A SEMINAR PAPER ON

Organic Fertilizer as a Strategy of Sustainable Land Management and Climate Change Mitigation

Course Title: Seminar

Course Code: SSC 598

Term: Summer, 2018

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ABSTRACT

Bangladesh is a densely populated country with minimum cultivable land. Moreover, agriculture faces so many threats. Such as, land degradation, soil erosion, organic matter depletion, acidification, natural hazards etc. Production is hampered by these constraints. But we have to feed our increasing population at any cost. For this we must adopt sustainable land management as well as reduce the greenhouse gases(GHS) to mitigate climate change. Climate change is the global concern now-a-days. By considering all of these aspect, organic fertilizer is the one & only solution. Organic fertilizer can improve the soil physical, chemical and biological properties. Organic fertilizer contributes to sustainable land management by improving these properties. Organic fertilizer also reduces the greenhouse gases(GHG) to mitigate climate change greatly. So organic fertilizer application is very much needed to feed our population with sustainable land management as well as mitigate climate change and increase the food security

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CHAPTER I

INTRODUCTION

Agriculture plays a vital role in economic development of Bangladesh. Agriculture is the most important sector of Bangladesh economy due to its role in food security, employment and livelihood. Still more than 70% of the people in Bangladesh are directly or indirectly employed in this sector. The total area is about 14.76 million hectares and net cultivable area is about 8.52 Million hectares. Crop sub-sector of agriculture contributing about 12% of national GDP in the financial year 2013-14 where agriculture sector's total contribution to GDP was around 18.5%, Cropping intensity over 183% (BBS, 2014) approaching to 200%. Average farm size in the country is only 0.68 ha and land-man ratio is 0.06 ha, about 46 numbers are economic crops. In the populated countries basic agricultural challenges are identified as food security, productivity, climate change & vulnerability and primary source of livelihood (Hossain, 2012).

Agriculture faces great challenges as it has to confront climate change, loss of biological diversity, loss of soil fertility, water shortage, etc. Quality of land is deteriorating due to degradation of soil fertility (e.g. nutrient imbalance), soil erosion, soil and water pollution, depletion of soil organic matter, water logging, increased soil salinity, acidification and deforestation. Excessive and injudicious use of chemical fertilizers by the farmer, threatening soil and human health and degrading of agricultural environment and destroy agriculture biodiversity (Hassan, 2017). Unfortunately, no long term strategy has been suggested to manage agriculture biodiversity or effective use of agriculture biodiversity for improving food production. Obviously, to feed 150 million people is a great challenge. Modern agriculture systems should give attention to conserve agricultural biodiversity. We should adopt techniques of sustainable agriculture system like mixed farming systems, organic agriculture, integrated pest management, more use of organic fertilizers, crop rotation, recycling crop and animal wastes, no-tillage or minimum tillage agriculture, inter-cropping, multi-cropping, cover crops, etc. (Hassan, 2017). Sustainable Land Management is the potential utilization of soils, water, plants and animals for the production of goods to meet human needs (Sanz *et al.*, 2017).

We have resources and techniques but need integration and patronization of good practices. It seems that plant production based on application of organic fertilizers is more stable than application of chemical fertilizers. So, there has been lots of attention from agronomists, ecologists and consumers in terms of organic fertilizers (Azimzadeh, 2014; Azimzadeh, 2013; Salehabadi, 2013). Organic agriculture is now-a-days introduced in more than 130 countries with a total area of 30.4 million hectares in 0.7 million number of organic farm. This consist of 0.65% of the total agriculture land of the world (Willer *et al.*, 2008).

Agriculture is both a significant contributor to greenhouse gas(GHG) emissions and one of the first sectors to suffer from the impacts of climate change. Many farmers have already seen their harvests destroyed by the changing climatic conditions. It is essential to evaluate how the agricultural sector can assist minimize GHG emissions, as well as how it can effective prepare for the negative effect of climate change, while still ascertain food security (FAO, 2016). The use of synthetic pesticides has negative impacts on flora and fauna, but also on human health, while the excessive use of nitrogen affects the nitrogen cycle. This has also negative effect on eutrophication of water bodies, enhanced GHG emissions and biodiversity losses (Muller *et al.*, 2016). The use of synthetic fertilizers results in technological dependence, enhances production costs, reduce soil organic matter (OM) and the capability for water storage, and changes soil structure and soil pH (Dudgeon *et al*., 2006).

Organic agriculture is considered as a suitable agricultural production area to safeguard accord between human welfare and sustainable development. It may be stated that organic issues are yet to be reviewed as an important factor in the research institutions and by the policy makers. Government should adopt policies, product standardization and support plans &programs (Hossain, 2012). Soils upper horizons with less than 1% organic matter are mostly limited to desert areas (Perie and Ouimet, 2008). Organic fertilizers are an ecological alternative to increase fertility and crop production in sustainable agroecosystems (Wu *et al*., 2005). Their use improves the physical, chemical and biological characteristics of the soil (Vargas and Suarez, 2007), even though they are lower in nutrients compared with inorganic fertilizers. Nitrogen (N) content in composts is 1 to 3% and the N mineralization rate is approximately 10% (Sikora and Enkiri, 2001). Therefore, only a fraction of N and other the nutrients are available the first year after the application. However, organic fertilizers may be substituted for chemical fertilizers and improve the characteristics of cultivated vegetables. Bio-fertilizers, inoculants and fungi has microbial organism with a specific fertilizer effect (Odlare, *et al*., 2014). As an important component of soil, microorganisms have the functions of decomposition, nutrition, transmission and regulation of plant growth and so on (Pan, *et al*., 2016). They have important practical significance for soil physical and chemical properties and biological function and element cycle (Ramezanian, *et al*., 2015). The active ingredients of microbial fertilizer are mainly microorganisms and other active substances. The essence of microbial fertilizer is to increase the species and quantity of microorganisms in the soil and reconstruct the biological community of the system, so as to improve the soil state (Schoebitz, *et al*., 2014). Studies have shown that the application of microbial fertilizer can significantly increase the species and number of microorganisms in the main soil, thereby enhancing soil physical fertility and biological fertility (Sarmadi, *et al*., 2016). Global experts on climate change affirm that Bangladesh, due to its geographical exposure as a deltaic region, will be subject to serious climactic vulnerabilities during the 21st century. The inexorable developments in climate change could become a major threat to the country's aspirations to ensure food security, sustainable development and poverty eradication. Agriculture is by far the most climate-sensitive sector. Hence, it is imperative that our agriculture sector adapts to the impacts of climate change and improve the resilience of food production systems in order to feed a growing population. Agriculture is most sensitive to climate change as its productivity totally rely on climactic factors.

