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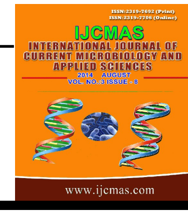

Original Research Article

Influence of Organic and Synthetic Fertilizers on Soil Physical Properties

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A B S T R A C T

Conventional management of soils (i.e. intensive cultivations and the use of synthetic agrochemicals) has often been associated with degradation in soil quality whereas organic farming has been suggested as an approach that conserves and protects the soil environment. Present study was conducted near the vegetable farm in the soil microbiological section, Department of Soil Science, CSKHPKV, Palampur in rice-lentil cropping sequence with organic, integrated and inorganic nutrient management. There were eight treatments with three replications and randomized block design. The surface and subsurface soil samples were collected before sowing and after harvesting from each treatment (0-15cm and 15-30 cm deep samples) and were analyzed for physical properties. This research is attempts to find difference in physical properties of soil under different farming practices. In the present investigation no significant difference in grain yield has been recorded in integrated and organic farming system, but significant difference was reported in the soil physical properties. Soil physical properties were found to be improved in the treatments supplemented with organic manures.

K e y w o r d s

Physical properties, organic, integrated, inorganic nutrient management, biofertilizer

Introduction

Growing concerns about the environmental, economic and social effects of chemical-dependent conventional agriculture have led many farmers and consumers to seek alternative practices and systems that will make agriculture more sustainable. Alternative farming systems include 'organic', 'biological', 'biodynamic', 'ecological', and 'low input'. However, just because a farm is "organic" or 'Biodynamic,' for example, does not mean that it is sustainable. To be sustainable, it must produce food of high quality, be environmentally safe, protect the soil, and be profitable (Reganold *et al*., 1990). Organic farming uses no synthetic chemical fertilizers and pesticides; instead it emphasizes building up the soil with compost additions, animal and green manures, controlling pests naturally, rotating crops, and diversifying crops and livestock. Basically, organic farming is the creation of healthy and fertile soil. Organic agriculture can be defined as a method of production that places the highest emphasis on protecting and enhancing the environment and minimizing pollution (Liebhart, 2003).

The role of organic agriculture is to either enhance or sustain the overall quality and health of the soil ecosystem (Ekwue 1992). Organic agriculture is aimed at producing high quality food produce that is not only rich in nutrients but also contributes to health care and well-being of mankind. Since organic farming eliminates the use of most 'conventional' fertilizers, pesticides, animal drugs and food additives, it can improve soil, water and environmental quality and thus improve the overall quality of life. Organic agriculture is now practiced in more than 130 countries with a total area of 30.4 million hectares in 0.7 million number of organic farm. This constitutes about 0.65% of the total agriculture land of the world (Willer *et al.* 2008). During the last several decades, much research has focused on increasing productivity and protecting environmental quality under different farming systems. These studies show that conventional farming's use of chemical fertilizers and pesticides has increased crop yields and enhanced food security around the globe (Pang & Letey 2000). However, despite the high yields associated with it, conventional farming's ability to sustain soil fertility and environmental quality has been called into question (Pang & Letey 2000). Conventional farming systems are reported to be associated with a decline in soil structure and soil aggregation, a decrease in water infiltration and an increase in soil bulk density, soil salinity, nitrogen leaching and ground water contamination (Logsdon *et al*., 1993; McGarry *et al*., 2000).

In agriculture, soil quality refers to the soil's ability to sustain production (Lal, 1994). High soil quality is associated with efficient use of water, nutrients and pesticides, improvement in water and air quality, mitigation of greenhouse gas emission, and increase in agronomic production (Lal 1994). Soil quality cannot be measured directly, but is inferred from static or dynamic soil quality indicators (SQIs) or measurable soil attributes generally influenced by land use and soil-management practices (Sanchez-Maranon *et al.*, 2002; Seybold *et al.*, 1997; Shukla *et al.*, 2006). Soil's physical properties can be used as indicators for making soil-quality assessments and for determining the sustainability of farming systems. The physical properties of the soils such as saturated and unsaturated hydraulic conductivity, water retention capacity, bulk density, total porosity, pore size distribution, soil resistance to penetration, aggregation, and aggregate stability were improved in plots amended with sewage (Aggelides and Londra 2000). It is well understood that the key to long-term success in organic farming is good soil management. There is at present a lack of comparative research into soil physical properties between organic and conventional management. The present study summarizes the effect of organic farming on the soil physical properties. The results will help provide a platform for future research into the impacts of organic farming on soil physical characteristics. The main aim of this study was to examine the effects of the application of organic residues (crop residues, farmyard manure and biofertilizers) on some soil physical properties.

