Impact of organic and conventional practices on, soil health and crop yield under tropical and subtropical environment of Bangladesh

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Abstract— *This study was carried out to evaluate the improvement of soil fertility and crop yield using formulated organic fertilizers in a Randomized Complete Block Design (RCBD) from October 2008 to April 2015 and the test crop was tomato, eggplant, cabbage and cauliflower. The physicochemical properties, behavior and persistence of plant beneficial microorganisms including nitrogen fixing bacteria, (e.g. Rhizobium sp., Azotobacter sp.), phosphate solubilizing bacteria e.g. (Bacillus sp. Pseudomonas sp., Phosphobacteria), Aspergillus sp. and Trichoderma sp., in the amended/ non-amended block were evaluated each year. The soil beneficial microbial populations and health properties including pH, nitrogen content, organic matter, phosphorus, K, Ca, and S, increased significantly in the compost-amended soils compared to the conventional practices. The total nitrogen (N) content and the organic matter of compost amended soil were 215% and 200% higher respectively than that of conventional practices (CP). Furthermore, significant increase of available organic matter, N, P, & K was observed in the compost-amended soils compared to conventional and control block. Furthermore, microbial population showed significant linear correlations with the organic matter contents of the soils and yearly vegetables yield increased gradually and was reached to almost identical to conventional field within 5 years, implying that the soil amended with BIOFER compost increased the soil fertility, and vegetables yields. Thus, application of BAOFER compost at the rate of 15 t/ha/year was found adequate in improving the vegetable yields and soil health in open field cultivation under subtropical climatic conditions.*

Keywords— Organic; conventional; production practices; soil microorganisms; soil health; crop yield and tropical environment.

I. INTRODUCTION

In the last four decades Organic Farming (OF) has increased substantially around the world including small holding countries of Asia and Africa (Willer and Lernoud 2015.). The aim of of is to produce safe food in sufficient quantity while being environmental friendly and attain sustainability. Being a tropical and subtropical country like Bangladesh, the major challenges for OF are yield of crops, optimization of the nutrients cycling of the agro-ecosystem and development of more suitable alternative soil fertility strategies. Soil organic matter (SOM) is a key indicator of fertility; affects crop growth and yield, either directly by supplying nutrients or indirectly by modifying the soil physical properties, thereby improving the root environment and, thus, stimulating plant growth(Chang, et al 2007). Pimental, et al. 2005 indicated that the highest total aerial dry matter and grain yields were associated with the highest organic matter contents of the soils. In addition, crop production based on the use of organic manures rather than chemical fertilizers is assumed to be a more sustainable type of agriculture. In recent years, the application of organic fertilizer has received great attention from environmentalists, agriculturists and consumers alike (Chang, et al., 2007). Gabriel et al., 2010 found that depending on crops, soil and weather conditions, organically managed crops yields on a per ha basis was equal to those from conventional agriculture. Organic farming has become very popular and is steadily increasing the area of production around the globe and possesses the highest in Asia. For growing vegetable crops organically, it is required an adequate and continuous supply of essential nutrients for proper growth and maximal high quality yields. But, low yields associate to starvation of plants from slow releasing organic fertlizers, difficulties in weed control, and cumbersome pest management methods are the main concern against organic agriculture. Ponisio *et al* 2014 to their meta analysis showed that organic yields are only 19.2% (+3.7%) lower than conventional yields, a smaller yield gap than previous estimates and effects of crop types and management practices on the yield gap, two agricultural diversification practices, multi-cropping and crop rotations, substantially reduce the yield gap (to 9+4% and 8+5%, respectively) when the methods were applied in only organic systems. The nutrients released after the biological breakdown of the soil organic matters supply the nutrients essential for plant growth in organic farming. However, in general, the mineralization rates of soil organic matter is slow both in humid tropical and humid arid region (Fernández et al., 2006 and Mary and Sanchez. 1990.). Therefore, to establish and maintain soil organic matter content to a certain level through the continuous application of compost can be effective strategies in organic farming. However, climate and soil significantly affect the accumulation and storage of organic matter in the soil because of the interactions of temperature and moisture on plant productivity and the ability of the soil mineral components to retain organic matter. Under tropical and subtropical climatic conditions, due to high cultivation frequency, and a low input of the organic matter content in the farmland soil generally it is common for the soil organic matter content to be lower than 20 g kg $^{-1}$ (Huang SN 1994).