Keeping these considerations in view, the present study has aimed with the following objectives

- To highlight the impact of organic fertilizer to achieve sustainable land management
- To review the appropriate methods of applying organic fertilizer for soil fertility and crop production
- To assess how to reduce greenhouse gases to mitigate climate change

CHAPTER II

MATERIALS AND METHODS

This seminar paper is completely a review paper. Therefore, all the information was collected from secondary sources with a view to prepare this paper. The key information was collected from various relevant books and journals, which were available in the library of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) and Bangladesh Agricultural Research Institute(BARI).For collecting recent information internet browsing was also done. Good suggestions, valuable information and kind consideration from my honorable major professor, research supervisor, course instructors and other resources personnel were taken to enrich this paper. After collecting necessary information, it has compiled and arranged chronologically for better understanding and clarification.

CHAPTER III

REVIEW OF FINDINGS

Organic fertilizer

Organic fertilizer fertilizers supply nutrients in small amounts over an extended period of time—just the way our plants need them.

The organic fertilizers can be grouped as; 1. Manures and composts, 2. Green manures, 3. Plant, stubble and root residues, 4. Other fertilizers

The multiple benefits of organic farming: Mitigation to climate change**,** increased biodiversity and resistance to disease and pests**,** conservation of soils**,** reduction of eutrophication and water pollution**,** positive impact on soil physical, chemical and microbiological properties

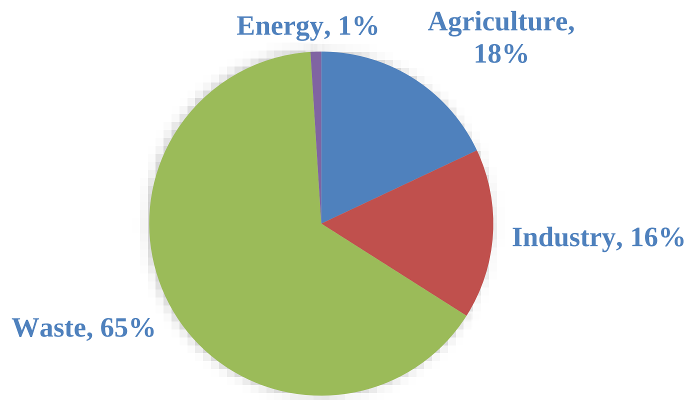
Sustainable Land Management

Sustainable Land Management Practices is the base for crop production. Soil resources of the country are experiencing pressure for increased food production. Increasing cropping intensity and mineralization of soil organic matter exhausts the soils capacity to support crops. For better production fertile soil is must. Organic manures can increase soil fertility and productivity. The control of land, water, biodiversity, and other environmental assets to meet human needs while ensuring the lengthy sustainability of ecosystem services and livelihoods is called Sustainable land management**.**

Climate change

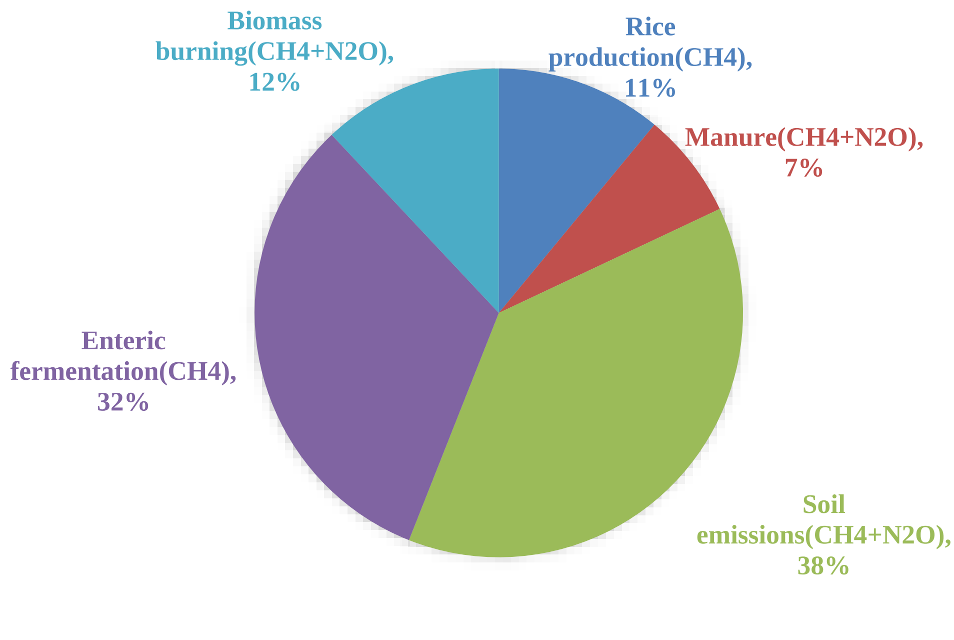
In 2010, the global emission of GHGs was about 50Bt CO_2 eq. in which contribution of India was of about 2.34Bt CO_2 eq. i.e., about 5% of the total emission. Agriculture contributed globally over 11% of the total GHGs emission (Ignaciuk, 2015). The contribution of Indian agriculture was about7% of global emission from agriculture. The energy sector in India contributes the highest amount GHGs (65%) followed by agriculture (18%) and industry (16%) (Fig 1)