Materials and Methods

General description of the area

Experimental Site

The research trial was conducted in soil microbiology section of CSKHPKV Palampur in rice-lentil cropping sequence with organic, inorganic and integrated nutrient management. The experimental farm is situated at $31^0 6^/$ N latitude and $76\ ^0 3^/$ E longitude at an altitude of about 1290 meters above mean sea level. The site lies in the Palam valley of Kangra district in the mid hill sub humid zone of Himachal Pradesh.

Climate and Weather

The climate of the experimental site is characterized as wet temperate with mild summers (March to June) and cool winters. The mean annual rainfall around Palampur during 2010-2011 was 1500 mm-3000 mm. The mean maximum temperature remains about 31^0C during the hottest months of May to June. December to February are the coldest months with mean minimum temperature of about 13.6^0C.

Soil

Soil of the study area at the start of the experiment was silty, clay loam in texture and classified as Typic Hapludalfs as per the Taxonomic system of soil classification (Soil Survey Staff, 1975).

Field studies

Experimental details

The field experiment was conducted on a pre-established experiment which comprised of eight treatments. The treatments were:
Numbers of treatment were 8 (eight) and replications were 3 (three). Plot size was 3.5 x 3.0 m and research design was Randomized Block Design (RBD). Recommended dose of chemical fertilizer NPK for Rice-90:40:40 and Lentil-10:20:10. Fertilizer's Source was Urea, Single Super Phosphate (SSP) and Murate of Potash (MOP) and bio-fertilizers used were *Azospirillum* and *Phosphate solublizing bacteria* (PSB).

Soil sampling

Surface (0-15cm) and subsurface (15-30cm) soil samples were collected before sowing and after the harvest of the three cropping sequences and were air dried and grinded in a wooden pestle and mortar to pass through 2 mm sieve and subsequently stored in polyethylene bags for determination of physical parameters.

Laboratory studies

The processed soil samples were analyzed physical properties (particle size distribution, bulk density, field capacity, water holding capacity, wilting point) from the following standard methods. Bulk density of soil at 0-15 and 15-30 cm were determined by Core sampler method (Piper, 1950). Water holding capacity of soil at 0-15 and 15-30 cm were determined by Keen's Box (Piper, 1950).Field capacity of soil at 0-15 and 15-30 cm were determined by Pressure plate apparatus (Richard, 1954) at one third (1/3) bar. Permanent wilting point of soil at 0-15 and 15-30 cm were determined by Pressure plate apparatus (Richard, 1954) at fifteen (15) bar. After the harvest of rice data on grain and straw yields were recorded.

Results and Discussion

Particle Size Distribution

The soil of the experimental area was found to be having silt content (50.50 %), sand content (28.60 %) and clay content (20.70 %) at depth 0-15 cm. While at 15-30 cm sand content was (32.40%), silt content (41.40%) and clay content (25.20%) (Table 1).

Bulk Density

The range of the data presented lies between 1.19 mg/cm3 to 1.46 mg/cm3 at surface (0-15 cm) and subsurface (15-30 cm). At the depth of 15-30 cm the data was found to be non-significant in both before sowing and after harvesting soil samples. The highest value was obtained for T_7 (recommended dose of NPK) 1.46 mg/cm3 and lowest value was obtained for control treatment (T_8). And the difference was non- significant among T_2, T_3, T_4, T_5 and T_6 (Table 2).

Field Capacity

The varying amount of field capacity of the various treatments was found to be lie between 2.54% to 30.27%. Amongst the two organic treatments, T_1 (tones Vermicompost + Bio-fertilizer + Chopped crop residues) gave higher moisture content at field capacity than T_2. Use of inorganic was found numerically inferior than organics. The highest moisture content at field capacity was observed in T_5 (1.75 tones Vermicompost + Bio-fertilizer + 67 kg/ha Neem cake + Half Nitrogen +Recommended P and K.) and T_3, T_4 and T_6 was at par. The highest (30.27%) values were obtained in T5 and lowest (22.54%) in T_8 (Table 3).The integrated treatments gave higher values for field capacity mainly because the integrated use of nutrients improved the soil aggregates and pores spaces which allowed the free movement of water within the soil thereby, increasing the moisture content at field capacity.

