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ORIGINAL RESEARCH ARTICLE OPEN ACCESS

SOIL PROPERTIES DURING TRANSITION FROM CONVENTIONAL TO ORGANIC FARMING SYSTEM IN KAVRE DISTRICT, NEPAL

Biboss Maharjan, Anon Chaulagain, Parikrama Sapkota, Dhurva P. Gauchan, Janardan Lamichanne*

Department of Biotechnology, School of Science, Kathmandu University

*Corresponding author's email: ljanardan@ku.edu.np

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ABSTRACT

The aim of this study was to investigate the response of soil physical and chemical properties during the transition from conventional to organic farming system. Soil samples were collected from five different farms:: "Hasera organic farm" under 10 years of organic farming, "Everything organic nursery" under 5 years of organic farming, "Grameen Krishi" under 3 years of transition from conventional to organic, "Gautamshree farm" under 1 years of transition from conventional to organic and "Kuntabeshi farm" under IPM practice as reference. Soil bulk density, moisture content, texture, NPK, CEC and soil organic matter was evaluated in soil samples collected at 0-15 cm. Soil organic matter (5.45%) was highest in Hasera farm, whereas lowest bulk density ($1.02 gcm^{-3}$) was also in Hasera farm. Lowest soil organic matter content was found in Gautamshree farm. Soils of all farms were under loam texture. Soil macronutrients were highest in Grameen Krishi farm. The overall pH value of all soil samples was slightly acidic to acidic.

Keywords: Farming practices, Organic, Conventional, Soil quality, Transition time

INTRODUCTION

Organic agriculture is the pioneer advocate of sustainable and safe production systems, which uses only natural pesticides and fertilizers [1] for maintaining soil health and environmental protection [2]. Organic agriculture integrates tradition, innovation and science to assist the mutual environment and promotes fair relationships and a good quality of life for all involved [3].

Organic farming is the tradition and culture of Nepalese people [4] that has been following organic practices with greater resource utilization and social cohesion in agriculture. However, after 1970s, with the rise of 'Green Revolution', the use of synthetic fertilizers and pesticides got fiercely increased for high productivity and ultimately the higher economic output– resulting arrays of social, environmental and ecological disturbances [5, 6]. Nevertheless, to overcome such externalities, with worldwide awareness, popularity of safe-sustainable food production and consumption system i.e. 'sustainable agriculture' is expanding [5, 7].

In expansion process, the switching from conventional to organic farming system, a transitional period is a mandatory step in order to restore and improve soil quality and process [8]. The conversion period takes about three to five years to stabilize soil properties, known as transitional time [9, 10]. Well-directed transition strategies should be implemented in organic farming systems for the minimization of yield loss and to stabilize soil properties [8]. A wide range of studies have focused on comparison of soil qualities between conventional and organic farming system, but, in Nepal neither studies on comparing