An effective contribution of the greenhouse gas (GHG) emissions by agriculture that are causing climate change 18% directly through agricultural tasks and an additional 7% to 14% by land utilization alteration (Ignaciuk, 2015). Different sectors of agriculture that contributes to emission of greenhouse gases. Here maximum emission occurred in case of soil emission (Fig 2).



(Source: Ignaciuk, 2015)

Fig 1. Emission of greenhouse gases from various sectors of Indian economy



(Source: IPCC, 2014)

Fig 2. Contribution of different greenhouse gases by different agricultural sector

Impacts of Climate Change

The hydrologic cycle now includes more frequent and intense droughts and floods in many agricultural regions. These events can damage and at times even destroy crops. Next 30-50 years, average temperatures will likely have enhanced by at least 1.0 °C. Anticipated regionally-dependent changes include increased number of heat waves and warm nights, a decreasing number of frost days, and a longer growing season in temperate zones. Over the next 30-50 years, CO_2 concentrations will increase to about 450 parts per million by volume (ppmv). The CO_2 response is expected to be higher on C_3 species (wheat, rice, and soybeans), which account for more than 95% of world's species than on C_4 species (corn and sorghum). C_3 weeds have responded well to elevated CO_2 levels, symbolizing the potential for increased weed pressure and reduced crop yields. The allocation of wild crop relatives, an increasingly important genetic resource for the breeding of crops, will be badly hampered. Price will enhance for the most important agricultural crops cereals and soybeans. This, in turn, leads to higher feed and therefore meat prices. Hence, climate change will minimize the growth in meat consumption slightly and create a more substantial fall in cereals consumption, leading to greater food insecurity.

Climate change mitigation

Climate change mitigation means to manage the greenhouse gases from emission. Here agriculture contribute a great role to mitigate greenhouse gases by organic fertilizer. Mitigation of climate change, is a human intervention to minimize the sources or improve the sinks of greenhouse gases (Field, 2014). Billions of people, particularly those in developing countries, will confound changes in climate patterns that will contribute to most severe water stress or flooding, and rising temperatures that will cause alter in crop growing seasons. This will enhance food limitation and allocation of disease vectors, putting populations at greater health and life risks. The temperature rises of 1 to 2.5° C by 2030 will have serious impacts, especially in terms of reduced crop yield. The farms productiveness is likely to hamper because of climate change, mainly in the 40 poorest countries in Africa and Asia. Increasing drought periods in many parts of the world and uneven rainfalls will reduce yield stability and put global food production at risk.

As the world demand solutions for facing the changing climates, the importance of mitigating the effects of greenhouse gas (GHG) emissions becomes increasingly important, especially in the agriculture sector which both emits and sequesters GHGs. Agriculture effects approximately onethird of global GHGs emission, emissions from livestock, the production of fertilizers, pesticides, machinery and equipment as well as soil degradation and use change for feed production are taken into account. Organic agriculture can be part of the solution to mitigate GHG gases through farming practices that build soil fertility, avoid use of synthetic fertilizer and enhance carbon sequestration. The GHG emissions from agriculture are broadly due to three gases: nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2). There are six mitigation measures that can assist to mitigation of these gases (Smith *et al*., 2008); 1. Cropland management, 2. Livestock management, 3. Manure/bio-solid management, 4. Bioenergy, 5. Grazing land management/pasture improvement, 6. Management of organic soils and restoration of degraded lands.

A research trial was conducted with organic, inorganic and integrated nutrient management. The experimental farm is situated in the Palam valley of Kangra district in the mid hill sub humid zone of Himachal Pradesh (Malik *et al.,*2014).

The treatments were designed as: T1 (tones Vermicompost + Bio-fertilizer + Chopped crop residues); T2 (1.75 tones Vermicompost + Bio-fertilizer + 67 kg/ha Neem cake + Half Nitrogen +Recommended P and K.); T3 (recommended dose of NPK); T4(Control plot)

Bulk Density

Table 1 showed the range of the data presented lies between 1.29 mg/cm3 to 1.46 mg/cm3 at surface (0- 15 cm) and subsurface (15-30 cm). At 15-30 cm depth the data was recorded to be in-significant in both before sowing and after harvesting soil samples. The highest value was obtained for T_3 (recommended dose of NPK) 1.46 mg/cm3 and lowest value was obtained for T_1 (tones Vermicompost + Bio-fertilizer + Chopped crop residues). And the difference was non- significant between T_3 (recommended dose of NPK) and control plot T_4.

