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Soil Quality Assessment of Conventional and Organic Farms in La Trinidad, Benguet

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ABSTRACT

The study was conducted in La Trinidad, Benguet to compare the physical and chemical properties and microbial biomass of soils in conventional and organic farms. The physical properties of the soil analyzed were bulk density, aggregate stability and water holding capacity while the chemical properties were soil pH, organic matter, cation exchange capacity, phosphorus and potassium. Microbial abundance of bacteria and fungi was likewise determined.

Soil samples from nine vegetable gardens representing organic farms and three for conventional farms were collected.

The results show that the three organic farms have significantly better physical and chemical properties than the conventional farms. Among the nine sampling areas representing organic farms, the Benguet State University (BSU) Organic Agriculture Demo-farm had significantly better physical and chemical properties than the other two organic farms.

Likewise, microbial biomass was significantly higher in organic farms than in conventional farms. Among the three organic farms, the highest bacterial count was observed from the College of Agriculture-Department of Agronomy Organic Farm while the lowest was from the Climate-Smart Agriculture organic farm. For fungal abundance, Climate-Smart Agriculture organic farm has the highest while the lowest was observed from the BSU Organic Agriculture Demo-farm.

Keywords: *conventional farms, organic farms, physical properties, chemical properties and microbial biomass*

INTRODUCTION

Soil is a collection of natural bodies occupying parts of the earth's surface. It is not just a medium for plant growth but is also a crucial component to most agricultural and environmental systems. Soil performs many roles in natural and managed environments, including facilitating plant growth, regulating water supplies, recycling materials, hosting soil organisms and providing physical support to plants. In most, it is a combination of the physical, chemical and biological properties of soil that determine the soil's ability to properly function for these different roles (Coyne and Thompson, 2006).

However, as life on earth continues, soils are slowly being harmed. As human population increases, demands for food also continue to grow. In order to satisfy food requirement, people became more dependent on the use of chemical inputs to grow crops. Majority believe that by increasing the dosage of chemical fertilizers, those demands will be met. Improper use of chemical fertilizers and other chemical inputs such as pesticides are not just harmful on human health but also to the soil. These chemical inputs can even kill the beneficial parasites, predators and soil microorganisms.

It is, therefore, important to have basic knowledge

on the properties of soil and the factors that affect those properties. Some factors may enhance and improve those soil properties while others may contribute to their deterioration. One of the important factors influencing soil properties is the presence of microorganisms in the soil environment. These microorganisms are responsible in decomposing animal and plant residues which convert these into organic matter, greatly influencing soil properties.

Fungi, bacteria, algae and viruses do not only influence and contribute to the improvement of soil properties but also contribute either in the form of loss or gain in the production of crops and livestock (Stefi and Josephine, 2013). Knowing the abundance of microorganisms and their role in the decomposition of organic matter will provide information on how these factors will influence the physical and chemical properties of soil.

The study determined the physical and chemical properties of soil and assess the abundance of soil microorganisms present in conventional and organic farms in La Trinidad.

The study was conducted at Benguet State University, La Trinidad, Benguet from April to November 2013.

MATERIALS AND METHODS

Soil samples were collected from the pre-identified conventional and organic farms of Benguet State University in La Trinidad, Benguet.

The agricultural lands selected to represent conventional farming were: 1) areas of the College of Agriculture (CA)-Agronomy Department, 2) the experiment area assigned to the Horticulture Research and Training Institute (HORTI) and 3) BSU Swamp Area. These farms were heavily applied with chemical inputs. For organic farms, soil samples were collected from the: 1) BSU-Organic Agriculture Demo Farm, 2) Climate-Smart Agriculture Center (CSAC) area for the Organic Fertilizers and Microbials Project and 3) CA-Agronomy area for the Varietal Selection and Seed Production for Organic Vegetable Production Project.

The BSU Organic Agriculture Demo Farm (BSU-OA Demo Farm) has been converted as organic farm for more than 10 years and was certified as organic farm by the Organic Certification Council of the Philippines (OCCP). The area for the CSAC Organic Fertilizers and Microbials Project is on its third year of conversion to organic farm while the CA-Agronomy area for the Varietal Selection and Seed Production for Organic Vegetable Production Project is on its 7th year as organic farm.