The biological component of soils usually responds more rapidly to changing soil conditions than either the chemical or physical properties (Forge et al., 2008 and Kukreja R and Meredith S 2011). Soil enzymatic activities have been used as indicators of soil fertility because they are a reflection of the effects of cultivation, soil properties and soil amendments (Pokharel et al., 2015). Thus this study was designed with formulated organic compost rich in biologically active compound with locally available natural elements including cow dung, compost, was applied in agricultural land to estimate the land fertility and crop yield. During the study period routine analysis of available chemical nutrient in the field was performed to determine the nutritional condition of fields.

II. MATERIAL AND METHODS

2.1 Study Area

The study area is at the Olericulture Division, Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during 2008-2015. The study area was altitude 3.66m, 23^{0} 59' 23" N and 90^{0} 24 ' 42" E (Figure 1) , and experiences a typical tropical and sub-tropical continental monsoon climate and sub humid climate (Huq and Shoaib, 2013) The mean annual air temperature is 31.9^{0}C. The mean annual precipitation is 451.8 mm, with approximately 72.9% occurring from June to October. The soils in this area are classified as Grey Terrace according to the USDA Soil Taxonomy (USDA. 1975) but the top soil land of the experimental field incorporated new alluvial soil during establishment of the farm.

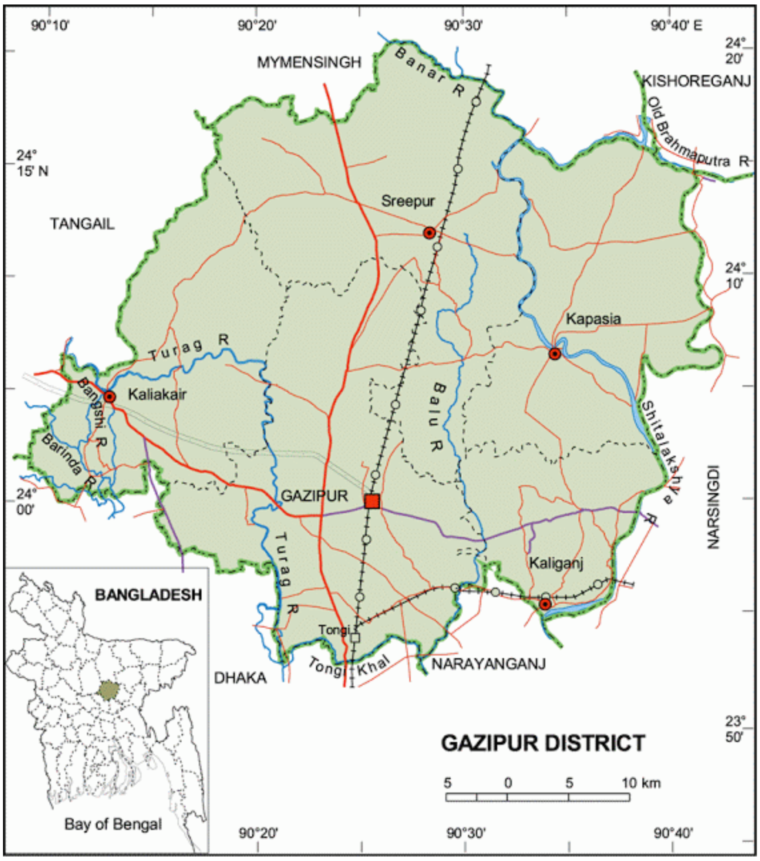

FIG: 1: LOCATION MAP OF THE EXPERIMENT

2.2 Experimental design

The organic conversion has been initiated in the October of 2008 separated into 3 (three) blocks namely; Organic block (soil amended with matured compost 15 t/ha every year, and biologically active organic fertilizer – BAOFER was applied as basal application), Control block (No organic and chemical amendment have been done in the study period, but weed management, crop growing methods were followed) and Conventional block (The block has been fertilized as per fertilizer recommendation guide- 2005 by Bangladesh Agricultural Research Council, Dhaka). The application procedure of fertilizer in each blocks are described in **Box 1**. In this study, split plot design was followed, where blocks were in main plot and crops in the subplot. Four crops (Eggplant, Tomato, Cabbage and Cauliflower) were grown (4 replication) consecutively for 7 years (2008-2015). The unit plot size was 4.0 m x 4.0 m. The tomato, eggplant, cabbage and cauliflower seedlings were raised separately under organic practices and were planted maintaining 50cm x 50cm, 80cm x 80 cm, 60 cm x 50 cm, 50 cm x 50 cm respectively in the main plots. The crop grown history was summarized in Box-2.