Table 1. Effect of different treatments on bulk density

Bulk density mg/cm3	**Before sowing Depth(cm)**		**After harvesting Depth(cm)**	
Treatments	0-15	15-30	0-15	15-30
T_1	1.21	1.31	1.31	1.41
T_2	1.26	1.36	1.36	1.43
T_3	1.33	1.36	1.43	1.46
T_4	1.19	1.35	1.29	1.44

(Source: Malik *et al.*,2014)

Field Capacity

Table 2 showed the varying amount of field capacity of the various treatments was found to be lie between 23.54% to 30.27%. The highest moisture content at field capacity was observed in T_2(1.75 tones Vermicompost + Bio-fertilizer + 67 kg/ha Neem cake + Half Nitrogen +Recommended P and K.) and lowest (25.16%) in control plot T_4 (Table 2) at sub surface. The integrated treatments gave higher values for field capacity mainly because the integrated use of nutrients improved the soil aggregates and pores spaces which allowed the free movement of water within the soil thereby, increasing the moisture content at field capacity.

Table 2. Effect of different treatments on field capacity

Field capacity(%)	**Before sowing Depth(cm)**		**After harvesting Depth(cm)**	
Treatments	0-15	15-30	0-15	15-30
T_1	26.27	28.85	27.17	28.34
T_2	28.32	29.43	29.18	30.27
T_3	24.82	26.57	25.81	27.30
T_4	22.54	24.59	23.54	25.16

(Source: Malik *et al.*, 2014)

Water Holding Capacity

Table 3 showed the water holding capacity of the various treatments ranged from 56.46% to 60.30%. The data revealed that it was significantly higher (59.43%) at 0-15 cm depth and (60.30 %) value at 15-30 cm for organic treatment T_1(tones Vermicompost + Bio-fertilizer + Chopped crop residues). The T_3(recommended dose of NPK) showed higher value for water holding capacity than T_4(control plot) at both the depths. The effect of organic, integrated and inorganic treatments on water holding capacity is depicted in Table 3.

The higher values obtained in organic treatments T_1 (tones Vermicompost + Bio-fertilizer + Chopped crop residues) and T_2(1.75 tones Vermicompost + Bio-fertilizer + 67 kg/ha Neem cake + Half Nitrogen +Recommended P and K) may be attributed to the organic matter (vermicompost and crop residues) which indirectly contributes to soil texture via increased soil faunal activity leading to improve the soil aggregation and porosity which ultimately increased the number of macro-pores and thus, infiltration rates. The organic matter was found contributing to the stability of soil aggregates and pores through the binding properties of organic material.

Table 3. Effect of different treatments on water holding capacity

Water holding capacity(%)	**Before sowing Depth(cm)**		**After harvesting Depth(cm)**	
Treatments	0-15	15-30	0-15	15-30
T_1	58.28	59.21	59.43	60.30
T_2	54.72	57.56	56.52	58.62
T_3	56.32	58.33	56.46	57.60
T_4	53.30	54.70	56.60	57.60

(Source: Malik *et al.*, 2014)

Permanent Wilting Point

Table 4 shows the range of Permanent wilting point was found to be lie between 15.63% to 20.51% in the various treatments at surface and subsurface levels. The highest (20.51%) value was obtained for T_2 (1.75 tones Vermicompost + Bio-fertilizer + 67 kg/ha Neem cake + Half Nitrogen +Recommended P and K) and lowest (14.22%) value for control plot T_4at surface (0-15 cm) soil. The data was found to be significant for all the treatments in both before sowing and after harvesting samples.

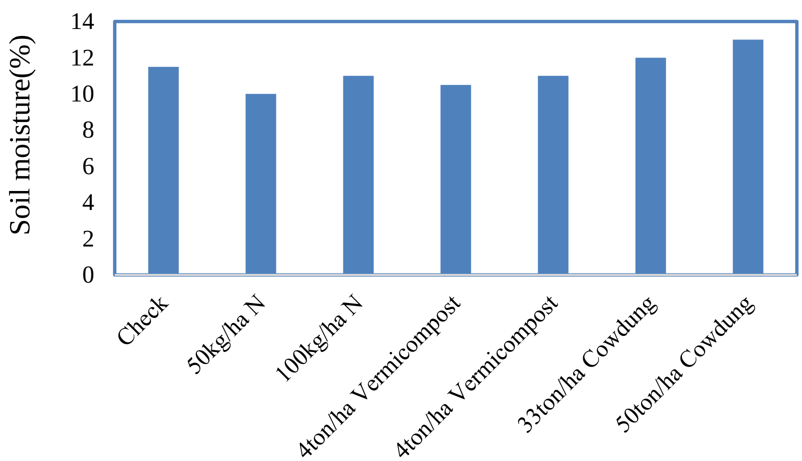
The permanent wilting point percentage was observed to be higher in subsurface soil as compared to surface soil (Table 4). The values for integrated treatment may be stated higher values of water holding capacity and higher organic matter in integrated treatments. Application of organic and inorganic together might have enhanced soil water holding capacity, which has effect on the enhancement of soil permanent wilting point.

Table 4. Effect of different treatments on permanent wilting point

Permanent wilting point(%)	Before sowing Depth(cm)		After harvesting Depth(cm)	
Treatments	0-15	15-30	0-15	15-30
T1	15.83	16.71	16.59	17.52
T2	16.77	18.42	18.77	20.51
T3	15.69	17.45	16.63	18.38
T4	14.22	16.33	15.63	17.50

(Source: Malik *et al.*, 2014)

Another experiment was conducted at Islamic Azad University of Shirvan. Fig 3 showed generally more soil moisture percent observed in cow manure compared with vermicompost and cow dung and the highest soil moisture percent belonged to 33 t/h and 50 t/h cow manure treatments. This is may be for better soil porosity and aggregation that lead to better water infiltration into the soil. Increasing soil water holding capacity by organic matter reported by several scientists (rasoulzadeh and yaghoubi, 2010; mahmoudi, 2008)



(Source: Azimzadeh, 2015)