Soil samples used for the analysis of the physical and chemical properties of soils were obtained from the following:

<u>a) Conventional Farm</u>
S1- HORTI (planted with broccoli)
S2- CA-Agronomy Conventional Farm (planted with potato)
S3- BSU Swamp Area (planted with strawberry)

<u>b) Organic Farm</u>
S4- CSAC Organic Farm 1 (planted with garden pea)
S5- CSAC Organic Farm 2 (planted with cabbage)
S6- CSAC Organic Farm 3 (planted with Chinese cabbage)
S7- CA-Agronomy Organic Farm 1 (planted with cabbage)
S8- CA-Agronomy Organic Farm 2 (planted with garden pea)
S9- CA-Agronomy Organic Farm 3 (planted with potato)
S10- BSU Organic Demo Farm Area 1 (planted with sugar beet)
S11- BSU Organic Demo Farm Area 2 (planted with lettuce)
S12- BSU Organic Demo Farm Area 3 (planted with chilli pepper)

Soil samples for the study on microbial abundance in soil were obtained from the following sites:

<u>a) Conventional Farm</u>
S1- Horticulture Research and Training Institute (planted with broccoli)
S2- CA-Agronomy Conventional Farm (planted with potato)
S3- BSU Swamp Area (planted with strawberry)

b) Organic Farm

S4- CSAC Organic Farm 1 (planted with garden pea)
S5- CA-Agronomy Organic Farm 1 (planted with cabbage)
S6- BSU Organic Demo Farm Area 1 (planted with sugar beet)

Preparation of culture media

Nutrient agar and potato dextrose agar were used as culture media for soil microorganisms.

Sterilization process

For the determination of microbial population, culture media, water blanks and glasswares were sterilized using an autoclave.

Dilution of soil samples

The samples were processed using soil dilution plate method.

Isolation of soil bacteria and fungi

The pour plate and spread plate methods were used in isolating bacteria and fungi, respectively.

The data gathered were:

A. Physical Properties of Soil

1. Bulk Density. The core method in determining the bulk density of the soil.
2. Aggregate stability of soil. The wet sieving technique was used in determining the aggregate stability of the soil.
3. Water holding capacity of the soil. The fresh weight and oven-dried weight of the soil were determined as basis for computing the water holding capacity.

B. Chemical Properties of Soil

1. Soil pH. The pH of the soil before planting and after harvest was measured using the pH meter in a 1:1 m/v soil and water solution.
2. Cation exchange capacity of the soil (m.e./100g). The Ammonium Acetate Method was used in determining the cation exchange capacity of the soil.
3. Organic matter content of the soil (%). This was determined using the Wakley Black Method.
4. Available phosphorous content of the soil (ppm). This was determined using the Bray No. 2 method.
5. Exchangeable potassium content of the soil (ppm). This was determined using the Flame Photometer method.

C. Abundance of soil microorganisms

The colony forming unit (cfu) per ml was used to determine the abundance of bacteria in the soil while fungal abundance was determined by counting each colony which has grown in each plate five days after plating.

The treatment were laid out following the Completely Randomized Design (CRD) with three replications. The physical and chemical properties of the soil were subjected to One-way ANOVA while the data gathered for microbial biomass were subjected to Two-way ANOVA. The Duncan's Multiple Range Test (DMRT) was used to test the level of significance between means.

RESULTS AND DISCUSSION

Physical Properties of Soils in Conventional and Organic Farms

Bulk density of the soil. Table 1 shows that the bulk density of soils collected from organic farms are significantly different from those in conventional farms. Based from the result, higher bulk density of soil was observed from those collected in conventional farms. The average bulk density is 1.45 g cm^{-3} which is much higher than the bulk density of organic farms indicating that soils in conventional farms are compacted.

Soils from the BSU-Organic Demo Farm, on the other hand, had the lowest bulk density values with an average of 1.08 g cm^{-3} as compared with the other two organic farms. The BSU-Organic Demo Farm with a bulk density of 1.15 g cm^{-3} has been devoted to organic farming for more than 10 years. The CA-Agronomy Organic Farm was on its 7th year as organic farm while the CSAC-Organic Farm with an average bulk density of 1.17 g cm^{-3} was on its 3rd year of conversion to organic farm.

The result indicates that the longer the time by which organic farming is practiced, the higher will be the probability that lower bulk density of the soil will be attained.

Bulk density is an indicator of soil compaction. It reflects the soil's ability to function for structural support, water and solute movement and soil aeration. Bulk densities above thresholds indicate impaired function. The ideal densities for plant growth are <1.60,<1.40 and <1.10g/cc for sandy, silty and clayey soils, respectively. Above these values are considered restrictive for root growth and poor movement of air and water through the soil (soilwater.com).

Aggregate stability. Aggregate stability of soil was determined based on their mean weight diameter. The soil is said to be very stable if the mean weight diameter is 3.5 and above. If the mean weight diameter is less than 3.5, the soil is prone to dispersion.

