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Physico-chemical and Microbial activity of soil under Conventional and Organic Agricultural Systems

P. K. Chauhan[1], V. Singh[2], Vinod Kumar Dhatwalia[3] and Abhishek B[4]

[1]Department of Biochemistry, Himachal Institute of Life Sciences, Paonta Sahib, H.P. India
[2]Department of Microbiology, Himachal Institute of Life Sciences, Paonta Sahib, H.P. India
[3]Department of Biotechnology, Beehive PG College of Advance Studies, Dehradun, U.K. India
[4]Department of Pharmaceutical Sciences, HIP, Paonta Sahib, H.P. India

ABSTRACT

The objective of this study was to evaluate the effects of conventional (inorganic) and organic agricultural systems on the physico chemical and microbial properties of soil. Microbial population counts were analyzed from soil samples collected from the surface (0-10 cm) and sub surface (10-20 cm) soil depths of the treated plots by soil plate and dilution plate methods for bacteria. Results of the physico chemical analysis showed that the inorganically treated plots had significantly higher pH, nitrogen, potassium, phosphorus contents than the organically treated plots. On the other hand organically treated plots have the maximum microbial population counts and microbial biomass carbon which is followed by the inorganically treated plots and control. Organic plots exhibited a significant variation in bacterial population in both the soil depths with the inorganically treated plots and control. The application of organic fertilizers increased the organic carbon content of the soil and thereby increasing the microbial counts and microbial biomass carbon. The use of inorganic fertilizers resulted in low organic carbon content, microbial counts and microbial biomass carbon of the soil, although it increased the soil's nitrogen, phosphorus and potassium level which could be explained by the rates of fertilizers being applied. From the present study it has been concluded that the soil under organic agricultural system presents higher microbial activity and microbial biomass carbon than the conventional or inorganic agricultural system.

Key words: Physico chemical, Microbial biomass, Organic & Inorganic fertilizers.

INTRODUCTION

Currently, there is widespread interest in developing sustainable agricultural systems that are less dependent on external inputs, especially fertilizers and herbicides, to reduce impacts on the environment and conserve and improve soils [1]. The use of agrochemicals has been the main option for increasing agricultural production in world. Fertilizers and pesticides are widely used by farmers in the forested zone where the population density fuels the demand for food. The intensive use of agrochemicals may lead to soil degradation, residues of agrochemicals in crops or groundwater and to negative effects on the health of agricultural workers, especially in intensive commercial horticulture, particularly in vegetable production [2]. Chemical fertilizers may gradually increase the acidity of the soil. Healthy soils are essential if the integrity of terrestrial ecosystems is to remain intact or to recover from disturbances such as drought, climate change, pest infestation, pollution, and human exploitation, including agriculture [3]. Protection of the soil is therefore a high priority and a thorough understanding of ecosystem processes is a critical factor in assuring that the soil remains healthy. Since fertilizers and pesticides are being widely used by farmers in peri-urban agriculture, it is important to consider their possible impact on soil health. A unique balance of chemical, physical, and biological especially microbial biomass contributes toward maintaining soil health.

Soil microbial biomass plays a critical role in ecosystem processes, such as carbon cycling, nutrient turnover, or the production of trace gases. Soil microbial activities, populations and communities are governed by environmental variables and agricultural system, as conventional and organic system [4]. Conventional agriculture has an important role in improving food productivity to meet human demands. However, this system has been largely dependent on intensive chemical inputs. On the other hand, organic agriculture does not use synthetic fertilizers and pesticides and attempt to close nutrient cycle on their farms, protect environmental quality and enhance beneficial biological interactions and processes [5]. Organic agriculture is gaining worldwide acceptance and has been expanding at annual rate of 20% in the last decade accounting for over 24 million hectares worldwide [6]. This system can reduce some negative effects attributed to conventional agriculture and has potential benefits in enhancing soil quality [7]. Soil quality is the capacity of soil to maintain some key ecological functions, such as decomposition and formation of soil organic matter [8]. Microbial processes are important for the management of farming system and improvement of soil quality. In this paper, the objective was to investigate physico-chemical and microbial activity of soil in areas under conventional and organic agricultural systems.