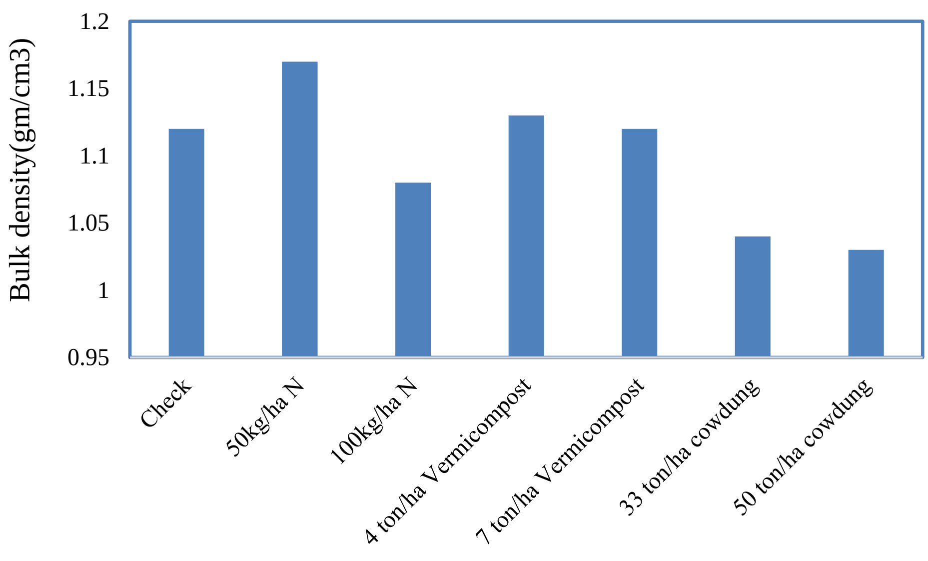
Fig 3. Effect of organic fertilizers in soil moisture (%)

Effect of organic fertilizers on soil bulk density and porosity

Among nitrogen fertilizer treatments soil bulk density in 50 kg/h nitrogen was significantly more. Increasing vermicompost from 4 t/h to 7 t/h decreased significantly soil bulk density by 5.4%. The difference of soil bulk density in 3 levels of cow manure (33 t/h, 50 t/h) were not significant but decrement effect of cow manure was more than all other treatments. According to fig 4 the highest soil bulk density observed in 50 kg/h nitrogen (1.15 g/cm^3 and the lowest soil bulk density observed in application of 50 t/h cow manure (1.03 g/cm^3). Decreasing rate of soil bulk density in 50 t/h cow manure compared with check and 50 kg/h nitrogen fertilizer treatments were 7.2% and 11.2% respectively. More effect of cow manure can attribute to lower small aggregates and better soil aggregates size distribution (Fig 4 and Fig 5). As expected nitrogen fertilizer (50 kg/h) showed higher soil bulk density than all other treatments but lower soil bulk density in 50 kg/k and 100 kg/h nitrogen may be being because of more root canal in these treatments. Several reports indicated positive effect of organic matter on soil physical properties.

Rasulzadeh and Yaghubi (2010) reported that cattle manure decreased soil bulk density and increased soil porosity because of better soil aggregation. They also reported that application of cattle manure restores the damaged soil structure by increasing its organic carbon, infiltration, hydraulic conductivity, size of aggregates.

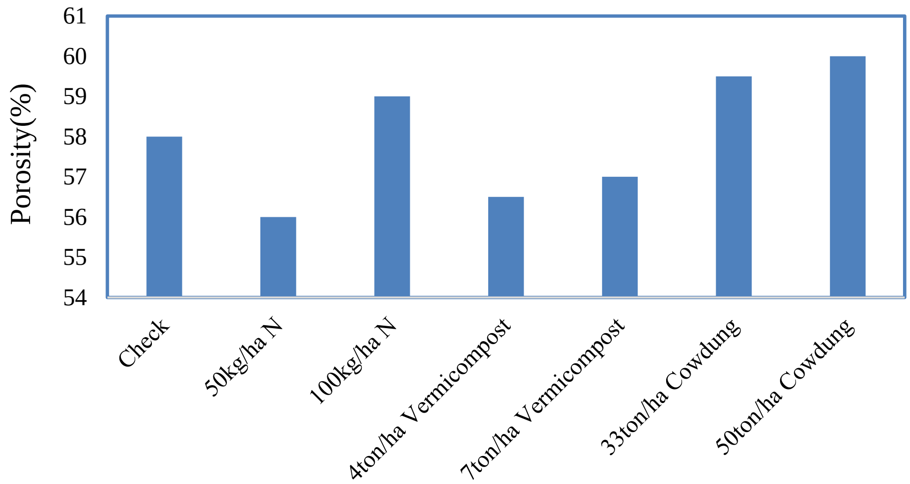
It had been shown that application of organic matter improved soil properties such as aggregation, water-holding capacity, soil bulk density, porosity and resistance to water and wind erosion (Franzluebbers,2002). Azimzadeh (2002) also reported lower soil bulk density in surface layer of soil in conservation tillage system because of higher organic carbon in conservation tillage systems.



(Source: Azimzadeh, 2015)

Fig 4. Effects of different organic approaches to soil bulk density

Fig 5 showed the variation of soil porosity under the effect of these treatments were exactly opposite with bulk density. Application of 50 t/h cow manure showed the highest porosity (fig 5) and the lowest soil bulk density (Fig 4). Using 50 kg/h nitrogen showed the lowest soil porosity (Fig 5) and the highest soil bulk density (Fig 4). Organic manure can improve soil physical properties through decreasing soil bulk density and better porosity and soil aggregation. As indicated the best effect on soil bulk density and porosity belonged to cow manure treatments.