As presented in Table 1, the aggregate stability of soils from organic farms is significantly higher than those from conventional farms. The Table shows that the aggregate stability of soils among the three organic farms differed significantly from each other. More stable soil aggregates were observed from the BSU-Organic Demo Farms with an average aggregate stability of 4.63. The conventional farms has an average aggregate stability of 2.44, which is much lower than the stable aggregate stability of 3.5 or higher.

Organic matter and biological processes greatly affect soil aggregation (Brady and Weil, 2002). In this study, soil samples with higher organic matter content and microbial counts have better soil aggregation than soil samples with lower organic matter and microbial counts.

Water holding capacity. The water holding capacity of soils collected from conventional and organic farms differed from each other, with the water holding capacities of soils generally much higher in organic farms than conventional farms (Table 1). The result also shows that significant differences were observed among soils in organic farms. The BSU-Organic Demo Farms had significantly higher water holding capacity of 102.37%, followed by the CA-Agro Organic Farms (93.86%) and CSAC Organic Farms (91.52%). The conventional farms has the lowest average water holding capacity of 82.83%.

One of the main functions of soil is to store and supply moisture to plants between rainfalls or irrigations. Evaporation from the soil surface, transpiration by plants and deep percolation combine to reduce soil moisture status between water applications. If the water content becomes too low, plants become stressed. The plant available moisture storage capacity of a soil provides a buffer which determines a plant's capacity to withstand dry spells (soilwater.com). On the other hand, organic matter affects the physical properties of the soil and its overall health. Physical properties influenced by organic matter include soil structure and water holding capacity (FAO, 2005).

Chemical Properties of Soils in Conventional and Organic Farms

Soil pH. Table 2 shows the pH of the different soil samples collected from conventional and organic farms. BSU Organic Demo Farms had the highest soil pH with an average value of 6.80, followed by the conventional farms (6.10). The lowest pH was observed from CSAC Organic Farms and CA-Agronomy Organic Farms which both have an average pH of 5.63. It was noted, however, that soil pH from both conventional and organic farms are within the preferred soil pH ranges of most crops.

According to Brady (1990), several types of soil reactions are distinguished based on soil pH values. Brady and Weil (2000) stated that organic matter buffers soil pH by the release of basic cation from organic complexes from which they are held with varying degrees and strength. Meanwhile, Lagman (2003) reported that pH will be significantly improved when compost is applied in soils.

Cation exchange capacity. Table 2 shows the cation exchange capacity (CEC) of soil samples collected from conventional and organic farms.

Table 1. Physical properties of soils collected from conventional and organic farms in La Trinidad, Benguet

Sampling Area	Physical Properties		
	Bulk density	Aggregate stability	Water holding capacity
	Conventional Farms		
S1– HORTI	1.48b	2.31h	74.30g
S2 - CA-Agro Conventional Farm	1.52a	2.35h	68.87h
S3 - BSU Swamp Area	1.34c	2.65g	105.32b
Average	1.45	2.44	82.83
	Organic Farms		
S4 - CSAC Organic Farm 1	1.17de	4.17c	97.13cd
S5 - CSAC Organic Farm 2	1.17d	3.38e	87.37f
S6 - CSAC Organic Farm 3	1.17de	4.17c	92.75de
Average	1.17	3.91	91.52
S7 - CA-Agro Organic Farm 1	1.14f	4.61b	97.13cd
S8 - CA-Agro Organic Farm 2	1.15ef	3.16f	94.67cde
S9 - CA-Agro Organic Farm 3	1.15ef	3.56d	89.79ef
Average	1.15	3.78	93.86
S10 - BSU OA Demo Farm 1	1.09h	4.66b	99.26c
S11 - BSU OA Demo Farm 2	1.12g	4.60b	97.24cd
S12 - BSU OA Demo Farm 3	1.03i	5.64a	110.62a
Average	1.08	4.63	102.37
CV (%)	0.8	1.7	3.1

Within a column, means with the same letter are not significantly different by 5% DMRT

The result shows that significant differences were observed among the sampling sites. Soil samples from the three organic farms had significantly higher CEC than those from the conventional farms. Likewise, significantly higher CEC values were obtained from the BSU-Organic Demo Farm as compared from CSAC and CA-Agronomy Organic Farms. This can be attributed to the high organic matter content of BSU-Organic Demo Farm that has been practicing organic farming for the last ten years as compared with CSAC and CA-Agronomy Organic Farms with only three and five years respectively as organic farms.

Cation exchange capacity represents the ability of the soil to hold cations in exchangeable forms and the factors that affect this soil property are soil texture, soil pH and organic matter.