Water Holding Capacity

The water holding capacity of the various treatments ranged from 53.30% to 60.30%. The data revealed that it was significantly higher (59.43%) at 0-15 cm depth and (60.30 %) value at 15-30 cm for organic treatment T_1.The after harvesting soil samples gave comparatively higher values than before sowing samples. The water holding capacity of T_2 was at par with T_6 in both before sowing and after harvesting soil samples. The T_7 (recommended dose of NPK) showed higher value for water holding capacity than T_8 at both the depths. The effect of organic, integrated and inorganic treatments on water holding capacity is depicted in (Table 4). The water holding capacity in subsurface soil for T_2, T_3, T_6 and T_7 was insignificant.

The higher values obtained in organic treatments T_1 and T_2 may be attributed to the organic matter (vermicompost and crop residues) which indirectly contributes to soil texture via increased soil faunal activity leading to improve the soil aggregation and porosity which ultimately increased the number of macro-pores and thus, infiltration rates. The organic matter was found contributing to the stability of soil aggregates and pores through the binding properties of organic material.

Permanent Wilting Point

The range of Permanent wilting point was found to be lie between 14.22% to 20.51% in the various treatments at surface and sub-surface levels. The highest (20.51%) value was obtained for T_5 and lowest (14.22%) value for T_8 at surface (0-15 cm) soil. Inorganic treatment gave the permanent wilting point value 15.69 % greater than control. The data was found to be significant for all the treatments in both before sowing and after harvesting samples. The permanent wilting point percentage was observed to be higher in subsurface soil as compared to surface soil (Table 5). The higher values for integrated treatment may be attributed to the higher values of water holding capacity and organic matter in integrated treatments.

Application of organic and inorganic together might have improved soil water holding capacity, which has resulted in the improvement of soil permanent wilting point.

Crop Yield

The results on the grain yield ranged from 1.33 tones/ha to 2.16 tones/ha. The data for grain yield was found to be significant and maximum (2.16 tones/ha) for T_6 and minimum (1.33 tones/ha) for T_8. Among the organic treatments T_1 gave the highest (2.13 tones/ha) grain yield and T_7 the chemical treatment gave grain yield of (1.33 tones/ha) which was found to be equivalent to T_8 (Table 6). The high yield obtained for T_6 treatment might be due to the integrated nutrient sources provided. The integrated sources made the continuous availability of nutrients from both organic and inorganic sources.

Straw yield

The data obtained for straw yield was maximum (4.86 tones/ha) for T_6 and minimum (2.16 tones/ha) for T_8. The data obtained was non-significant for T_1, T_4 and T_5 treatment. Among organic treatments T_1 gave highest straw yield. T_7 was found to have (3.70 tones/ha) of yield which was higher than T_8 (Table 6).

In agriculture, soil fertility declines over time due to continuous extraction of nutrients with crop harvest, soil acidification and compaction and when the replenishment with fresh nutrients is inadequate, over application is inevitable. Organic farming emerged as a potential alternative for meeting food demand, maintaining soil fertility. Soil's physical properties are the indicator of soil quality and determine how well a plant's roots grow and proliferate. Plant roots thrive in soil that has good aggregate stability (tilth), porosity, infiltration, drainage, water-holding capacity, bulk density, and resistance to crusting and compaction. An extensive root system that explores more soil volume naturally has access to more soil moisture and nutrients. The Water holding capacity was recorded maximum in the organic treatments followed by integrated and inorganic treatments respectively. Among the organic treatments T1 showed the maximum water holding capacity due to an addition of vermicompost and crop residues which ultimately increased the number of macro-pores and thus, infiltration rates. The similar findings have also been reported by Santhy *et al.* (1999). Sewage sludge significantly reduced soil bulk density after the third crop. Angin and Yaganoglu (2011) attributed the increase in water-holding capacity values in plot treated with sewage sludge to its high organic matter content. Although, crop residue application with or without fertilizer caused a little increase in water-holding capacity (Yaganoglu 2011).

Field capacity was recorded highest with the application of integrated nutrient management than organics and in-organics. The highest field capacity in integrated treatments has been ascribed to the integrated use of nutrients. The results were corroborated with findings of Walia *et al.* (2010). The maximum bulk density was found in the inorganic treatment followed by integrated treatments, organic treatments and control. Similar findings have been recorded by the Sharma *et al.* (2001). A trial conducted on long term experiment by Kaushal (2002) revealed that with the application of recommended dose of NPK along with FYM decreased bulk density to the lowest in soil over control (Kaushal 2002).

