Original Research Article

Enhancement of soil chemical properties through long term manuring and nitrogen fertilization in Bangladesh

ABSTRACT

Organic fertilizers are enriched with plant nutrients which may enhance the soil chemical properties. However, studies on the effect of long term manuring on soil properties is yet lacking in Bangladesh. Therefore, the present study was carried out to quantify the changes of chemical properties because of long term manuring and nitrogen fertilization in Salna silty clay loam soil under rice-wheat cropping system. The experimental plot received different organic materials for the last 26 years (1988-2014). The organic materials cowdung, compost, green manure and rice straw were applied at the rate of 25, 25, 7.5 and 1.5 t ha^{-1}, respectively in a yearly sequence. Three levels of nitrogen viz. 0, 75 and 100 kg ha^{-1} for rice and 0, 80 and 120 kg ha^{-1} for wheat were applied. Long-term application of organic materials significantly increased soil organic carbon and total N, Ca, S and decreased pH and P availability. Increase in soil organic carbon was found the highest under green manure and the lowest in rice straw applied soil. The green manure contributed to the maximum accumulation of soil nitrogen.

Keywords: Organic amendments, cowdung, compost, nitrogen fertilizer

1. INTRODUCTION

Most of the cultivable lands are degraded day by day due to indiscriminate use of agro-chemicals, luxury irrigation, intensive cropping with high yielding varieties, little or no use of organic materials and improper soil management practices, which causes deficiency of nutrient elements in the soil (Lal, 2008). As a result plants suffer from inadequate supply of nutrients which are manifested through poor crop performance. So, there is a need for addition of nutrients from the external source for better plant growth and higher yield. Application of organic materials results in a significant increase of SOC content, which demonstrates a positive role of organic amendments in soil conservation especially in tropical and subtropical climatic conditions (Alam et al., 2019).

But use of only inorganic fertilizer for a long period causes deterioration of physical condition, organic matter status and reduces crop yield. In such case, the use of organic manure has greatest benefits in soil health. Long term application of organic manure increases organic carbon, total nitrogen, available phosphorus, exchangeable Ca, K. So, combined application of organic manure and inorganic nitrogen fertilizer improves soil conditions and productivity. The available P, S and exchangeable K contents in post-harvest soil increase positively as compared to initial soils and significant positive influence on the enrichment of physiochemical properties of wetland paddy soil was reported by (Alam et. al 2019).

Most of the soils of Bangladesh are deficient in organic matter. Farmers don't apply organic matter regularly but they are only concerned about the application of N, P and K fertilizers. Moreover, the warm climate and the intensity of cultivation increase the decomposition rate of organic matter (Montemurro *et al*., 2007). By contrast, the build-up of organic matter in soils is a process much slower and more complex than its decline (Van-Camp *et al*., 2004). Zuazo and Pleguezuelo (2008) confirmed that reduced precipitation or increased temperature accelerates land degradation through the loss of soil organic carbon storage.

Rice-wheat cropping system is the most adopted and vital cropping system for achieving food security in Asia (Singh *et al*., 2007) and sustainability of this system is very important. To improve or to sustain the productivity of rice-wheat system in Bangladesh, Bhuiyan *et al*. (1993) recommended the long-term evaluation of the use of organic manure or green manure for maintaining soil fertility. So long term application of organic manure perhaps the best step to maintain the soil health in our climatic conditions. But such a step in Bangladesh is still meager.

Considering the above facts an experiment was initiated in 1988 to study the effect of long term manuring along with three doses of nitrogen on soil chemical properties. Soil nutrients data were obtained conducting the experiment in 2014.