The CEC values gathered for each of the soil samples can be explained by the pH values and organic matter content. According to Wolf (1999), cation exchange capacity is greatly influenced by soil organic matter. Based on the data gathered, the result shows that as the organic matter increases, cation exchange capacity also increases. Brady and Weil (1996) also pointed out that CEC of most soils increases with pH.

Organic matter content**.** The amount of organic matter of soils from the conventional and organic farms differed significantly from each other (Table 2). Soils from the three organic farms had significantly higher organic matter contents to those from the conventional farms.

The high OM content can be attributed to the number of years of operation as organic farm in which frequent compost application is practiced. The BSU Organic Demo-farm with its 10 years as organic farm had the highest organic matter content followed by the CA-Agronomy Organic Farm which is five years as organic farm while the CSAC-Organic Farm, which is on its 3rd year or

Table 2. Chemical properties of soils collected from conventional and organic farms in La Trinidad, Benguet

Sampling Area	Chemical Properties				
	Soil pH	CEC	OM content	P content	K content
	Conventional Farms				
S1 - HORTI	5.63f	24.40i	1.88f	16.58j	128.0cd
S2 - CA-Agro Conventional Farm	5.97d	21.90k	1.45g	14.92k	105.3f
S3 - BSU Swamp Area	6.69b	33.82d	2.29e	25.18i	155.0a
Average	6.10	26.71	1.87	18.89	129.43
	Organic Farms				
S4 - CSAC Organic Farm 1	5.62f	26.37g	3.57d	30.19e	105.7f
S5 - CSAC Organic Farm 2	5.65f	27.11f	3.38d	29.27g	131.7c
S6 - CSAC Organic Farm 3	5.62f	26.22g	3.58d	30.17e	103.0f
Average	5.63	26.57	3.51	29.88	113.47
S7 - CA-Agro Organic Farm 1	5.93g	25.64h	4.15c	33.22c	95.3g
S8 - CA-Agro Organic Farm 2	5.10h	22.93j	4.09c	32.16d	75.3h
S9 - CA-Agro Organic Farm 3	5.88e	30.50e	4.08c	29.46f	124.3d
Average	5.63	36.36	4.11	31.61	98.30
S10 - BSU OA Demo Farm 1	6.68b	58.21b	4.73b	35.84a	149.0b
S11 - BSU OA Demo Farm 2	6.48c	56.38c	4.27c	34.68b	117.3e
S12 - BSU OA Demo Farm 3	7.23a	68.09a	5.29a	28.72h	155.0a
Average	6.80	60.89	4.76	33.08	140.43
CV	0.6	0.4	4.6	0.1	2.7

Within a column, means with the same letter are not significantly different by 5% DMRT

conversion to organic farm, had lower OM content.

Phosphorus content of the soil**.** As shown in Table 2, the phosphorus content of soils is significantly higher in the three organic farms when compared with the soils from the conventional farms. Based from the result, BSU-Organic Demo Farm had the highest phosphorus content, although one sampling site (S12) had significantly lower P content than those from the CSAC and CA-Agronomy Organic Farms.

Phosphorus availability is greatly influenced by soil pH. In mineral soils, phosphate fixation is lowest and plant availability is highest when soil pH is maintained at the 6.0-7.0 range (Brady and Weil, 1996). Table 2 also shows that S2 (Conventional farm) has the lowest value for phosphorus content. The low value of P from this soil can be due to the acidic property of the soil.

Potassium content of the soil. Table 2 shows great variations of potassium contents of the different sampling sites in conventional and organic farms. S3 representing conventional farm and S12 of organic farm had the highest potassium contents which are significantly different from the other sampling sites. The lowest potassium contents were observed in two sampling sites from the CA-Agronomy Organic Farm followed by one sampling site from Conventional Farm.

According to Brady and Weil (1996), the availability of potassium is markedly influenced by soil texture, soil pH and rainfall. They mentioned that higher potassium contents are generally observed in clayey soil and higher soil pH values. On the other hand, potassium is much readily lost by leaching in areas with heavy rainfall.

Microbial Count of Soils from Conventional and Organic Farms

Bacterial Abundance of Soils from Conventional and Organic Farms. Table 3 shows the abundance of bacteria in conventional and organic farms. S5 (CA-Agronomy Organic Farm) had the highest bacterial count for 10-4, 10-5, 10-6 and 10-7 dilution and the lowest was observed from S1 (HORTI Conventional Farm) in dilution 10-4, 10-5 and 10-7. S2 also from Conventional Farm has the least number of bacteria for dilution 10-6.