BOX-1
TREATMENT OF THE EXPERIMENTS

Description of the treatment	Application of soil amending substances
Soil amended with matured compost 15 t/ha every year (Organic Block),	The compost was applied in two times 50:50 (September starting of Rabi season and Kharif I). During land preparations of designated the season half of the compost i.e . 3.75 t /ha were spread in the field and other half was applied in the pits and, or furrow of the crops during growing season with BAOFER @ 150g/pit of tomato, brinjal, cabbage, cauliflower
No organic and chemical fertilizers were applied for improving the soil (Control Block)	Natural vegetation were incorporated during land preparation
For the Control Block , conventional practices including excess chemical fertilizer were applied every year (Conventional)	**Tomato and Brinjal:** The crop was fertilized with cow dung 10 ton, urea 550kg, TSP 450kg and MP 250kg per ha, respectively. Half of the quantity of cow dung, entire TSP and half of the MP were applied during land preparation. The remaining half of the cow dung was applied during pit preparation. The rest of MP and entire urea were applied at three equal installments at 15, 30 and 45 days after transplanting. **Cabbage and Cauliflower:** The land was fertilized with Cowdung- Urea-TSP-MP –Boron - Molybdenum @ 10t-240-150-220-2-1 kg/ha respectively.

BOX 2
CROP GROWN HISTORY 2008-15

Year	Rabi	Kharif I	Kharif II
2008-09	Vegetables	Vegetables	Green manure
2009-10	Vegetables	Vegetables	Green manure
2010-11	Vegetables	Vegetables	Rice
2011-12	Vegetables	Vegetables	Rice
2012-13	Vegetables	Vegetables	Rice
2013-14	Vegetables	Vegetables	Green manure
2014-15	Vegetables	Vegetables	-

Rabi= Mid October – Mid March, Kharif I= Mid-March – Mid June, Kharif= Mid June – Mid October

2.3 Plant materials

The vegetables crops tomato (var. BARI Tomato 15), eggplant (var. BARI Begun 5), Cabbage (var. Atlas 70) and, Cauliflower (var. BARI Fulkopi 1) were used in this study. Seedling were raised in the plastic pot in the organic media (50 % soil + 48% Compost + 2% BAOFER) and seedling were transplant in the main plots at age of 28-32 days. Each year, crops yield components were measured and crop yields were calculated. Moreover, products quality parameters were assessed in accordance to local market standards.

2.4 Preparation of BAOFER

Biologically active organic fertilizer (BAOFER) is an organic fertilizer constituted of rice bran, mustard oil cake, fish debris, poultry refuge, ash, water, agricultural soil and half composted cow dung. All the ingredients were mixed together at the rate of 200kg, 100kg, 50kg, 300kg, 25kg 10kg and 15kg respectively. Fifty percent water is being applied in the heap and mixed thoroughly. The heap was covered with bamboo mat and allowed for aerobic composting. After completing the mesophilic and thermophilic stage, the compost has been matured. To accelerate the composting and protection from nutrient combustion, the heap was broken down to remove the heat during the composting. A thermometer was inserted in the heap to record the temperature. Maturity of the compost was tested using panelist and nutrition status was evaluated. The physicochemical properties of BIOFER were given in Table 1.

TABLE 1
BIOFER PHYSICOCHEMICAL CHARACTERISTICS

1. Colour = Dark Grey
2. Physical conditions = Non-granular form
3. Odour = Absence of foul odour
4. Moisture = 16.1 %
5. pH = 8.0
6. Organic Carbon = 19.8%
7. Total Nitrogen(N) =2.27%
8. C:N =9.2:1
9. **Phosphorous(P) =3.67%**
10. **Potassium(K) =1.93%**
11. **Sulphur(S) =0.40%**
12. Zinc(Zn) =0.05%
13. Copper(Cu) =0.002%
14. **Chromium(Cr) =0.00ppm**
15. **Cadmium(Cd) =0.00ppm**
16. **Lead(Pb) =0.00ppm**
17. **Nickel(Ni) =0.00ppm**
18. Inert material 0.1%

2.5 Soil sampling for chemical analysis

Soil samples were collected from the plots every year in the month of October after land preparation for the winter from 15cm and 30 cm depth from each plot with a stainless steel soil probe. The soil cores from the same plot were placed in a clean plastic bucket and mixed thoroughly to form a composite sample. Composite samples were transferred immediately into sterilized polyethylene bags and kept in cold storage boxes for about 4 h until delivered to the laboratory. Once in the laboratory, all visible roots and plant fragments were removed manually from the soil samples. The field-moist soil samples were sieved to pass through an 8-mm sieve by gently breaking soil clods along natural breaking points. The soil was air-dried and stored at room temperature for fractionation of soil aggregate.

2.6 Analysis of chemical properties of soil and BAOFER

Chemical properties of the sampled soil have been analyzed every year at the analytical laboratory of Soil Resources and Development Institute (SRDI), Dhaka. The chemical analyses were done on a dry matter basis and the methods are given in the table 2.