(Source: Azimzadeh, 2015)

Fig 5**.** Impact of different organic manure to soil porosity (%)

Crop Yield

Table 5 showed the results on the grain yield ranged from 1.33 tones/ha to 2.16 tones/ha. The data for grain yield was found to be significant and maximum (2.13 tones/ha) for T_1 (tones Vermicompost + Bio-fertilizer + Chopped crop residues) and minimum (1.33 tones/ha) for control plot T_4. Among the organic treatments T_1 gave the highest (2.13 tones/ha) grain yield and $T_4$the chemical treatment gave grain yield of (1.33 tones/ha).

The high yield obtained for T_1treatment might be due to the integrated nutrient sources provided. The integrated sources made the continuous availability of nutrients from both organic and inorganic sources.

Straw yield

The data obtained for straw yield was maximum (4.76 tones/ha) for T_2 (1.75 tones Vermicompost + Bio-fertilizer + 67 kg/ha Neem cake + Half Nitrogen +Recommended P and K) and minimum (2.16 tones/ha) for control plot T_4 (table 5). This might be happened due to integrated nutrient sources.

Table 5. Effect of different treatments on yield

Yield(ton/ha)		
Treatments	Crop Yield(ton/ha)	Straw Yield(ton/ha)
T_1	2.13*	4.33*
T_2	2.10*	4.76*
T_3	1.33	3.70
T_4	1.33	2.16

(Source: Malik *et al.*, 2014)

The organic fertilized soils had higher organic C contents than the control soils after 365 days (table 6). The soil with the fermented manure fertilizer had the highest C content (2.87%). The organic fertilizers increased the levels of C in the soil, which leads to an increase infertility because of an increase in microorganism activity using C as energy source (Saldana,2014). Compared to the control, organic fertilizers also increased the N content in soils (table 6). The largest increase in soil N was with the fermented manure (0.26%). According to Wu*et al*. (2005), the application of organic fertilizer increased the N content in soil because of the greater N and organic C concentration in the fertilizer. The available P content in soil increased significantly with the application of fermented manure compared with the control. The average total N content increased up to 16%after 365 days with the use of organic fertilizers. Fermented manure conserved higher soil levels of total N than the control. Compared with the control, the organic fertilizers maintained a higher soil content of available P. The vermicompost conserved high P levels in the soil (58higher than the control, respectively). Organic fertilizers increased the availability of P because as the organic component decays it releases CO_2, and higher CO_2 concentrations would increase the decomposition rate of phosphate minerals and thereby increase the available P in the soil. These minerals synthesize phospho-humic complexes that are available to the plant and allow for the exchange of organic radicals by phosphates.

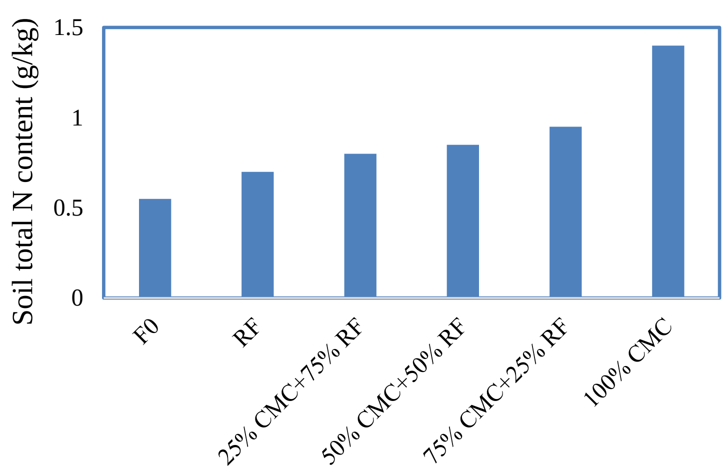
According to table 6, all of the treatments increased K content in the soil. Saldana *et al*., (2014) suggested that K lixiviation is normal because K is a very mobile element in the soil; K provided by composts, sometimes higher than 85%, is an alternative to compensate for losses by leaching. The capacity of fermented manure, vermicompost and compost to supply nutrients to the soil occurs because they have the highest active mineralization rates (Saldana *et al*., 2014).

Table 6. Organic carbon and nutrient contents in the soil with organic amendments 365 days after application

Treatments	Organic C(%)	Total N(%)	Available P(mg/kg)	Exchangeable K(cmol/kg)
	365d	365d	365d	365d
Control Plot	2.39	0.22	5.19	0.32
Compost	2.41	0.21	7.58	0.37
Vermicompost	2.25	0.21	12.49	0.50
Fermented Manure	2.87	0.26	12.09	0.34
Chemical Fertilizer	2.35	0.21	10.94	0.31

(Source: Saldana *et al.*, 2014)

Soil total N Content Fertilizer management also showed statistically significant effect on soil total N content (Fig 6). Without any fertilizer such as in the case of control plot, the soil total N decreased by 24% compared to the initial value in 2009. The soil total N in the plots treated with only recommended fertilizer slightly decreased by 8%. However, the soil total N in the plots fertilized with CMC alone or combined with recommended fertilizer increased in varying degrees (Fig. 6). At the same total N, P, K application rate, when the ratio of cattle manure compost increased, the soil total N in the topsoil (0–20 cm) also increased. When the ratio of CMC input was more than 50%, the soil total N content was significantly greater than those treated with merely CF (Fig. 6). These results indicated that application of organic manure alone or combined with CF could increase nitrogen use efficiency.