EXPERIMENTAL SECTION

In order to assess the effect of agricultural systems on soil properties and microbial diversity, a study was superimposed on the on-going long-term field experiment at Paonta Sahib, Distt. Sirmour, H.P. The field experiment was established in 2010 to investigate the effect of continuous application of conventional and organic agricultural system in a maize-wheat rotation. The area is sub-humid with an average bimodal rainfall of 750 mm and two cropping seasons per year. The soil is well-drained, very deep dark reddish and friable clay.

Experimental design
The field experiment was a randomized split- pot deign, consisting of organic and inorganic fertilizer treatments. According to the type of fertilizer treatments, each of the experimental plots was designated as C, O and IN for control, organically and inorganically treated plots respectively. The organically treated plot was amended with a mixture of farmyard manure (900 kg $plots^{-1}$) while the inorganically treated plot was amended with a mixture of urea (220 g $plot^{-1}$). Control was also set up without the addition of any fertilizers.

Soil sampling
Soil samples were collected aseptically from the surface (0 – 10 cm) and the sub surface (10 - 20 cm) soil depths in each experimental plot at monthly intervals starting from pretransplanting period (July) till post harvest period (December) for six months. From each plot, soil samples were collected randomly and mixed thoroughly to get a homogenous mixture. About 250 gm of the soil samples were collected and stored at 4^{oC} and were used for microbial analysis and the remaining were air dried and sieved for the determinations of physico-chemical properties of soil.

Physico-chemical analysis of the soils
Soil temperature was noted by using soil thermometer at the time of sample collection. pH of the samples were taken by using an electronic digital pH meter in 1:5 soil water suspension. The moisture content of the soil samples were determined gravimetrically by weighing, drying in a hot air oven at 105 ^{o}C for 24 h and then reweighing. Organic carbon was determined by the method given by Anderson and Ingram (1993) [9]. Total nitrogen, available phosphorus and potassium were determined by Kjeldahl distillation [10], molybdenum blue method [11].

Microbiological analysis of the soil samples: The microbiological analysis of the soil samples were carried out according to the methods of Oyeleke & Manga (2008a) [12] and Rabah *et al*., (2008) [13]. The bacterial isolates were identified and characterized using standard biochemical tests [14]. The tests employed include colonial, morphological characteristics, gram stain, motility, catalase, methyl red, Voges- Proskaeur, indole production, urease activity, H_2S and gas production, citrate utilization, glucose, sucrose, and lactose utilization tests.

Statistical Analysis: Analysis of variance (ANOVA) for soil microbial population, microbial biomass carbon and physico-chemical properties were analyzed by using statistical version 6.

RESULTS AND DISCUSSION

Physico chemical analysis of soil: The highest organic carbon content was observed in organically treated plots and the least in control plots at both the surface and sub- surface soil depths. Organic carbon in control plots showed significant variation with organically and inorganically treated plots at the surface soil depths, whereas, at the sub surface soil depth, significant variations were observed between all the plots according to the statistical analysis (**Table-1**).

Table-1. Physico chemical analysis of soil samples under conventional and organic agricultural systems at surface (0-10 cm) and sub surface (10-20 cm) soil depths

Soil depth	Soil properties	Control	Organic field	Inorganic field
0-10 cm	pH	5.320±0.18	5.130±0.15	5.360±0.14
	Moisture content (%)	48.930±0.94	45.460±1.31	44.360±1.44
	Organic carbon (%)	2.170±0.05	2.320±0.04	2.290±0.04
	Total nitrogen (%)	0.430±0.05	0.490±0.05	0.520±0.05
	Phosphorus (μg g^{-1} dry soil)	14.350±0.53	16.960±0.59	18.220±0.75
	Potassium (mg g^{-1} dry soil)	0.027±0.003	0.031±0.003	0.036±0.004
10-20 cm	pH	5.240±0.14	5.280±0.99	5.170±0.17
	Moisture content (%)	55.860±0.65	54.180±0.15	52.960±0.80
	Organic carbon (%)	2.120±0.06	2.360±0.04	2.310±0.04
	Total nitrogen (%)	0.440±0.31	0.550±0.03	0.570±0.05
	Phosphorus (μg g^{-1} dry soil)	14.060±0.48	15.310±0.50	16.280±0.57
	Potassium (mg g^{-1} dry soil)	0.020±0.002	0.022±0.002	0.027±0.003