TABLE 2
THE METHODS OF CHEMICAL ANALYSIS

Name of elements	Methods of analysis	References
N (%)	Kjeldahl Method	Bremner and Mulvaney,1982
Organic –C (%)	Wet oxidation method	Bremner and Mulvaney,1982
P (µg/g)	Modified Olsen method (Acid soils)	Olsen and Sommers. 1982
S (µg/g)	Calcium dihydrogen Phosphate extraction	Fox, et al. 1964
K (µ eq. /100g)	N-NH_4O Ac Extraction	Peterson, 2002
Ca (µ eq. /100g)	N-NH_4O Ac Extraction	Lindsay, and Norvell., 1978
Mg (µ eq. /100g)	N-NH_4O Ac Extraction	Lindsay, and Norvell., 1978
B (µg/g)	Calcium Chloride extraction	Jackson, 1973.

2.7 Soil sampling for microbial study

Field-moist soil samples were collected from root zone of the different crops passed through a 2-mm sieve and stored in plastic bags at 4^0C for analysis of microbial biomass. All the samples were transported to the laboratory in coolbox and kept at 4^0C until use.

2.8 Microbiological Analysis

The microbial populations including quality parameter (total aerobic bacteria, coliform bacteria, indicator *Escherichia coli*,), other common pathogens (*Klebsiella* sp., *Salmonella* sp., and *Shigella* sp,) and soil beneficial microorganisms including *Pseudomonas sp, Bacillus* sp. *Rhizobium* sp. *Azotobacter* sp. Phosphobacteria and Phosphate Solubilizing Fungi, Total Fungal population and *Trichoderma* sp. were determined using standard microbiological plate count methods followed by biochemical and API immunoassay techniques and the methods of detection was presented in table 3.

TABLE 3
MICROBIAL ANALYSIS OF ORGANIC, CONTROL AND CONVENTIONAL FIELD SOIL SAMPLES.

Microorganisms of interest	Isolation and identification method
Total Aerobic bacteria Coliform bacteria *Escherichia coli* *Citrobacter spp* *Aeromonas spp.*	Surface plated method followed by biochemical test (Gowsalya, et al., 2014)
Bacillus spp., *Pseudomonas* spp., *Azotobacter* spp., *Rhizobium* spp., *Klebsiella* spp	Surface plated method followed by API immunoassay analysis (Ashish et al., 2011, Aysel Uğur et al., 2012, Ridvan 2009 and Jakaria Al-Mujahidy et al., 2013)
Phosphate solubilizing fungi Phosphobacteria	Surface plated method on selective agar (Emilce et al., 2011)[25]
Total Fungal count *Trichoderma* spp. Nitrogen fixing fungi	Surface plated method followed by Microscopy (Rohilla and Salar 2012)
Salmonella spp., Shigella spp.,	Surface plated methods on selective agar (Romain et al., 2013.)

2.9 Statistical analysis

Pooled analysis of variance (ANOVA) was used to test the effects of different treatments, production year and crops yield. Least significance difference (LSD) and Tukey's honestly significant difference test (Tukey's HSD) was used to compare the difference at P 0.05 level. Data analysis was done using Statistical Tool for Agricultural Research program (STAR 2.0.1).

III. RESULTS

The physicochemical characteristics of BAOFER (organic fertilizer) were given in **Table 2**. The average maximum temperature and rainfall variations among the seasons were recorded. The maximum and minimum temperature was recorded as 29.2^0C, in 2008 and 34.2^0C in 2013 respectively. The average lowest rainfall was recorded in Rabi cropping season was

6.0 mm in 2012 (Bangladesh Weather forecast database). In Bangladesh, Rabi season (is characterized by dry, sunny and warm weather at the beginning and at the end, but cool in December-February. The average length of the Rabi growing period ranges from 120 -135 days and Rabi crops were used as residual moisture absorber for soil) is considered as the best season for vegetable production.

Comparison of organic, control, and conventionally grown vegetables production yield (t/ha) from 2008-2015was presented in Table **4**. It was observed that organically grown vegetables showed consistent increased of production per hectare and the initial yearly production of tomato in organic block was 55.45 t/ha in 2008, and increased to 65.91 t/ha in 2015, which is approximately 10.5 tons higher than the initial production year. Similarly, an increase of 6.2 t/ha for eggplant, 5.9 t/ha for cabbage and 9.0 t/ha for cauliflower production was observed within 7 years (Table 4). On the other hand, control field also gradually increased crop production pattern compared to conventional field but the yield was very poor. The conventional fertilizer treated plots showed minimum increase in the production yield throughout the 5 years of study. This results suggested that the inorganic fertilizers can initiate a bulk crop production instantly but unable to increase the yield rate significantly despite the continued application of these fertilizers in the field. This could be a symptomatic view of soil nutrient instability due to the unprofessional conduct of chemical fertilizers on irrigated lands resulting in the loss of soil fertility suggested by previous researches (Katsunori, 2003). Curative measures are mandatory for agricultural lands as there are many human induced reasons for soil nutrition depletion. Thus adequate and balanced fertilization could be the potential step to shape up the soil health (Turrión et al., 2010). This was evidenced while evaluating the poor production of control block of this study for both types of crops (**Table 4**).