(Source: Guo *et al.*, 2016)

Fig 6. Effect of organic manure to increase the total

Table 7 shows some selected soil chemical properties of the soils used for the study after 6 weeks. Among the treatments, 120 kg N/ha and 120 kg N/ha + 3t/haBiochar showed the least pH. The low pH observed is due to acidification resulting from dissociation of urea to produce H+ ions. The results show that 120 kg N/ha is too high an application rate for the soils studied. At low pH, P fixation is enhanced resulting in low plant growth. The high cost of inorganic fertilizers and the low biomass yield from high inorganic N application indicates that such application rate is not economical. Besides smallholder farmers are not in a position to apply at such rate. The application of lime may be necessary to increase soil pH under such management scenario. Resource poor farmers in developing countries however, cannot apply adequate amount of lime. Under this condition, the use of limited amount of lime along with nutrient efficient and elemental toxicity resistant plant species or genotypes within species is a complimentary solution for improving crop productivity on acid soils. The total N ranged from 0.16% in the control unamend treatment to 0.20 in the 3t/ha biochar + 4t/ha Cattle manure treatment.

Table 7. Effect of different biochar doses for improving soil chemical properties

Treatments	Soil PH	Organic C	%N	K
Control	5.49	1.23	0.16	0.16
Control + 3t/ha Biochar	5.49	1.33	0.18	0.18
120 kg N/ ha	5.22	1.26	0.19	0.16
120 kg N/ha + 3t/ha Biochar	5.23	1.34	0.18	0.20
4 t/ha Manure	5.53	1.23	0.20	0.16
4 t/ha Manure + 3t/ha Biochar	5.54	1.26	0.18	0.13

(Source: Yeboah *et al*., 2009)

Another study concluded that organic fertilizer nourishes the microorganism and increases their number. For this reason, chicken manure gave the highest number of microorganism than the others (Lin *et al*., 2010).

Table 8. Number of microorganism in different treatment

Treatments	Bacteria (unit/g)	Epiphyte (unit/g)	Actinomyces(unit/g)
Control plot	5.35×10^{6}	2.40×10^{5}	6.60×10^{5}
Inorganic fertilizer	6.10×10^{6}	4.00×10^{5}	5.70×10^{5}
Cattle manure	5.40×10^{6}	2.20×10^{5}	8.15×10^{5}
Organic compound fertilizer of monosodium glutamate	3.80×10^{6}	5.95×10^{5}	8.05×10^{5}
Chicken manure	2.85×10^{7}	1.95×10^{6}	3.95×10^{6}

(Source: Lin *et al*., 2010)

A field experiment was conducted at the Eco-Farm Research Station of Shandong Agricultural University, based in Pingyi County, Shandong Province, Eastern China.

The Treatments were designed as: (1) Without any fertilizer(F_0); (2) Recommended fertilizer(RF); (3) 25% Cattle Manure Compost(CMC)+75% of recommended fertilizer; NPKM1; (4) 50% Cattle Manure Compost(CMC)+50% of recommended fertilizer; NPKM2; (5) 75% Cattle Manure Compost combined(CMC)+25% of recommended fertilizer NPKM3; (6) 100% Cattle Manure Compost(CMC).

The 5-year application of cattle manure compost (CMC) combined with chemical fertilizer (CF) at various rates had statistically significant effect on soil organic matter (SOM) content as well as SOC content (Table 9). Compared with control plot(F_0), SOM in all the plots fertilized with CMC has been increased by 28%, 46%, 74%, and 87% at 0–20 cm soil depth, with the greatest SOM content being noted in soil fertilized with CMC alone. Recommended fertilizer had no statistically significant effect on SOM accumulation (Table 9).

Table 9. Effect of organic manure in increasing soil organic matter

Treatments	Soil organic carbon(%)	Soil organic matter(%)
Control plot (F_0)	0.78	1.34
Recommended Fertilizer (RF)	0.82	1.41
25% CMC+75% of RF	0.99	1.71
50% CMC+50% of RF	1.13	1.95
75% CMC+25% of RF	1.35	2.33
100% CMC	1.46	2.51

(Source: Guo *et al.*, 2016)

Mitigation of Nitrous Oxide Emission

Nitrous oxide is produced in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N_2). Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a byproduct of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic N in soil through additions of synthetic or organic fertilizers, manure, crop residues, sewage sludge or mineralization of N in soil organic matter following drainage/management of organic soils and cultivation/land-use change on mineral soils. Options for reducing N_2O emission from soil includes enhancing N use efficiency and reducing loss of applied N in soil, using organic manure etc.

Mitigation of Methane Emission from Rice Fields

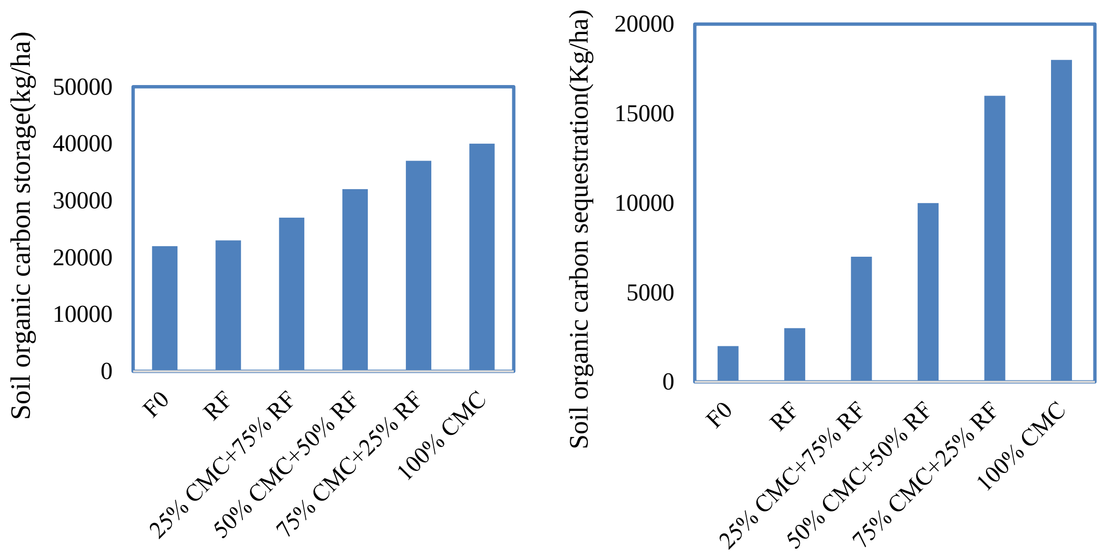
Methane is produced in soil during microbial decomposition of organic matter under anaerobic conditions. Rice fields submerged under water are the potential source of CH_4 production. Possible measure to reduce the emission of methane is to improve organic matter management by promoting aerobic degradation through composting or incorporating it into soil during off-season drained period.