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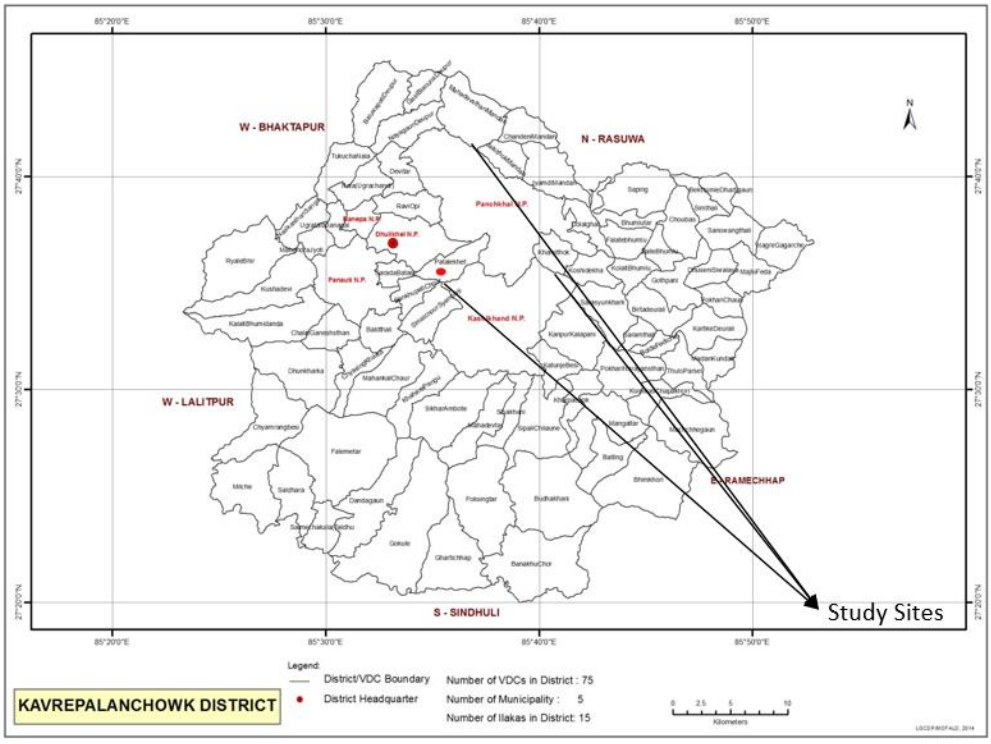
soil quality of conventional and organic farming system nor the research studying how soil indicators respond during the transitional period from conventional to organic farming system has been done till date. Therefore, this study compares soil properties of identically managed organic and transitional plots differing only in duration of organic management (under 1 and 3 years of transition from conventional to organic, under 6 years of organic and under 10 years of organic farm) in Kavre district, Nepal. A conventional plot (IPM farm) was included for reference purpose.

MATERIALS AND METHODS

Study Area

The study was conducted in the five farms (farm under IPM, under 1 and 3 years of transition from conventional to organic, under 6 years of organic and under 10 years of organic farm) in Patalekhet, Kaherelthok and Mahadevsthan VDCs of Kavreplanchok district approximately 42 KM east from Kathmandu (11 km east from Dhulikhel), at an altitude of 4200 ft. (around 1,400 meter). This is a region with a temperate mountain climate throughout the year and the temperature in this district ranges from 5^{o}C in winter to 35^{o}C in summer.

Soil samples were obtained from following plots: “Hasera organic farm” under 10 years of organic farming, “Everything organic nursery” under 5 years of organic farming, “Grameen Krishi” under 3 years of transition from conventional to organic, “Gautamshree farm” under 1 years of transition from conventional to organic and “Kuntabeshi farm” under IPM practice. The size of each experimental plot is approximately 15m^2.



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Soil Sampling and analysis

Soil samples were collected from independent areas of each study plots on December 2015. In each area, a grid with five points was selected to collect soil samples in 0-15cm depth. A spade and hand trowel was used carefully to dig out the top layer of soil after the removal of top vegetative layer. A five cm diameter corer was used to extract bulk density from each layer. The samples size was 25 (5sites *5 replications). A total of nine soil parameters were analyzed, which include pH, Soil organic matter (SOM), Cation Exchange Capacity (CEC), soil bulk density, texture type, gravimetric moisture content and concentration of N, P, and K. Lab analysis of the samples were conducted in organic farm lab, environmental lab and aquatic ecology center at Kathmandu University. Methods applied for analysis of each parameter are tabulated (Table1).

Table 1. References of methods used for analysis of 8 parameters

S.N.	Soil Parameter	Analysis Method used
1	Soil Bulk density	Soil Corer method
2	Soil Texture	Soil hydrometer method
3	Soil Moisture Content	Oven Dry Method
4	Soil pH	1:1 soil water ratio using pH probe
5	Organic matter/carbon	Dry combustion
6	Total nitrogen	Kjeldahl method
7	Available phosphorus	Modified Olsen method
8	Exchangeable potassium	Ammonium acetate extraction
9	Cation exchange capacity	NH4OAc-KCl extraction

The study was carried out in a completely randomized design with 5 replicates. For the detection of significant difference between the areas studied Analyses of variance (ANOVA) were used. All the statistical analyses were performed with the MS-Excel (Version 2010) package.