The Table further shows that soil samples gathered from organic farms (S4, S5 and S6) have higher counts for bacterial abundance than soil samples gathered from conventional farms (S1, S2 and S3).

The farm which shows to have the highest number of bacterial abundance was observed from CA-Agronomy Organic Farm and the least number of bacterial abundance was observed from the HORTI conventional farm.

Schjonning *et al.*, (2004) reported that organic matter supports life processes from a wide range of species of microbes and fauna. The decomposition of organic matter yields NH_4^+, NO_3^-, PO_3^-, SO_4, micronutrients and CO_2 which provides metabolic energy for soil microorganism and fauna. It helps in the chelation of metals, buffer in slightly acid and alkaline soils and cements soil particles into aggregates and contributes to water retention.

Fungal Abundance of Soil from Conventional and Organic Farms

Among the organic farms sampled, S4 (CSAC-Organic Farm) had the highest count of soil fungi for all the dilutions among all the other soil samples (Table 4). The lowest counts for soil fungi were observed in one organic farm (S6 - BSU OA Demo Farm) and in the three conventional farms. Based on interview with the farm operator, the organic fertilizers that were applied in S4 were formulated using *Trichoderma* as decomposition enhancer, hence, the high population of fungi in the soil. The same organic fertilizers were applied in the CA-Agronomy organic farm.

Trichoderma is a fungus found to be an efficient decomposer because it enhances the composting process. It is isolated from soil, decaying organic wood and other forms of plant organic material (Barak and Chet, 1986; Chet, 1987; Harman and Bjorkman, 1987; and Howell, 2003). The fungus is free-living and is highly interactive in roots, soil, and foliar environments. For many years, *Trichoderma* is known for producing a wide range of antibiotic substances and parasitize other fungi. The fungus has been acclaimed to be effective, eco-friendly and cheap, nullifying the undesirable effects of agricultural chemicals particularly organochlorines, organophosphates and carbamates (Chaudari *et al.*, 2011).

CONCLUSIONS AND RECOMMENDATIONS

The physical properties of soils in organic farms such as bulk density, aggregate stability and water holding capacity have values ideal for plant and root growth and ease of movement of air and water through the soil.

Among the three organic farms, the BSU Organic Agriculture Demo-Farm, which has been used as organic farm for more than 10 years has the lowest bulk density values and highest values for aggregate stability and water holding capacity. On the other hand, compacted soils, poor aggregate stability and lower water holding capacity are common in conventional farms.

Table 3. Bacterial abundance of soils in conventional and organic farms in La Trinidad, Benguet

Sampling Area cfu/ml	Bacterial Abundance (after 48 hours)			
	10_4	10_5	10_6	10_7
		Conventional Farm		
S1 – HORTI	20	17	28	15
S2 - CA-Agro Convl Farm	357	113	9	18
S3 - BSU, Swamp Area	107	70	37	20
		Organic Farm		
S4 - CSAC Organic Farm	193	210	24	24
S5 - CA-Agro Organic Farm	443	677	75	61
S6 - BSU OA Demo Farm	367	203	31	30

Table 4. Fungal abundance of soils in conventional and organic farms in La Trinidad, Benguet

Sampling Area cfu/ml	Fungal Abundance (after 48 hours)			
	10_4	10_5	10_6	10_7
		Conventional Farm		
S1 – HORTI	17.0	10.7	20.0	6.0
S2 - CA-Agro Convl Farm	8.3	10.7	12.3	14.0
S3 - BSU, Swamp Area	10.0	6.7	14.7	8.0
		Organic Farm		
S4 - CSAC Organic Farm	16.3	48.3	32.0	16.7
S5 - CA-Agro Organic Farm	25.0	28.7	12.0	10.7
S6 - BSU OA Demo-Farm	6.7	5.3	21.0	8.7

Likewise, the chemical properties of soils such as soil pH, cation exchange capacity, organic matter content, available phosphorus contents and exchangeable potassium contents in the three organic farms are adequate for plant growthand development. Higher values can be obtained from organic farms with more than 10 years of conversion as in the case of the BSU Organic Agriculture Demo-farm. The conventional farms have comparable values for soil pH and exchangeable potassium.

However, the cation exchange capacity, organic matter and available phosphorus contents are much lower as compared with the three organic farms.

The three organic farms have greater number of soil bacteria and soil fungi than in conventional farms. The CA Organic Farms had the highest bacterial counts while the CSAC Organic Farms had the highest fungal abundance.

To prevent soil degradation in conventional farms and to maintain soil productivity in organic farms, the application of good quality organic and microbial fertilizers are recommended to improve the physical, chemical and biological properties of soil.

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