Inorganically treated plots amended with a mixture of urea (220 g $plot^{-1}$) showed highest content of total nitrogen, available phosphorus and exchangeable potassium followed by the organically treated plots amended with a mixture of farmyard manure (900 kg $plots^{-1}$) and least in control at both the surface and sub surface soil depths. Total nitrogen in control plots showed significant variations with the organically and inorganically treated plots according to the statistical analysis, at both the soil depths whereas, available phosphorus and exchangeable potassium showed significant variation between all the plots according to the statistical analysis at both the soil depths (**Table-1**). Agricultural use of soil affected its chemical properties. Soil from the organic plot showed an increase in organic carbon content, compared to other plots, this might be due to the addition of organic contents as they are the sources of nitrogen and carbon to soils. This is in accordance with Kumar *et. al.,* (2000) [15] who found that the organic materials which are applied in combination with inorganic fertilizer gave greater residual soil fertility in terms of increase in organic carbon content from 0.36 % to as high as 0.61% and the available N, P and K in two years cropping cycles. The application of organic manures significantly increased the soil organic carbon content whereas, chemical fertilizers had no effect [16]. The increase in soil organic carbon content can depend on both organic inputs as well as higher crop residue fall to soil. It has been found that nitrogen content was higher in the inorganic plots compared to organic and control plots. This may be due to the addition of urea which is destined for use as nitrogen release fertilizers. This is also in accordance to the study done by Parham *et. al.,* (2002) [17] where manure treated soil was compared with inorganic fertilizers treated soil in which inorganic fertilizer treated soil showed higher nitrogen content. The lower value of total nitrogen in organic plots could be as a result of crop uptake, immobilization by microorganisms and nitrogen loss through volatilization [18]. Available phosphorous is higher in the inorganically treated plot compared to organic.

Microbial biomass carbon: Microbial biomass carbon differed among soils amended with different treatments as well as at different soil depths. The highest microbial biomass carbon was observed in the organically treated plots amended with a mixture of farmyard manure followed by the inorganically treated plots amended with a mixture of urea and the least in control plots. With respect to the soil depth, the increase was more in the sub surface (10-20 cm) soil depth than in the surface (0-10 cm) soil depth. A positive effect of organic fertilizers on the microbial biomass nitrogen and the carbon content in the soil was also observed by Cerny *et. al.,* (2008)

[19]. The present study showed that microbial biomass carbon increased with soil depths which are supported by many researchers.

Microbial Diversity: A significantly higher population of microbes was reported in the upper soil horizon (0-10 cm) but there were no significant difference between the treatments. The application of organic fertilizers led to an increase in microbial populations. Plots with inorganic fertilizers alone were applied had the lowest microbial populations. In case of organic field the bacterial population in the 0-10 cm layer was 45.6 x 10^5 cfu g^{-1} dry wt. soil where as in 10-20 cm layer it was 14.2 x 10^5 cfu g^{-1} dry wt. soil. On the other hand in case of inorganic field the bacterial population in the 0-10 cm layer was 24.3 x 10^5 cfu g^{-1} dry wt. soil where as in 10-20 cm layer it was 7.6 x 10^5 cfu g^{-1} dry wt. soil **Table-2**.

Table 2. Microbial populations in soil samples under conventional and organic agricultural systems at surface (0-10 cm) and sub surface (10-20 cm) soil depths (c.f.u. g^{-1} dry wt. soil)

Treatments	Bacteria x 10^5	
	0-10 cm	**10-20 cm**
Control	25.3 x 10^5	5.2 x 10^5
Organic field	45.6 x 10^5	14.2 x 10^5
Inorganic field	24.3 x 10^5	7.6 x 10^5

From the present study it has been concluded that the addition of organic inputs increased the bacterial populations in both the soil depths in comparison with inorganic inputs. This study was in accordance with D.W. Lotter *et. al.*, (2003) [20], they have also studied the performance of organic and conventional cropping systems in an extreme climate year at the Rodale Institute in Berks County, southeastern Pennsylvania and the evidences were presented that organic crop systems perform better than conventionally managed crop systems during climate extremes, in this case for both drought and excessive rainfall. Pulleman *et al*. (2003) [21] compared soil structure and organic matter dynamics on conventional (non-organic) and organic arable farms and they found that the organic farming is the key to long-term success in good soil management. So to maintain soil fertility, it is necessary to add nutrients to agricultural systems and the farmers should have to use mineral fertilizers, organic waste and various management techniques to maintain soil fertility.

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