TABLE: 4
PRODUCTION YIELDS OF TOMATO, EGGPLANT, CAULIFLOWER AND CABBAGE UNDER ORGANIC, CONTROL AND CONVENTIONAL PRACTICES

Year	Production Practices	Tomato Yield (t/ha)	Eggplant Yield (t/ha)	Cauliflower Yield (t/ha)	Cabbage Yield (t/ha)
2008-09	Organic Block	55.45	21.02	48.19	67.37
	Control	10.06	4.24	10.37	15.15
	Conventional	68.57	32.95	63.91	78.04
2009-10	Organic Block	57.33	22.20	42.30	68.47
	Control	10.49	3.85	9.37	14.45
	Conventional	69.26	36.80	60.88	77.24
2010-11	Organic Block	55.85	21.11	43.43	69.06
	Control	9.97	4.21	11.17	14.40
	Conventional	71.83	34.04	64.65	79.67
2011-12	Organic Block	51.60	23.09	49.32	68.91
	Control	12.53	4.83	11.36	16.45
	Conventional	68.67	35.91	65.20	79.83
2012-13	Organic Block	61.97	25.54	53.23	67.63
	Control	11.78	5.74	13.20	17.40
	Conventional	66.23	35.15	63.71	78.30
2013-14	Organic Block	64.82	26.54	53.20	69.50
	Control	12.14	6.41	12.38	17.72
	Conventional	71.34	34.43	63.95	79.00
2014-15	Organic Block	65.91	27.23	57.27	73.26
	Control	13.52	5.82	15.25	19.44
	Conventional	70.94	36.90	65.87	80.03
Significance		*	*	*	*
Year		*	*	*	*
Production practices		*	*	*	*
Pooled (Year: production Practices)		ns	ns	ns	ns

[a]*ns= Non-significant * Significant at p<0.05, ** Significant at p<0.01*

3.1 Physiochemical parameter

The Physiochemical study including pH, Organic Matter OM(%), Total Available Nitrogen (%), Potassium (K), Calcium (Ca), Magnesium (Mg), Phosphorus(P), Sulpher(S) and Boron(Bo) were analyzed each year to evaluate the soil condition of different experimental blocks from 15 and 30 cm depth were shown in **Table 5**.

3.1.1 pH

The soil pH of different experimental organic block, control and conventional experimental field was found neutral. In organic block, the pH was recorded as 7.0 in 2008 and 7.2 in 2013. Similar experimental results were found in other experimental blocks. However, in conventional field weak acidic pH (6.5) was observed from 2008 to 2012 and the pH changes to 7.5 in 2013. It was seen from the Table 6 & 7 that the organic matter in conventional field increased gradually from 1.47% in 2008 to 2.56 % in 2012. The more the organic matter in conventional field, the greater the pH and this changes might be due to the organic matter that causes pH increase either by mineralization of organic anions to CO_2 and water (thereby removing H+) or because of the 'alkaline' nature of the organic material. There are non-significant differences (<0.001) in the pH were observed in other experimental blocks. The temporary nature of the pH changes illustrates the difficulties of monitoring pH changes in the field. It also indicates that long-term changes in pH as well as short-term variations are there that do not necessarily reflect the overall long-term changes but may have an effect on plant growth.

3.1.2 Organic matter

In this study, organic matters in organic block increased gradually with time and in 2013 organic matter were recorded as 3.05 % and hence, increase the productivity of the field. The tomato grown in organic experimental field in 2008 was recorded as 55.45 t/ha and increased to 65.91 t/ha in 2013. On the other hand, conventionally grown tomato showed inconsistent production yield/year and the production was increased from 68.57 t/ha in 2008 to 70.94 t/ha in 2013. In addition, significant differences (<0.05) between control, conventional and organic production was observed in every year. **(Table 5)**

3.1.3 Nitrogen (N), Phosphorus (P) & Potassium (K)

The total available nitrogen content increased consistently with time and reach to maximum of 0.17% in 2013 at the organic block. The adequate concentrations of N are 1.5% and the ranges of N in plants are 0.06-6.0%. On the other hand conventional field showed 0.13% of total available nitrogen content (Table 5). In control field, total available nitrogen did not increase much compare to conventional and organic field.