2. MATERIALS AND METHODS

2.1 Study site

The current study is a part of long-term manuring experiment that started in July, 1988 with T. aman rice-wheat cropping sequence at Bangabandhu Sheikh Mujibur Rahman Agricultural University. The experimental farm is located in the center of the Agro-ecological Zone (AEZ) of Madhupur Tract (AEZ-28) at about 24.23°North Latitude and 90.08° East Longitude having a mean elevation of 8.4m above mean sea level and about 40 km north of Dhaka. The climate of the location is tropical monsoon. In the present experiment, soil properties were studied after 26 years of the LTE. The land selected for the long-term experiment had been a virgin land where no crop was grown before. The soil belongs to Salna series representing the Shallow Red Brown Terrace and is classifed as Inceptisols according to USDA Taxonomy (Brammer, 1978 and FAO, 1988). The soil is characterized by heavy clays within 50 cm from the surface and is acidic in nature. Some basic chemical properties of the soil, prior to setting the LTE, are presented in the Table 1.

Table 1. Chemical properties of initial soil (0-15 cm) of the long-term experimental plot (Islam, 2003)

Parameters	1988	2003
pH	5.60	5.88
Organic carbon (%)	0.42	0.30

....include eight treatments, five for different organic....... and three for nitrogen.....

Total nitrogen (%)	0.03	0.05

The soil data of the present study were compared with the data found in 2003.

2.2 Experimental design

The experimental design of the study was in a factorial randomized complete block design with two replications and plot size was 12m × 7m. The factorial experiment included five different organic materials treatments (application of cow-dung (CD) @ 25 t/ha, compost @ 25 t/ha, green epilipile leaves @ 7.5 t/ha, rice straw (RS) @ 1.5 t/ha, no manure application) and three nitrogen treatments (For rice 0, 75 and 100 kg N/ha and for wheat 0, 80 and 120 kg N/ha). The high yielding rice variety BRRI dhan39 and wheat variety BARI Gom 24 (prodip) were used as the test crops. Seeds were collected from Bangladesh Agricultural Development Corporation (BADC). One week after proper paddling the field, twenty-five-days old seedlings of BRRI dhan39 were transplanted maintaining a spacing of 25 cm × 20 cm and wheat seeds were directly sown in 18th November 2013 in continuous lines having the line to line distance of 20 cm. Fertilizer doses of P and K were applied as triple super phosphate (TSP)and muriate of potash (MoP) at the rate of 44.05 and 66.67 kg ha-1).The whole amount of TSP, MoP and gypsum was applied during final land preparation. Urea was applied in three equal splits at final land preparation, 15 days after transplanting (DAT) and 5-7 days before panicle initiation stage. At maturity BRRI dhan39 was harvested in 28th September 2013 and BARI Gom 24 was harvested in 20th March 2014.

2.3 Soil sampling and analysis

After harvesting of wheat soil samples from each plot were collected from 0-15 cm depth.. Chemical properties of soil were analyzed using standard methods such as soil pH was determined by using a glass electrode pH meter as outlined by Jackson (1973), Total organic carbon was estimated by wet oxidation method devised by Walkley and Black (1935), Total nitrogen was determined by Kjeldahl Method described by Jackson (1973), Available phosphorus was determined by Bray and Curtz (1945) method, Exchangeable potassium was determined by Jackson (1973), Exchangeable calcium and magnesium was determined by ammonium acetate extraction method described by Black (1965), Available sulphur were determined by turbidimetric method described by Black (1965).

