Assessment of Physicochemical and Microbio -logical Properties of Soil from Organic Vegetable Farms in Bangladesh

Md. Nazim Uddin[a], Md. Kamrul Hasan[b], M. A. Matin[b], Abdul Khaleque[d], Md. Latiful Bari[c*]

Abstract

Background. Organic fertilization is the key input for agro-ecological farming, which consistently keep the soil healthy, fertile and productive. In order to assess the sustainability of organic farming, the physicochemical and microbiological properties of soils from organic, semi-organic and conventional farms cultivating tomato, potato and bottle gourd were analyzed in this study. **Method.** The physicochemical parameters including content of P-, K, and other major and micro-minerals as well as organic matter, presence of heavy metal, etc. and 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, *Tricoderma* sp. and total fungal population were determined using standard microbiological plate count methods followed by biochemical and API immunoassay techniques. **Results.** The results revealed that organic matter, available N and P content were always found higher in organic fertilizer farming than that of semi-organic and chemical fertilizer farming. The soil beneficial microorganisms, soil quality microorganisms, and pathogens content was found higher in organic fertilizer farming compared to other two methods of farming. The total input in production of tomato, potato and bottle gourd in organic fertilizer farming was found lowest compared to semi-organic and chemical fertilizer farming.

Conclusion. The results of this study demonstrated that the use of properly composted organic fertilizers only can ensure safe crop production, increase soil health, improve agro-ecology, but decreased yield compared to chemical farms.

Significance | Improvement of soil health, fertility and agro-ecology through organic farming

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Abbreviations: CFU, Colony Forming Unit; HYV, High Yield Variety; GMO, Genetically Modified Organisms; NGO, Non-Governmental Organization; STW, Shallow Tube Well; OM, Organic Matter; MoP, Potassium Chloride.

Introduction

The term 'Agro-ecological farming' refers to the farming systems that uses both living and non-living natural resources for food production while not damaging these resources and links to ecology, culture, economics and society to create healthy environments, food production and communities (Brodt, *et al.*, 2011). Four properties including productivity, stability, sustainability and equitability are

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interconnected and integral part of a successful agro-ecosystem. As the design of agro-ecology was developed to mimic naturally occurring ecological systems and traditionally sustainable farming systems, a number of additional terms appeared to describe an agro-ecological farming system, including biological agriculture, sustainable agriculture (Pretty 2008), organic agriculture (Zehnder *et al.*, 2007), biodynamic agriculture (Reeve *et al.,* 2011), natural systems agriculture (Glover *et al.,* 2010; Franzluebbers *et al.,* 2014), agro-forestry (Anderson and Sinclair 1993), restoration agriculture (Shepard 2013), permaculture (Ferguson and Lovell 2014), and traditional agriculture (Altieri 2002). Components of current industrialized agriculture can also be viewed as an agro-ecological design, especially when incorporating natural processes occurring in ecological systems and traditionally sustainable farming systems (Zehnder *et al* 2007; Wezel *et al*. 2014). Agro-ecological farming or organic farming strives to create stable food production systems that are resilient to environmental perturbations such as climate change and disease. The only way to achieve this goal is to go beyond thinking of farms as linear systems in which inputs (acreage, fertilizer, pesticides etc.) influence the output (food yield), and start treating farmland as complex webs of ecological interactions.