The phosphorus content in different experimental organic blocks increased gradually with time and reach to maximum of 84.87 μg/g in 2013 at the organic block. The adequate concentrations of phosphorus required in plants are ranges from 0.15%-0.5% on dry weight basis.

The initial potassium content in 2008 was recorded as 0.291 μ eq. /100g and increased to 0.421 μ eq. /100g in 2010 and decreased in 2011, and was found stable 0.351 μ eq. /100g in 2012 and 2013 in organic block . On the other hand, the potassium content in conventional field soil was recorded as 0.331 μ eq. /100g in 2008 and increased to 0.582 μ eq. /100g in 2010 and decreased trend was observed throughout the study period. The adequate concentrations of potassium (K) required in plants are ranges from 0.80% -8% on dry weight basis.

3.1.4 Calcium (Ca) & Magnesium (Mg)

The calcium content in the soil was recorded as 21.94 μ eq. /100g in 2013 in organic soil. On the other hand, lower calcium was recorded in the conventional soil throughout the study period (Table 5). The adequate concentrations of calcium required in plants are 0.10%-6% (dry weight basis).

The initial magnesium content in organic soil was recorded as 4.02 μ eq. /100g in 2008-2009 and gradually increased to 9.8 μ eq. /100g. On the other hand, lower magnesium content was recorded in the conventional soil throughout the study period (Table 5). The adequate concentrations of magnesium required are 0.2 % and the ranges in plants are ranges from 0.05%-1.0% on dry weight basis.

TABLE 5
SOIL NUTRIENT ATTRIBUTES AT 15 CM AND 30CM DEPTH OF ORGANIC, CONTROL AND CONVENTIONAL EXPERIMENTAL FIELD FROM 2008-2013*

		30cm depth									15cm depth								
Year	**Production Block**	pH	OM	N	K	Ca	Mg	P	S	B	pH	OM	N	K	Ca	Mg	P	S	B
2008-09	**Organic**	6.8	1.88	0.094	0.5	7.19	4.02	47.4	2.80	1.6	7.03	1.53	0.08	0.291	11.44	4.06	49.33	2.50	0.60
	Control	6.8	0.74	0.037	0.32	9.53	3.58	28.0	2.36	0.75	7.02	1.47	0.07	0.271	8.98	3.51	55.61	3.62	1.14
	Conventional	6.9	0.67	0.038	0.36	23.21	4.95	19.9	5.90	0.69	6.52	1.47	0.07	0.331	8.35	3.57	86.51	2.96	0.97
2009-10	**Organic**	7.1	1.55	0.078	0.29	14.12	4.17	15.4	2.75	0.20	6.82	1.98	0.10	0.421	6.16	4.06	52.03	3.89	1.33
	Control	7.0	1.28	0.064	0.33	10.68	4.19	13.0	2.90	0.19	7.02	1.20	0.06	0.271	17.62	3.63	17.34	3.49	0.35
	Conventional	7.5	0.61	0.031	0.26	30.21	3.93	18.5	5.20	0.15	6.42	1.08	0.80	0.582	9.20	3.17	75.55	1.15	0.57
2010-11	**Organic**	7.9	0.55	0.03	0.32	15.16	4.14	39.9	11.35	0.19	7.72	2.82	0.16	0.370	13.38	4.17	154.54	28.78	0.25
	Control	8.1	0.71	0.04	0.23	10.03	3.22	65.7	6.08	0.15	7.92	1.72	0.10	0.291	9.19	2.80	52.21	12.05	0.08
	Conventional	7.5	0.61	0.031	0.26	30.21	3.93	18.5	5.20	0.15	6.52	1.47	0.07	0.331	8.36	3.57	86.51	2.96	0.93
2011-12	**Organic**	7.6	1.34	0.08	0.69	14.7	10.4	24.8	11.23	0.56	7.18	2.17	0.12	0.351	19.02	9.27	80.91	27.95	0.49
	Control	7.4	2.17	0.12	0.18	19.2	9.50	62.7	24.67	1.10	7.38	1.77	0.10	0.241	18.52	9.07	5489	33.32	0.88
	Conventional	6.7	2.17	0.13	0.22	21.5	10.4	59.3	19.35	0.42	6.93	2.56	0.15	0.171	19.63	10.07	43.23	19.54	0.34
2012-13	**Organic**	7.7	2.58	0.15	0.39	22.2	9.80	49.2	26.14	0.75	7.19	3.05	0.17	0.351	21.94	10.36	84.87	68.61	0.39
	Control	7.8	1.74	0.10	0.40	11.3	3.90	22.9	33.21	0.51	7.89	1.97	0.11	0.261	8.55	2.99	34.07	29.14	0.25
	Conventional	7.5	1.1	0.06	0.23	8.80	2.80	47.2	29.59	0.71	7.49	2.23	0.13	0.238	8.86	3.09	72.05	37.07	0.33