2.4 Statistical analysis

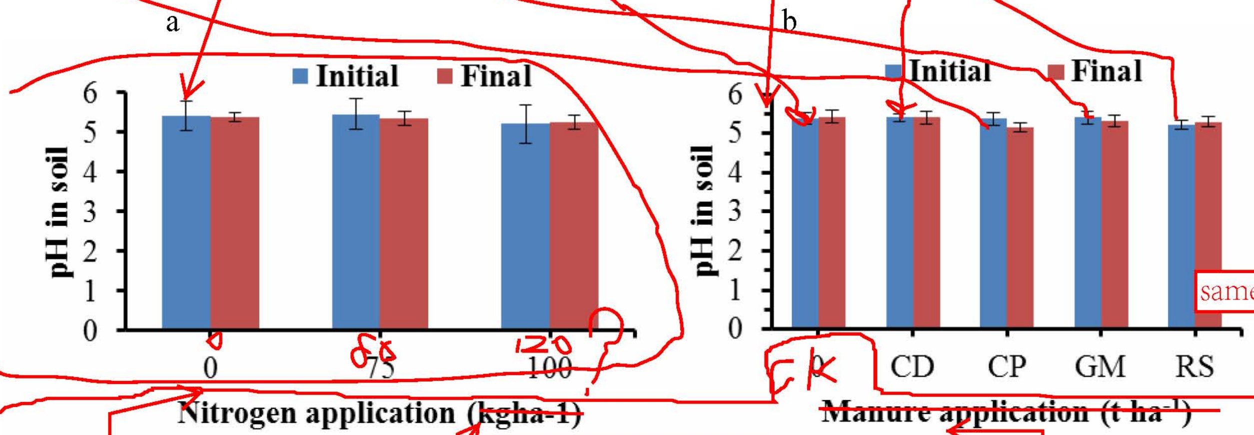
No ANOVA and means comparison results in the text.

Data were statistically analyzed using statistics10.0 software. ANOVA and univariate analyses were performed to test all parameters. Treatment means were separated by least significant difference (LSD). Different graphs were prepared using Microsoft Excel (Office 2007).

3. RESULTS AND DISCUSSION

3.1 Soil pH

In 2003 the initial pH of soil was 5.80 in control plot (No manure), 5.91 in cowdung treated plot, 5.94 in compost treated plot, 5.90 in green manure treated plot and 5.88 in rice straw treated plot



(Figure 1). After long-term application of organic manure soil pH decreased in all treatments over the initial value. The pH values of control, cowdung, compost, green manure and rice straw treated plots were 5.42, 5.41, 5.16, 5.33 and 5.30, respectively which decreased over the initial

Figure 1. Combined effect of long-term application of N and OM on soil pH

value. Chang *et al.* (1991) found that soil pH decreased with increasing rate of manure application. Ghuman and Sur (2006) stated that the effect of manuring on soil properties and yield of wheat obtained significant decrease of 3.0 units in soil pH in the plots green manured for five years. Whenever organic manure added to the soil, pH decreased due to the formation of different organic acid that are incorporated into the soil at the beginning of the manure decomposition.

3.2 Total organic carbon

The initial organic carbon of soil (2003) in long-term experimental plot was 0.30% in control plot (No manure), 0.35% in cowdung treated plot, 0.35% in compost treated plot, 0.33% in green manure treated plot and 0.34% in rice straw treated plot (Figure 2). Due to application of fertilizer and manure during the last 26 years, the amount of soil OM increased in all treatments over the initial value. The reasons for increasing the OM in soil might be the addition of organic residues and manures, and also crop residues that remained in the field after harvest. The organic carbon values of control, cowdung, compost, green manure and rice straw treated plots were 0.75, 0.83, 0.90, 0.95 and 0.76%, respectively. An observation over the data showed the highest value of organic carbon (0.95%) in green manure treated plot (Figure 2).