Bangladesh is one of the most densely populated countries in the world with more than 16.56 million people living in small area of 147,570 square kilometers (BBS, 2019) with 8.55-million-hectares of cultivable lands to produce food for her ever-increasing population. The cultivable lands are being decreased(the amount of per capita land declined from 0.17 hectare in 1961 to 0.05 hectare in 2016)steadily due to population growth, rapid industrialization and infrastructural development (World Bank, 2019). However, agriculture plays a pivotal role in overall economic development of the country and more than 70% of the population depends on agriculture (World Bank 2016) and to ensure food for the huge population, 'Green revolution' was appeared in 1960s with the concept of 'producing more food' within very short period and was implemented in Bangladesh like other Asian countries. In addition, introduction of new crop varieties (e.g. HYV), use of chemical fertilizers, and pesticides, as well as groundwater irrigation increased the crop production by many folds and has achieved food self-sufficiency within a very short period. On the other hand, intensive crop cultivation using synthetic fertilizers and other chemicals had created terrible stress on farm ecosystems such as soil health degradation, topsoil depletion and degradation, reduced soil microbial activities, groundwater contamination. The people around the world are expressing great concern over the indiscriminate use of chemicals in the field and emphasize on the use of organic and/or biofertilizers in the agriculture field (Mishra, 2005). Long term cultivation with chemical fertilizers usually leads to a decrease in soil organic matter content (SOC), total N contents (Dick, 1992) and crop yield (Bhandari *et al.*, 2002; Regmi *et al.*, 2002). The SOC in such agriculture area is very low (0.5%-2%), whereas SOC should be maintained over 3% to get higher crop yield. Many scientific evidences had proved that the reduction or non-use of synthetic chemicals can reduce environmental hazards and possible adverse effects substantially. Therefore, agricultural scientists, environmentalists and policy makers are now advocating ecological farming, eco-friendly agriculture and integrated intensive farming system based on the principle of integration of both organic and inorganic farming systems so as to acquire the target of agricultural production without causing severe environmental problems (Buddhibhuvaneswari, 2005).

Organic agriculture may be a cost-effective method that can trim down rural poverty and curb pollution, because different types of organic amendments including animal and vermi compost, green manure to be prepared by themselves, and use in fields to maintain the soil physical, chemical and biological properties. However, farmers' own produced organic fertilizers in many cases are not hygienic and/or even producers are not bothered about the maturation of compost. In addition, some heavy metals like cadmium (Cd), lead (Pb) and chromium (Cr) and pathogens such as *Salmonella, E. coli* were observed in farmers' produced organic fertilizers. Some commercial fertilizers contain cotton seeds as ingredients which might be genetically modified organisms (GMO) contaminated. The objectives of the eco-friendly/ organic farming in Bangladesh are mainly to protect natural and agricultural resources from further degradation, contamination and to ensure long term sustainability in agricultural system. In this study, a comparative assessment of physicochemical and microbiological properties of soils from organic, semi-organic and conventional farms that produced tomato, potato and bottle gourd was performed.

Methods

The study has been carried out by surveying different districts of Bangladesh by using standards questionnaires and inputs were analyzed at designated laboratory of Bangladesh. The total study is presented in the Fig. 1.

Distribution of samples

The study focused on the four districts in Bangladesh viz., Jhenaidha, Gazipur, Tangail and Naogan. The sample farmers for organic, semi-organic and chemical fertilizer farming constituted 180 farms (60 of each category). The survey also covered three organic fertilizer producing company, 21 farm level organic fertilizer producer, 9 Trader/Dealer/Sub-dealer and 3 government personnel and 3 NGO personnel from the selected districts (Table 1). Face to face interview technique using a pre-designed and pre-tested questionnaire was followed to collect the primary data from the selected farmers. The selection of farms was done purposively to cover selected crops under organic farming. The study covered commonly practiced three vegetables crops such as tomato, potato and bottle gourd. District wise distribution of selected farming categories are presented in Table 2. Although 60 farms were selected for organic farm category, total number of plots stands 96 for the same group as one farmer produced more than one organic crops under study in the same year (Table 2). For making comparison similar number of semi-organic and chemical farming was also chosen from the same locality and crops and final sample size were 297 for three crops and three categories of production practices.

Table 1 | Category wise sample distribution in the study areas

Category	Sample distribution (no.)							
	Gazipur	Tangail	Noagaon	Jhenaidah	Rajbari	Bogra	Comilla	Total
Smallholder farmer:								
Organic fertilizer	10	10	20	20	-	-	-	60
Semi-organic fertilizer	10	10	20	20	-	-	-	60
Chemical fertilizer	10	10	20	20	-	-	-	60
Organic fertilizer producing company	2	-	-	-	-	-	1	3
Farm level organic fertilizer producer	3	2	5	5	3	3	-	21
Trader/Dealer/Sub-dealer	3	3	-	3	-	-	-	9
Govt. Institution (DAE/BARC/BARI)	2	-	-	1	-	-	-	3
NGO	1	-	-	1	1	-	-	3
Total	41	35	65	70	4	3	1	219