[a]*The average value of three replicate samples*

3.1.5 Sulfur (S) & Boron (B)

Trace amount of Sulfur and boron are required for plant growth and development and thus adequate concentrations 0.10-1.5% of sulfur and 0.02-0.8% of boron are required for the plant. Sulfur content in organic block increased rapidly from 2.5 μ eq. /100g in 2008 to 68.61 μ eq. /100g in 2013. on the other hand boron content was 0.60 in 2008 and decreased to 0.39 in 2013. Irrespective of block, boron content was decreased throughout the study period (Table 5).

3.2 Microbiological Parameter

Distribution of quality control microorganisms including total coliform count, *Escherichia coli*, *Salmonella* spp *Shigella* spp and other soil essential microorganisms including *Bacillus* spp, *Pseudomonas* spp, Phosphobacteria, Azotobacter, Rhizobium spp. Phosphate solubilizing fungi and Nitrogen fixing fungi microorganism in organic soil amended with BAOFER, at the rate of 15 t/ha since 2008 and other conventional and control field soil were shown in **Table 6.** The average aerobic bacterial count in BAOFER, control and conventional soil was recorded as was 9.05 ± 0.54 CFU/g, 8.96 ± 0.28 CFU/g and 8.76 CFU/g, respectively. Total coliform counts in these samples were recorded as 7.54 ± 0.01 CFU/g, 6.51 CFU/g and 6.25 CFU/g. However, non-detectable level of *E. coli*, *Salmonella* spp and *Shigella* was observed in all the soil sample analyzed. On the other hand, higher number of essential microorganisms including *Bacillus* spp, (6.18 ± 0.285) CFU/g, Phosphobacteria (9.41 ± 0.42) CFU/g, Azotobacter (9.36 ± 0.27 CFU/g), Rhizobium (9.76 ± 0.19 CFU/g), phosphate solubilizing fungi (9.28 ± 0.14 CFU/g), and Nitrogen fixing fungi (9.32 ± 0.15 CFU/g) was present in BAOFER compared to control and conventional soil. Presence of higher number of rhizobium spp increases the plant health and soil fertility. Isolated microorganisms from organic plots showed bio-availability for N-fixation and P solubilization *in vitro* (data not shown).

TABLE 6
COMPARISON OF MICROBIAL DIVERSITY IN SOIL AMENDED WITH BAOFER CONTROL AND CONVENTIONAL WHILE PRODUCING DIFFERENT VEGETABLE AT THE FIELD LEVEL

	BAOFER	Organic block	Control block	Conventional
Microorganisms	Average	Average Cabbage producing field soil	No amendment as control	Conventional field with chemical fertilizers
Total aerobic bacteria	9.05 ± 0.54	9.35± 0.12	6.41± 0.37	6.25± 0.43
Total coliform bacteria	7.54 ± 0.01	6.51± 0.25	<1.0	<1.0
Escherichia coli	<1.0*	<1.0	<1.0	<1.0
Salmonella spp	<1.0	<1.0	<1.0	<1.0
Shigella spp	<1.0	<1.0	7.54 ± 0.39	6.33± 0.32
Bacillus spp.	6.18 ± 0.29	7.15± 0.31	2.58 ± 0.14	<1.0
Pseudomonas spp	<1.0	2.345± 0.30	8.33 ± 0.20	8.21± 0.26
Phosphobacteria	9.41 ± 0.42	8.42± 0.24	6.15 ± 0.19	5.01± 0.19
Azotobacter spp	9.36 ± 0.27	5.21± 0.21	5.05 ± 0.53	<1.0
Klebsiella spp	5.95 ± 0.12	3.91± 0.14	9.13 ± 0.62	8.98± 0.29
Rhizobium spp	9.76 ± 0.19	7.85± 0.34	8.27 ± 0.21	7.90± 0.25
Total fungal count	8.99 ± 0.77	8.13± 0.26	7.88 ± 0.40	7.25± 0.16
Phosphate solubilizing fungi	9.28 ± 0.14	7.87± 0.41	5.95 ± 0.43	5.65± 0.32
Nitrogen fixing fungi	9.32 ± 0.15	6.09± 0.27	7.73 ± 0.71	5.3± 0.22
Aeromonas spp	<1.0	<1.0	<1.0	<1.0
Citrobacter spp	<1.0	<1.0	<1.0	<1.0

[a]***The mean values ± SD obtained from three individual trials *<1.0= below detection level. The minimum detection level was 1.0 log CFU/g***

IV. DISCUSSIONS

High organic matter content in the soil along with microbes richness ensure the improvement of yield as tropical and subtropical climates threat to deposition of OM but organic practices protect the OM of the soil and alleviate the adverse effects on vegetable growth.