Another study concluded that Organic carbon storage in the top soil (0-20 cm) was found to be significantly higher in 25% Cattle Manure Compost(CMC)+75% of recommended fertilizer, 50% Cattle Manure Compost(CMC)+50% of recommended fertilizer, 75% Cattle Manure Compost combined(CMC)+25% of recommended fertilizer. But 100% CMC is in highest position than others. 100% CMC found to be considerably higher in the plots fertilized with only CMC. The finding clearly supports the hypothesis that organic fertilization has positive impacts on SOM, soil organic carbon storage and sequestration. In this study, the above-ground biomass was removed from field plots, so there were no crop residues incorporated into the soil. Thus the input of organic carbon mainly came from root biomass and CMC (Fig 7).

After 5 years of fertilizer managements, the Soil Organic Matter (SOM) in all plots increased. However, for recommended fertilizer and control plot(F0), the SOM increased slightly, with the former being higher. A 9-year experiment (2000–2008) indicated that long-term organic fertilizer applications slightly increased soil organic matter content in the same plot, however SOM decreased in plots without fertilizer application (Celik*et al*., 2010). It was once reported that carbon input was significantly increased from root biomass under the N treatment compared with the control plot; however, neither organic carbon concentration nor carbon storage was significantly changed under the merely N treatment (Lou *et al*., 2011).

These results indicate that root biomass as carbon source input does not significantly affect the changes in the soil organic carbon storage. Nevertheless, still some argued that significant increases in organic carbon concentration or storage might also happen under chemical N fertilization alone management (Purakayastha*et al*., 2008). Those differences seem to mainly depend on the added N rate, the crop residue management and the tillage regime (Su *et al*., 2006).

There were significant and positive correlations were noted between CMC (Cattle Manure Compost) and SOM (Soil Organic Matter), indicating the carbon supplementation occurred to soil with the manure compost. CMC alone or combined with CF significantly increased SOM, which generally increased before the soil is C-saturated (Fig. 7). Therefore, organic manure might be the most important carbon source to restore SOM. In the investigation here, significant and positive correlations were noted between CMC and SOM, indicating the carbon supplementation occurred to soil with the manure compost. CMC alone or combined with CF significantly increased SOM, which generally increased before the soil is C-saturated (Fig.7). Therefore, organic manure might be the most important carbon source to restore SOM.



(Source: Guo *et al*., 2016)

Fig 7. Effect of different treatment in reducing greenhouse gas emission

Table 10 showed the amount of carbon dioxide that has the potential to be captured if all the agricultural waste from biomass was converted to biochar to form carbon sinks. Corn is mainly produced by the United States and China, and based on the experimental data, yields the best conversion of total potential carbon thus the largest amount of carbon dioxide capturing (Allyson,2011).

Table 10. Carbon sequestration by different biochar

Biomass	**Million tons/Year 2009**	**Total Bio char(Million tons)**	**Total potential carbon in Bio char(Million)**	**CO_2reduction (million tons)**
Rice	678	226.04	93.85	275
Peanuts	29	12.25	8.57	25.1
Manure	900	330.21	108.9	319
Cob	817	200.32	150.4	441
Husks	250	77.23	39.38	115

(Source: Allyson, 2011)

CHAPTER IV

CONCLUSION

Bangladesh's economy is extremely subjected to its agricultural sector. To feed a large number of population, we must adopt sustainable technology to increase the yield with less number of cultivable land. Agriculture faces great challenges to climate change, loss of biological diversity, loss of soil fertility, water shortage, soil erosion, land degradation soil and water pollution, depletion of soil organic matter, water logging, increased soil salinity, acidification and deforestation. These constraints can be controlled by organic fertilizer. The application of Vermicompost + Bio-fertilizer + Chopped crop residues is the possible measure for sustainable land management by improving soil physical properties and yield. Vermicompost & fermented manure increases the chemical properties. Chicken manure drastically increase the soil microorganism. Another study concluded that, application of 50ton/ha cow dung can have the positive impact on soil porosity, bulk density and porosity. Sustainable land management is largely dependent on soil fertility & productivity. Soil fertility & productivity is totally depending on soil organic matter. 100% cattle manure compost can increase the soil organic carbon storage and soil carbon sequestration. Our agriculture faces serious loss due to climate change day by day. To reduce greenhouse gases (CO_2& NO_2), application of biochar and 100% cattle manure compost have great contribution. So it can be recommended that vermicompost, 100% cattle manure compost, fermented manure, 33ton/ha cow dung and Biochar can be applied in our agricultural soil to achieve sustainable land management as well as climate change mitigation.

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