Table 2 | Distribution of plots studied under selected crops

Crop	Categories	No. of plots studied			
		Gazipur & Tangail	Jhenaidah	Noagaon	All
Tomato	Organic	15	9	14	38
	Semi-organic	15	9	14	38
	Chemical	15	9	14	38
Potato	Organic	7	11	16	34
	Semi-organic	7	11	16	34
	Chemical	7	11	16	34
Bottle gourd	Organic	9	12	6	27
	Semi-organic	9	12	6	27
	Chemical	9	12	6	27
	All	93	96	108	297

Table 3 | Distribution of soil and organic fertilizer samples collected for nutritional and risk analysis

Crop	**System**	**No. of plots studied**				
		Gazipur	Noagaon	Jhenaidah	Rajbari	All
Soil sample (at 15 cm depth)	Organic	1	1	1	-	3
	Semi-organic	1	1	1	-	3
	Chemical	1	1	1	-	3
Organic fertilizer sample	Vermi-compost	-	-	-	2	2
	Commercial compost	3	-	-	-	3
	All	5	3	4	2	14

Table 4 | Average microbiological status of the soil samples collected from organic, semi organic and chemical farming field (15 cm depth) of the study area.

Microorganisms	Log CFU/g of soil		
	Organic farm	Semi-Organic farm	Chemical farm
Quality microorganisms			
TABC (Total aerobic bacterial count)	8.55 ± 0.22	6.36 ± 0.21	8.48 ± 0.22
Coliform	6.25 ± 0.36	4.21 ± 0.57	5.24 ± 0.34
E. coli	<1.0	<1.0	<1.0
Total fungal count	8.65 ± 0.07	7.87 ± 0.20	8.22 ± 0.20
Pathogenic microorganisms			
Staphylococcus spp.	5.86 ± 0.10	5.73 ± 0.13	5.73 ± 0.13
Vibrio spp.	3.89 ± 0.63	<1.0	2.75 ± 1.12
Salmonella spp.	<1.0	<1.0	<1.0
Klebsiella	4.72 ± 0.31	3.45 ± 0.01	3.00 ± 0.00
Beneficial microorganisms			
Bacillus spp.	6.73 ± 0.03	5.67 ± 0.03	6.47 ± 0.03
Pseudomonas spp.	1.89 ± 2.67	<1.0	<1.0
Phosphate solubilizing fungi	8.24 ± 0.34	4.04 ± 0.14	8.12 ± 0.31
Phosphobacteria	9.13 ± 0.07	8.32 ± 0.12	8.02 ± 0.09
Azotobacter	8.23 ± 0.38	6.29 ± 0.06	6.79 ± 0.08
Rhizobium	8.16 ± 0.06	8.40 ± 0.16	8.00 ± 0.06
Tricoderma sp.	8.63 ± 0.14	6.75 ± 0.11	6.80 ± 0.10

The average ± SDa (n=3)

Preparation of different organic fertilizers and field application

Several organic fertilizers including vermi compost, pile or heap compost, quick compost and tricho-compost were prepared according to the established methods of BARI, 2015. In addition, commercial organic fertilizers include, Bio-gen organic, Mazim Organics, Mazumder organics, were collected from the company directly before use in the field. Field application of organic fertilizer was done as per the farmers' practices and recommendation of local agriculture officer in respective fields.

Selection of agriculture field for samples collection and analysis

For physico-chemical and microbiological analysis of soil and organic fertilizers, 14 samples were collected from different stakeholders and study locations. The sampling covered 3 soil samples each from organic, semi-organic and chemical fertilizer applying farms in three locations (Table 3). Also, five organic fertilizer samples were collected from two vermi compost producing farms and three commercial compost producing farms according to their recipes.

Soil and fertilizer samples collection and analysis

Soil samples were collected from the plots (nine samples namely, organic, semi-organic and chemical farming from 3 locations) from 15 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 hours 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.

Methods of Chemical Analysis

Chemical properties of the sampled soil have been analyzed at the analytical laboratories of Centre for Advanced Research in Sciences (CARS), University of Dhaka, Bangladesh. The chemical analyses were done on a dry matter basis. Analytical methods were used for each constituent such as, organic carbon by Tyurin method using Mohr's salt, total nitrogen through digestion with sulfuric acid in presence of $CuSo_4$ catalyst following modified Kjeldahl method (Bremner and Mulvaney, 1982), Phosphorus (P) by colorimetric assay with ammonium molybdate using spectrophotometer (Olsen and Sommers. 1982), Sulfur (S) following Turbidity method (Fox *et al.*, 1964) and other elements (Fe, Zn K and Cu) and heavy metals (Pb, Cd, and Ni) were determined through digestion with nitric acid (HNO_3) and perchloric acid mixture using Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978; Jackson, 1973).