Organic soils receive different forms of compost, each year as a nutrient supplement. In addition to supplying plant nutrients, such compost adds organic matters contributing numerous indirect benefits to the soil. Indirect benefits of such soil organic amendments are often neglected and get less credit than the high yield obtained in short time in conventional production system. That may be due to a lack of available information and/or poor understanding on soil biology in system approach and sustainability. Numerous studies over time conclusively exhibited that organic farming systems increase diversity (Gabriel et al., 2010) and abundance of the soil microbial community (Forge et al., 2008), suppression of plant diseases (Clark et al., 1998), and increase soil fertility organic matter, activity of soil enzymes over time, as well as influence the structure and functions of the soil food web (Oka, 2009). In addition, soil microbes play an important role in enhancing nutrient mineralization and mobilization in soil. Soil microbes also contribute to preventing accumulation of nitrates and phosphates, as well as reducing the loss of nutrients, by slowing release of nutrients from the soils and increasing the tolerance of plants to stress. Thus, soils with such organic amendments are considered better from a system perspective, in terms of microbial activities and sustainability. On the other hand, conventional systems relying on chemicals are targeted to boost production and pay less or no attention to soil organic matter. The conventional production practices, such as tillage (Angers et al., 1997), fertilizers (Kleineidam et al., 2010), and pesticides, especially their long-term use, affect soil microbes negatively and are considered to have an adverse effect on soil health and productivity.

In general, healthier soils should consist of a diverse mixture of organisms including microbes (fungi, bacteria, and algae), microfauna (protozoa), and mesofauna (arthropods and nematodes with high levels of biological activity. Without biological diversity, density, and activity, a soil ecosystem would be vulnerable to environmental changes, disturbances, and other stresses. The role played by each microbial group and their interactions with many other residents organisms in soil are important, comprising a complex of soil biological processes, releasing plant nutrients, and maintaining soil structure and ecosystem productivity. The biological mineralization of nutrients at rates sufficient to meet crop needs with a minimal loss to the environment is an important component of soil quality for agro-ecosystems (Glover et al., 2000). Soil biota, considered a key factor of resource efficient agriculture, contribute to soil enrichment which increases crop yield and nutrient mineralization, such as increasing N and P uptake and reducing P and N leaching(Bender and van der Heijde 2014). Soil nutrients can play an important role in determining the abundance of soil microorganisms (Koorem et al., 2014), and a decline in soil biodiversity can negatively affect several ecosystem functions(de Vries et al., 2013 and Wang et al.,2014). Thus, it is important to consider both soil nutrient content and the abundance of soil microbes in a system to determine the soil health and sustainability.

Out of several benefits, the main indirect benefit of organic farm is its richness of biodiversity and supports on average 30 % more species than conventional farmland. Furthermore, organic farming provides solutions for resource efficiency in terms of nutrient management, energy use, and water efficiency, with the potential to produce future perspectives of organic production (Kukreja and Meredith 2011). In addition, organic soils have generally higher stored carbon and humus building (Niggli U., 2010) and are considered better than conventional production systems. Greater activities of soil microbes in organic soils contribute to soil health and sustainability of organic production systems. Several factors effect microbial communities in organic and conventional systems, generating differences in quality and quantity of crops produced. Among such factors, production inputs such as tillage, nutrient sources, such as compost and chemical fertilizers, pesticides (fungicides, herbicides, insecticides), and cropping patterns are major contributors. Organic production systems rely on composts as a nutrient supplement and also serve as the sole carbon source required for soil microbes. In contrast, conventional practices heavily rely on chemicals, tillage, and intensive cropping which are found to impact soil microbes negatively (Angers et al., 1997) and (Kleineidam et al., 2010). However, all of these practices used in conventional system impact different groups of microbes differentially.

V. CONCLUSION

The study result demonstrated that the soil microbial and nutritional properties were increased significantly in the compost-amended organic block compared to the conventional block. The total nitrogen (N) content and the organic matter were 215% and 200% higher respectively in organic block than that of conventional block. Furthermore, significant increase of available organic matter, N, P, & K was observed in the compost-amended soils compared to conventional and control block. Thus, the application of adequate amount of compost and organic fertilizers were able to increase soil fertility and crop yield.

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