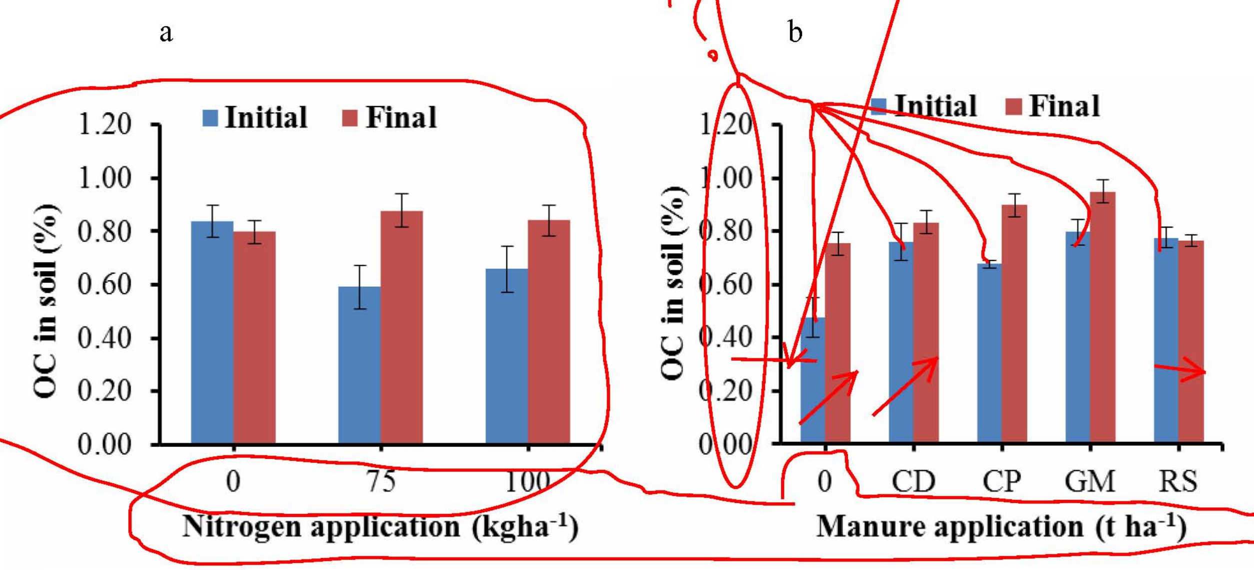


Figure 2. Combined effect of long-term application of N and OM on OC content of soil

The results indicated that the long-term application of organic manure could enrich total organic carbon of soil. Mandal *et al.,*(2003) found that the total organic carbon was higher under green manuring treated plots than fallow. Similar results were also found by Mehla *et al.,* (2008) who stated that continuous rice-wheat cropping for eight years with press mud and FYM amended treatments significantly increased the organic carbon content of soil from its initial status.

3.3 Total nitrogen

Long-term manuring increased the total N content in soil (Figure 3). The initial soil contained 0.07% N in the control plot (No manure), 0.08% in cowdung and compost, 0.09% in green manure and 0.07% in rice straw treated plots. In the present study, the total N percentage increased over the initial value due to fertilization and long-term manuring for the last 26 years. The highest value of nitrogen (0.13%) was found in the green manure treated plot and lowest (0.08) in the control after long-term manuring. Long-term fertilizer experiment conducted by Santhy *et al.,*(1998) at Tamil Nadu, India, since 1972found that the inclusion of farmyard manure with inorganic fertilizers maintained the highest available N. Mehla *et al.*, (2008) reported that the balanced application of N, P, K and Zn with and without organic

<0.06%

No mentioned in text

amendments increased the available N status of soil over their initial status. Nitrogen is the most limiting plant nutrient in all ecosystems. Regular application of nitrogen using both organic and inorganic sources might ensure a good supply of this nutrient for better crop production and soil health.