RESULTS AND DISCUSSIONS

Soil Texture Class

Table 2. Soil texture of different sites

Farm	Percentage (%)			Remarks
	Clay	Sand	Silt	
Hasera OF	26.2	22.5	51.3	Silt Loam
Everything ON	15.8	31.9	52.3	Silt Loam
Grameen Krishi	22	33.4	44.6	Loam
Gautamshree	16	52.3	31.7	Sandy Loam
Kuntabeshi	21	33.6	45.4	Loam

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Soil texture of different farms was determined using USDA textural system. In all the farms, percentage silt was highest followed by the percentage sand and percentage clay. Thus from the textural triangle, the farms had textural class of silt loam, loam and sandy loam.

Since all the farms are from the same geological locations i.e. mid hills of Nepal, no significant difference ($p<0.05$) in textural class was observed. Clay content was found low in Gautamshree (16%) and Everything ON (15.8%) as both farms had shallower soils on steeper slopes, which has significant effect on soil organic matter content of soil [11].

Soil Bulk Density and Soil moisture content

Table 3. Soil Bulk density and gravimetric moisture content (mean ± S.D) of the different farms

Farm	Soil Bulk Density(gcm^{-3})	Soil Moisture content (%)
Hasera Organic farm	1.02±0.16	17.24±3.35
Everything Organic Nursery	1.19±0.14	21.03±2.75
Grameen Krishi	1.06±0.08	21.76±3.21
Gautamshree Farm	1.44±0.02	17.51±2.21
Kuntabeshi Farm	1.21±0.10	18.26±2.35

Bulk density (gcm^{-3}) of soil is an indicator of soil compaction. It reflects the soil's ability to function for structural support, soil aeration and water and solute movement [12]. Soil bulk density was not significantly different at 5% level of significance, but arguably higher in Gautamshree farm, as total pore space in sand dominating soil will be less than silt or clay dominating soil [13]. Alternatively, compared to IPM based farm (Kuntabeshi), bulk density of transitional and organic plots were low, suggesting the improved soil physical properties due to continuous annual amendment of organic manure such as FYM in organic and transitional plots [14, 15, 16].

General properties of soil under different age of organic management and IPM based farm

Table 4. pH and Cation exchange capacity (m.e./100gm) (mean ± S.D) of the different farms

Farming System	pH	CEC (m.e./100gm)
Hasera OF	5.89±0.28	46.35±2.42
EoN	4.88±0.29	33.62±3.06
Grameen Krishi Farm	6.74±0.59	20.62±5.58
Gautamshree	3.85±0.45	24.88±3.75
Kunatabeshi Farm	3.81±0.42	37.56±7.43

Soil pH was significantly different ($p<0.05$) between different farms, with slight higher pH in established organic plots and transition plots than reference site coinciding the results with previous studies [11, 16, 17, 18]. Increase in soil pH can be attributed to addition of organic manure which complexes and reduces Al and Fe and increases base saturation [15, 19].

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Soil Cation exchange capacity was highest in Hasera organic farm (46.35) and significantly different at 5% level of significance. There is a positive correlation between Cation exchange capacity (CEC) and organic matter content of the soil [20].

Soil Macro Nutrients

Table 5. Mean ± S.D macronutrients content (in %) of soil of different research farms

Farming System	Total N	Available P	Available K
Hasera OF	0.125 ± 0.049	0.048± 0.022	0.037± 0.027
EoN	0.142± 0.029	0.067± 0.030	0.019± 0.014
Grameen Krishi Farm	0.229± 0.032	0.067± 0.010	0.080± 0.021
Gautamshree	0.094± 0.013	0.050± 0.026	0.031± 0.009
Kunatabeshi Farm	0.149± 0.018	0.077± 0.022	0.003± 0.001

Soil properties (NPK) were significantly different ($p<0.05$), but the resultis inconsistent with previously established soil hypothesis [21] that, soil properties (NPK) in established organic plots will be an arguably superior to transitional plots. Concentrations of soil macronutrients were highest in Grameen Krishi (3 years under transition). There are at least two explanations for the higher concentrations of soil NPK in Grameen Krishi. First, before transforming to organic, chemicals fertilizers and pesticides were excessively used in that farm. Therefore, un-harvested accumulated fertilizers in soil might have resulted in higher concentrations, considering the loss due to leaching and erosion is limited [22]. Another could be, the use of chemical fertilizers farmers in this farm has not totally stopped. With sudden stop of chemical fertilizers in initial year of transition, farmers have to face immense economic loss. So, farmers are more inclined to slowly reduce the amount of chemical fertilizer, and at the same time increase the amount of natural fertilizer. This is the best option on such chemical fertilizer and pesticide prone farming site. Accordingly, still with more than three years of transition, Grameen Krishi still has not developed into an established organic farm.