Microbiological Analysis

The microbial populations including quality parameter, total aerobic bacteria, coliform bacteria, *E. coli*, *Citrobacter* spp. and *Aeromonas* spp. were analyzed in surface plate method followed by biochemical tests as per described by Owsalya *et al.*, 2014. Other bacteria including *Bacillus* spp., *Pseudomonas* spp., *Azotobacter* spp., *Rhizobium* spp., *Klebsiella* spp. were identified using surface plate method followed by API immunoassay analysis as per described by Jakaria Al-Mujahidy *et al.*, 2013; Aysel Uğur *et al.*, 2012; Ashish *et al.*, 2011; and Ridvan 2009, respectively. Phosphate solubilizing fungi and Phosphobacteria was identified using surface plate method on Pikovskaya's agar (PVK) and yeast malt agar plate, respectively as described by Emilce *et al.*, 2011. In addition, total fungal count, *Trichoderma* spp. and Nitrogen fixing fungi, was determined in surface plate method followed by microscopy as described by Rohilla and Salar 2012. Furthermore, *Salmonella* spp., and *Shigella* spp., was detected using surface plate methods on Salmonella-Shigella (SS) agar (Oxoid, UK) followed by biochemical test as described by Romain *et al.*, 2013.

Phytotoxicity studies of organic fertilizers

Germination test was conducted on vegetables namely; okra, radish, and amaranth using a mixture of sand and composts. Fifteen seeds of okra, radish, and amaranth were planted in a mixture of sand and compost. Compost and sand were mixed (volume basis) at mixing ratios of 75: 25 and 50:50 compost and sand. Experimental design used in this study was a completely randomized design with six replications. Six containers filled with sands were tested as controls. The containers were kept moistened by regular watering. After 48, 72 and 96 hrs, the numbers of germinated seeds were counted. Then, seedlings were harvested and germination index (GI) and length of radicals and shoots were measured (Luo *et al.*, 2018).

Results and Discussion

The existing agronomic practices and the level of inputs used in the area and the farms were categorized into three types of farming activities such as organic farming, semi-organic farming and chemical farming. Organic farming means those farms which are applying only organic fertilizers like pile or heap compost, vermicompost, quick compost, tricho-compost, cow dung etc. in their crop production. Similarly, those farmers are applying both organic fertilizers and chemical fertilizers are categorized as semi-organic farming and those who are applying only chemical fertilizer in their crop fields are treated as chemical farming.

In this study, the farmers either used their own land or use rented land for producing tomato, potato, bottle gourd etc. and the cropping period was considered as 4 months for selected vegetables that varied from crop to crop. All the farmers ploughed their land with the help of power tiller and the number of ploughing varied from farm to farm depending on the field soil condition. In addition, farmers used both families support and/or hired contract labour according to the need and most of the farmers used their own farms seedlings and transplant them in the field, however very few farmers purchase the seedlings in their cultivation. The organic fertilizer used farmers administered vermi compost, quick compost and cow-dung, while the semi- organic and chemical fertilizer used farmers administered four kinds of chemical fertilizers including urea, triple super phosphate (TSP)/ MoP, and zinc sulphate in the field to enhance agriculture production.

Furthermore, varied doses of pesticides mainly insecticides and fungicides were administered into the field by semi-organic and chemical fertilizer used farmers. Nevertheless, bamboo made fence/ macha were used to protect the crop from animal entry and almost all the farmers used irrigation water in their plot from shallow tube well (STW), however, very few farmers followed manual irrigation method for irrigation purpose.