Table.1 Particle size distribution

Soil Textural Classes	0-15 cm	15-30 cm
	Silty Clay Loam	
Sand (%)	28.60	32.40
Silt (%)	50.50	41.40
Clay (%)	20.70	25.20

Figure.1 Rice crop

Table.2 Effect of different treatments on bulk density

Bulk Density mg/cm3	Before Sowing Depth(cm)		After Harvesting Depth(cm)	
Treatments	**0-15**	**15-30**	**0-15**	**15-30**
T1	1.21	1.31	1.31*	1.41
T2	1.23*	1.36	1.33*	1.45
T3	1.26*	1.34	1.36*	1.44
T4	1.29*	1.33	1.39*	1.43
T5	1.26*	1.36	1.36*	1.43
T6	1.28*	1.36	1.38*	1.45
T7	1.33	1.36	1.43	1.46
T8	1.19	1.35	1.29	1.44
CD Value(P=0.05)	**0.09**	**0.07(NS)**	**0.12**	**0.08(NS)**

* The mean is non significant

Table.3 Effect of different treatments on field capacity

Field Capacity (%)	Before Sowing Depth (cm)		After Harvesting Depth (cm)	
Treatments	**0-15**	**15-30**	**0-15**	**15-30**
T1	26.27*	28.85*	27.17*	28.34*
T2	25.51	27.48*	26.66*	28.13*
T3	27.45*	29.29*	28.40*	30.24*
T4	26.21*	28.66*	27.38*	28.61*
T5	28.32	29.43	29.18	30.27
T6	27.40*	28.31*	28.20*	30.08*
T7	24.82	26.57	25.81	27.30
T8	22.54	24.59	23.54	25.16
CD Value(P=0.05)	**2.86**	**2.34**	**2.67**	**2.35**

* The mean is non significant

Table.4 Effect of different treatments on water holding capacity

Water Holding Capacity (%)	Before Sowing Depth (cm)		After Harvesting Depth (cm)	
Treatments	**0-15**	**15-30**	**0-15**	**15-30**
T1	58.28	59.21	59.43	60.30
T2	57.19*	58.25*	59.3*	59.53*
T3	56.85*	57.43*	57.36*	58.29*
T4	54.16	56.44	57.53*	58.10
T5	54.72	57.56*	56.52	58.62*
T6	57.53*	59.37*	59.21*	59.58*
T7	56.32*	58.33*	56.46	57.60
T8	53.30	54.70	56.60	57.60
CD Value(P=0.05)	**2.45**	**2.63**	**2.35**	**2.12**

* The mean is non significant

Table.5 Effect of different treatments on permanent wilting point

Permanent Wilting Point (%)	Before Sowing Depth (cm)		After Harvesting Depth (cm)	
Treatments	**0-15**	**15-30**	**0-15**	**15-30**
T1	15.83	16.71	16.59	17.52
T2	14.38	16.55	15.42	17.48
T3	16.69	17.36	17.42	19.47
T4	15.33	17.25	16.36	18.34
T5	16.77	18.42	18.77	20.51
T6	16.32	18.12	17.73	20.44
T7	15.69	17.45	16.63	18.38
T8	14.22	16.33	15.63	17.50
CD Value(P=0.05)	**2.87**	**2.68**	**2.66**	**2.22**

Table.6 Effect of different treatments on yield

Yield		
Treatments	**Grain Yield(tones/ha)**	**Straw Yield(tones/ha)**
T1	2.13*	4.33*
T2	1.73	2.33
T3	1.40	3.43
T4	1.80	4.56*
T5	2.10*	4.76*
T6	2.16	4.86
T7	1.33	3.70
T8	1.33	2.16

* The mean is non significant

Similarly, Bhattacharya *et al.* (2004) studied the dynamics of soil characteristics in an ongoing long term fertility experiment at Uttaranchal and reported minimum bulk density with the application of NPK and FYM treatment (Bhattacharya *et al.* 2004). Permanent wilting point was recorded maximum in integrated nutrient management due to higher values of water holding capacity and organic matter. The use of organic inputs such as crop residues and manures has great potential for improving soil productivity and crop yield through improvement of the soil physical properties and nutrient supply (Abbasi *et al*. 2009). Crop yield was found to be maximum in integrated treatments and the organic treatments were non significantly lower than the integrated treatments. Kundu *et al*., (1994) reported the effect of crop waste on production in a rice-wheat crop sequence under rain-fed conditions on sandy loam soils of West Bengal and recorded the highest paddy grain yields in the treatment receiving crop waste at 3 t/ha coupled with either 25% or 50% of the recommended dose of mineral fertilizer than he treatment receiving organic crop waste alone. Organically managed soils provide a more stable soil structure than conventionally managed soils.

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