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Soil Organic Matter

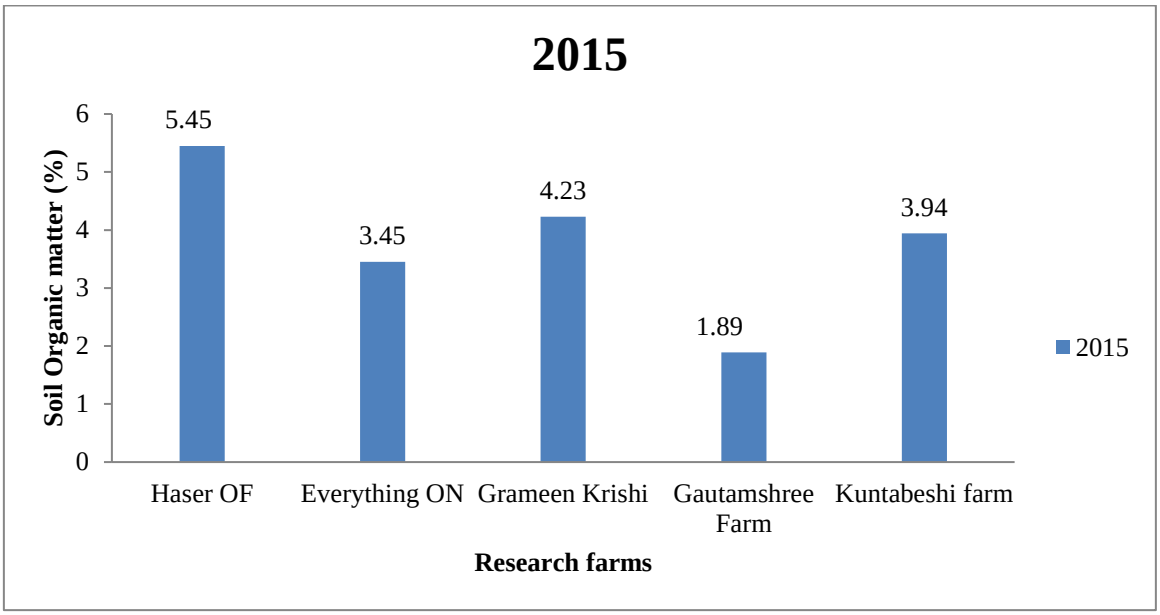

Figure 1. Graph showing the mean soil organic matter content (%) of five study farms (Age of organic farms is in the decreasing order of left to right).

Organic matter was highest in Hasera farm (10 years under organic farming) and least in Gautam Shree Farm (1 year under transition) (Figure 1). With the increase duration of organic management, there is an increasing trend of concentrations of soil organic matter in farms. This result is consistent with some earlier studies [8, 21, and 23]. However, there was a slight decrement in comparing soil OM of 'everything organic nursery' to transitional plots of 'Grameen Krishi'. The lower clay content and use of casually managed farm yard manure could be the reason behind it [11, 24].

CONCLUSIONS

With increase duration of organic management, our results clearly showed that transitional period is necessary to improve soil organic matter content with other physical and chemical properties. High input of natural fertilizers not only buildup C in soil but also improves other parameters alike pH, bulk density and CEC content. However, in transitional time soil nutrient management in organic farming system is still a big challenge, as shown by our results. Also, with very limited literature on soil of organic farming, we still have an incomplete understanding of the challenges, benefits and limitations of organic farming system in Nepal. Therefore, this observation suggests, for organic farming transition, in designing the transitional time required, we should not overlook the history of agricultural practices in the farm, along with social and economic considerations. In addition, the research recommends for conversion of virgin land and previously chemical used farms to organic farms 3 year and 5 year transition time requirements respectively for changes in soil quality of organic farming.

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