Input required for tomato cultivation

On an average, the semi-organic farming applied urea at the rate of 269 kg/ha, TSP 212 kg/ha, MoP 152 kg/ha and cow dung 12836 kg/ha whereas chemical fertilizer farming used Urea at the rate 277 kg/ha, TSP 238 kg/ha and MoP 168 kg/ha. On the contrary, the organic fertilizer farming applied only organic components like vermi compost at the rate of 610 kg/ha, pile compost 588 kg/ha and cowdung 15860 kg/ha. Organic fertilizer farming used 244 man-days per hectare of human labor, while semi-organic and chemical fertilizer farming used 255 man-days and 250 man-days respectively (Table 4). It was observed that the semi-organic fertilizer farming used higher amount of inputs compared to organic fertilizer farming because organic fertilizer farming was closely monitored by some NGOs and instructed them to follow recommended dose of organic fertilizers. The semi-organic and chemical fertilizer farming used pesticides and chemical fertilizers indiscriminately hence required more amounts of human labor. In the study areas, semi-organic and chemical fertilizer farming applied pesticides, irrigation and weeding twice a season. Organic fertilizer farming harvested their crop 13 times, whereas it was 15 times for semi-organic and chemical fertilizer using farmers in the study areas.

Input required for potato cultivation

On an average, the organic fertilizer used farmers applied vermi compost at the rate of 537 kg/ha, pile compost 397 kg/ha and cowdung 15784 kg/hato their potato field. On the contrary, the semi-organic farmers applied urea at the rate of 362 kg/ha, TSP 192 kg/ha, MoP 193 kg/ha and cow dung 12764 kg/ha, whereas chemical fertilizer farming used urea at the rate 379 kg/ha, TSP 188 kg/ha and MoP 289 kg/ha. Organic fertilizer farming used 281 man-days per hectare of human labor, while semi-organic and chemical fertilizer farming used 291 man-days and 288 man-days respectively (Table 4). In the study areas, on an average, both organic, semi-organic and chemical fertilizer farming applied irrigation twice a season and they did not do any weeding in their crop field.

Input required for bottle gourd cultivation

Organic farms used 233 man-days of human labour per hectare while, semi-organic and chemical farms used 238 man-days and 235 man-days respectively in the study areas (Table 4). On an average, the semi-organic fertilizer farms applied urea at the rate of 395 kg/ha, TSP 236 kg/ha, MoP 205 kg/ha and cow dung 12758 kg/ha, whereas chemical fertilizer farms used urea at the rate 456 kg/ha, TSP 268 kg/ha and MoP 233 kg/ha. On the contrary, the organic fertilizer farms applied vermi compost to their bottle gourd field at the rate of 530 kg/ha, pile compost 696 kg/ha and cowdung 15618 kg/ha. In the study, on an average, organic, semi-organic and chemical fertilizer farms irrigated their field twice per season and harvested the product a total of 14 times and 15 times, respectively.

Yield performance

It was observed that irrespective of types of vegetable, semi-organic farms average yield is higher than that of chemical & organic farm, which is 17.33% (5.23 ton/ha) higher than organic and 5.53% (1.67 ton/ha) than chemical farm for tomato. However, in case of potato yield, organic farm average yield was 27.82% (7.25 ton/ha)less than the semi organic farms and 3.95% (1.03 ton/ha)less in chemical farms. In organic farming bottle gourd average yield decreased to 18.38% (5.08 ton/ha) compared with semi organic farm and this value was 2.02% (0.56 ton/ha) decreased compared to chemical farms (Fig. 2). Among the vegetables analyzed, the highest reduction of 27.87% in potato yield in organic farm was recorded. This decreased caused financial loss to the farmers and thus not interested in organic farming. The lowest reduction of 17.33% was recorded in tomato yield in organic farming compared to semi-organic farms.

Nutritional status of organic fertilizer

Since organic fertilizers are thought to be beneficial source of plant nutrients and organic matter and thus, farmers often use it in plant production to increase productivity. The nutritional status of vermin compost and commercial organic fertilizer results showed higher OM content, nitrogen content and C: N ratio (Supp. Table 1). However, these fertilizers can also be a potential source of environmental pollution because there are increasing evidence that organic fertilizers can have high concentrations of heavy metals such as Cr, Ni, As, Cd, and Pb. If organic fertilizers are applied to an agricultural area, some heavy metals could be accumulated in agricultural lands, some of which could be transferred to the human body (Lopes, *et al.*, 2011; Franco *et al.*, 2006). However, in this study, all the fertilizers analyzed possess certain amount of heavy metals, but the values were within the maximum permissible level in the vermi compost (Supp. Table 2).

