removal have been practiced since the past 10 years. In CS, chemical fertilizers were applied in the form of elements of nitrogen, phosphorus, and potassium in 20:10:10 kg/acre

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ratio, respectively. The fertilizers were applied annually for the past 10 years. Within each from OS, CS, and control, four 10×10-m areas were selected for uniform topology and soil type. Soil samples were collected randomly from three fields, at the depth of 15 cm, in each of the four selected areas in May 2012. Three samples collected from four areas were randomly mixed, and the composite was considered as the three replicates for analysis. Soil samples were kept in plastic bags on ice and transported to the laboratory and stored at 4°C. Soil samples were sieved to pass 2-mm round-holed sieve. Visible organic matter was removed, before analysis and samples were split into two subsamples. One was stored at 4°C for microbial and physical analysis and the other was air dried and stored for chemical analysis and the residual soil was air-dried for chemical analysis.

3. Results and Discussion

In order to analyze the influence of fertilizers fortification on soil physicochemical properties and microbial population summarized in Table 1, 2 & 3. Soil samples from three plots were deep black granular sandy loam in CS, brown granular sandy loam from control, and black granular sandy loam from OS. In organically treated soil the sand, slit and clay % were 78.4, 16.2 & 5.4 respectively (Table 1).

Table 1: Physical properties of three different soils

Parameters	Control	Conventional	Organic
Sand %	77.5	77.8	78.4
Slit %	16.4	17.4	16.2
Clay %	6.1	4.8	5.4
Textural class	brown granular sandy loam	Deep black granular sandy loam	Black granular sandy loam

The Chemical treatment showed an increase in pH (7.9) and EC (0.53dSm^{-1}). High inputs of FYM, vermicompost and organic liquids in the OS resulted in significantly enhanced total available nitrogen (450.16Kg ha^{-1}), phosphorus (40.26Kg ha^{-1}), and potassium (406.78Kg ha^{-1}) compared with CS and control soils (Table 2). Results of this study demonstrate that total organic C content in OS soil was about 1.03% and it was higher compared to the CS (0.45%) and control (0.38%) soils. Chemical fertilizers significantly affected soil micro nutrients (Table 2). The highest total soil Fe levels (21.34ppm), Mn (24.68ppm), Zn (3.47ppm) and Cu (1.78ppm) were observed in the OS and followed the trend OS>CS>control.

Table 2 – Chemical properties of three different soils

Parameters	Unit	Control	Conventional	Organic
pH	-	6.6	7.9	7.2
EC	dSm^{-1}	0.25	0.53	0.42
N	Kg ha^{-1}	288.51	317.73	450.16
P	Kg ha^{-1}	16.8	20.4	40.23
K	Kg ha^{-1}	214.32	273.97	406.78
Organic carbon	%	0.38±0.05	0.45±0.02	1.03±0.02
Fe	ppm	7.08	10.92	21.34
Mn	ppm	17.34	21.52	24.68
Zn	ppm	0.96	2.36	3.47
Cu	ppm	0.51	1.24	1.78
Microbial biomass carbon	µg gm−1 of dry soil	135.46±7.39	147.38±10.05	188.16±4.75
Readily mineralizable carbon	µg gm−1 of dry soil	126.87±3.55	138.37±6.45	192.26±2.67

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Microbial population (heterogeneous bacteria and actinomycetes) was also significantly higher in OS compared to CS and control soil which was further confirmed by higher microbial biomass carbon content in OS(188.16 µg gm^{-1}) which was higher compared to CS (147.38µg gm^{-1})and control(135.46µg gm^{-1}) soils. Results demonstrate that the highest microbial population was recorded in OS soil samples followed by control and CS (Table -3). Soil microbes like bacteria, fungi and actinomycetes were recorded 5.46, 2.55 and 4.85 respectively.

Table - 3: Microbial properties of three different soils

Microbial population (log CFU g−1 soil)	Control	Conventional	Organic
Bacteria	4.75	4.26	5.46
Fungi	2.37	2.25	2.55
Actinomycetes	4.26	3.28	4.85

In present study, results showed that compared to OS or control soil samples, microbial population is significantly reduced in chemical fertilizer-managed soil (CS). Organic manure has significant impact on the biomass C and the activity, compared with mineral fertilizers. This was in agreement with the results obtained by Chu *et al*., (2007). Application of organic amendments to soil not only increases the total organic carbon content and its different fractions but also has a series of effects on microbial proliferation and activity was also reported by Bastida *et al*., (2008). Lagomarsino *et al*., (2009), Nannipieri *et al*. (2008) and Shi *et al*., (2006) have reported that enzyme activities in the soil are related to the organic matter and microbial biomass. The application of cow dung to improve the crop yield has been indicated since the time of Kautilya (*ca*. 300 BC), which was later continuously followed by Indian farmers in various ways (Nene YL 2006). Swain and Ray (2009) has reported some plant growth promoting rhizobacteria isolated from cow dung; our result supported the view that cow dung compost amendment (OS) activates comparatively more microorganisms than conventionally used chemical fertilizers. This higher activity of microbes possibly leads to the enhanced soil organic carbon, soil organic nitrogen, and microbial biomass in OS and control soil compared to CS as shown in Table- 2.

Organic management soil (OS), which is known primarily for the application of organic fertilizer and the absence of artificial fertilizers, resulted in significantly higher DON amounts than that of conventional management soil (CS). This result is consistent with Ge *et al*., (2010a) for soluble organic N in soil solutions extracted from greenhouse and open-field horticultural soils. Organic fertilizers increase the numbers of beneficial microbes in the soil that contribute to soil fertility. For tomato cultivation, Tu *et al*., (2006) showed that microbial biomass and microbial activity were generally higher in organically managed soils, cotton gin trash being most effective, than conventional soil treatment with synthetic fertilizers.

3.1 Conclusion

The results of our study indicated that organic soil management practices have a substantial effect on soil macro, micro nutrients and microbial population. Additional studies investigating the long-term functional significance of organic C and N under different soil management practices, particularly in organic practices, are therefore warranted. Organic management currently provides a clear advantage over conventional farming as a whole with respect to microbial diversity. This review indicates that organic farming has the potential to help in achieving the conservation of soil biodiversity. Organic farming systems have the potential to deliver significant environmental benefits. The effect of changing to organic farming will depend on specific cropping and management practices on each farm. It is important that we study and improve nutrient management on all farm systems and in the context of plant, animal and human health in order to develop more sustainable farming systems. It can be concluded that organic farming practices were beneficial in increasing the soil fertility and soil health for the long term use.

4. References

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