Phytotoxicity

In order to evaluate the direct effects of compost on the germination and development of root system, the effect of mixing ratios of soil-compost on the seed germination and early seedling growth of okra was studied. Seeds of okra were planted in plastic pots containing mixtures of sand and compost. The compost in both mixing ratios influenced the germination by various fertilizers. Strong inhibitory effect of compost on germination by S_4 and S_5 commercial fertilizers was observed. Since both the fertilizers contain pressed mud as ingredients and secondary metabolites coming from pressed mud might have inhibited the germinations. However, root length was not affected by organic fertilizers (Fig. 3).

Impact of organic production on soil chemical properties

It was revealed that the soils of organic farms contain more amount of available nutrient compared to the semi organic and chemical farms. Organic matter is the nutrient storehouse and it was revealed that F1, F4 and F7 contained more amounts of OM compared to other counterpart. The chemical farms F3, F6 and F9 were found to contain

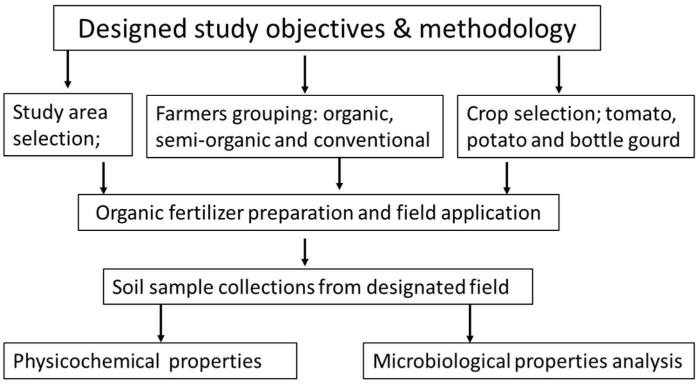

Figure 1 I Schematic chart of the study

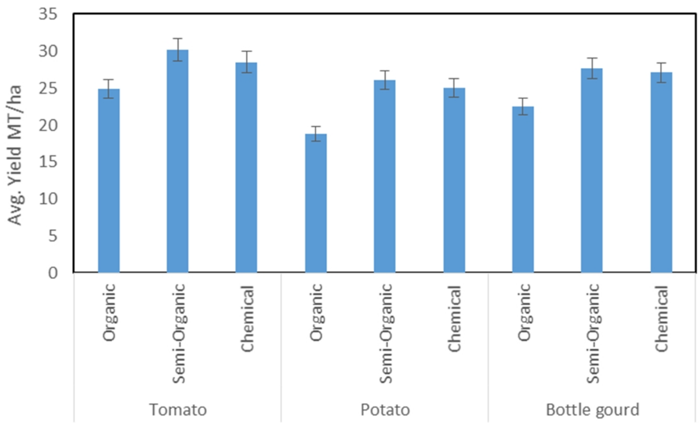

Figure 2 I Yield of tomato, potato and bottle gourd under organic, semi-organic and chemical fertilizer farming *(ton/ha)*

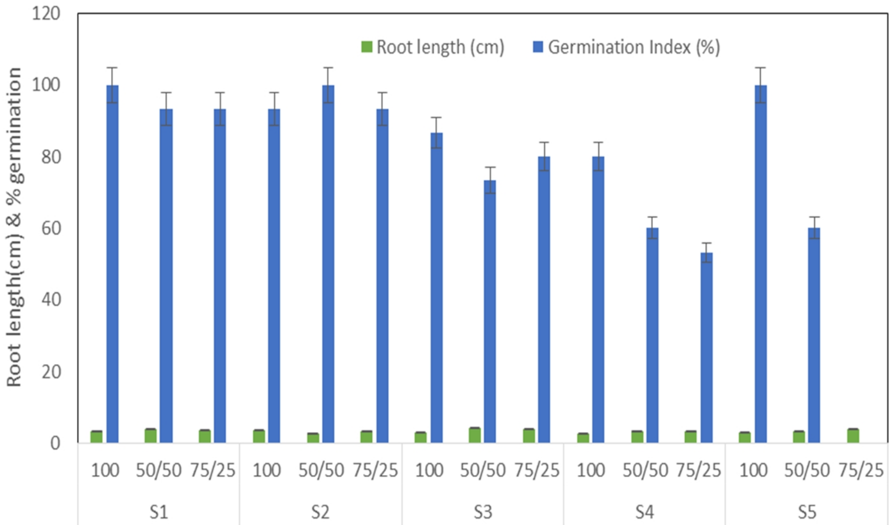

Figure 3 I Effect of different mixing ratios of soil: compost concentration on germination index (%) and root length of bottle gourd at 96 hours.
Here, S_1= Vermi compost sample from Rajbari, raw materials- only cowdung,
S_2= Vermicompost sample from Balidanga, Rajbari, raw materials- cowdung, neem leaves, mahogany fruits, banana leaves and ash,
S_3= Commercial organic fertilizers sample from Mati organics (Bio-gen), raw materials- bio slurry, cotton seeds, cowdung, poultry litter, ash.
S_4= Commercial organic fertilizers sample from Mazim organics, raw materials- sugarcane pressed mud, cotton seeds, cowdung, poultry litter, ash, Tricho- leachate,
S_5= Commercial organic fertilizers sample from Mazim organics, raw materials- sugarcane pressed mud, cotton seeds, cowdung, poultry litter, ash, Tricho- leachate (prepared for ACI Ltd.).

the lowest amount of organic matter. Nitrogen is the key element for maintaining growth of crops and it was revealed from the test results that nitrogen was detected below the critical level (CL) in the chemical farms and the organic and semi-organic soil contained it close to CL. It could be due to the excessive use of chemicals that inhibited the biological properties of the soils (Supp. Table 2).

Impact of production practices on soil microbial properties

Irrespective of soil type and conditions, pathogenic microorganisms were not found in any of the field soil sample tested (Supp. Table 3). However, presence of higher number of coliform bacteria was visible in all the soil samples indicating the lack of environmental hygienic practices. Although higher number of *Bacillus* spp.(6.73 ± 0.03 log CFU/g) was recorded in all the field samples, lower number of *Pseudomonas* spp. (1.89 ± 2.67log CFU/g) was observed in the field soil. This might be due to the presence of higher number of *Tricoderma* spp (8.63 ± 0.14) in the field soil. As *Pseudomonas* spp. contribute in phosphate utilization and nodulation of plant thus supplementation of these bacteria is required in these fields to ensure proper utilization of phosphate and plant growth. It has been recommended that presence of 8.0 log CFU/g of phosphate utilizing bacteria (Phosphate solubilizing fungi, phosphobacteria etc.) and nitrogen fixing microorganisms (Azotobacter, Rhizobium, Nitrogen fixing fungi) is required for better production, however, irrespective of field condition, one or two important beneficial bacterial population was found lower than the required number in the field soil (Girmay Kalayu, 2019). Therefore, irrespective of field practices, supplementation of these beneficial microorganisms is necessary to improve the soil fertility and increased yield.

Limitations of the study

The sample size and sampling location does not represent the organic farming community of the country as a whole hence the findings of the study should be applied carefully.

Farmers used to provide information on agricultural practices based on his memory. Sometimes they cannot recall all the practices performed for a particular crop as record keeping is almost absent in farm management.

Conclusion

The success of industrial agriculture and the green revolution in recent decades has often masked significant externalities, affecting natural resources and human health as well as agriculture itself. On the contrary, irrespective of vegetables produced, the chemical farming soils showed lowest amount of organic matter, and nitrogen content below the critical level, an indicator of poor soil health. The organic farming improves soil health but the presence of pathogenic microorganisms in organic fertilizers might create microbial hazards in the vegetables. Thus, properly composted organic fertilizers only can ensure safe crop production, increase soil health, improving agro-ecology but lower yield. However, considering the economic value of food safety, soil health and agro-ecological improvement, 20-30% decrease in production yield could be acceptable, because post-harvest loss of these vegetables is about 35-37% yearly, and don't hamper food security. Thus, increasing consciousness on food safety, and conservation of environment as well as of health hazards caused by agrochemicals could bring a major shift in consumer preference towards food quality, particularly in the developed countries. Global consumers are increasingly looking forward to organic food that is considered safe and hazard free.

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Author Contribution

MNU did experiment and analysis, MKH designed the experiment and analysis, MAM did field work and arranged financial supports, AK did meticulous review and MLB composed the manuscript.

Competing Interests

The authors declare that they have no competing interests.

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