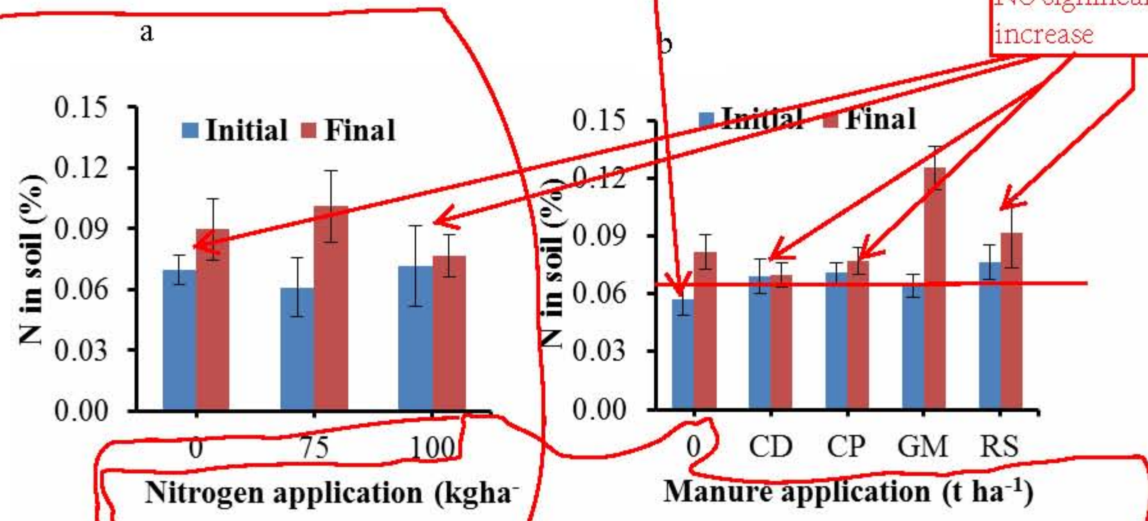


Figure 3. Combined effect of long-term application of N and OM on Total N content of soil

3.4 Available phosphorus

Long-term manuring has significant effect on the total P content in soil (Figure 4). Initial soil contained 27.52 mg P/kg soil in the control plot which was similar to rice straw treated plot, 26.26 mg P/kg soil in compost and green manure and highest P content was found in cowdung treated plot.

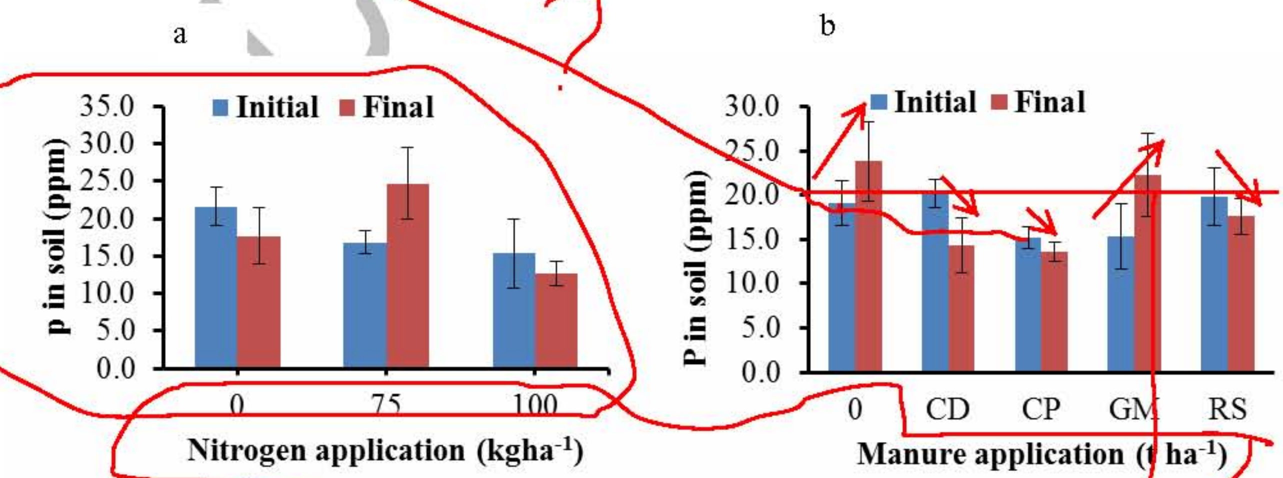


Figure 4. Combined effect of long-term application of N and OM on P content of soil

After long-term manuring the available P content decreased in all the treatments over the initial value. It might be due to higher uptake of P for the higher biomass yield. In an experiment Schlegel (1992) showed that soil P and K increased linearly with increased rates of beaf cattle manure compost. Conversely, increased rates of N fertilizer decreased soil P and K.

3.5 Exchangeable potassium

The exchangeable K^+ content of soil decreased over the initial level during the last 26 years. Exchangeable K^+ content was increased in the control plot. But in cowdung, compost and green manure treated plot the exchangeable K^+ content were 0.21 to 0.24 cmol/kg which decreased from 0.15 to 0.18 cmol/kg (Figure 5).

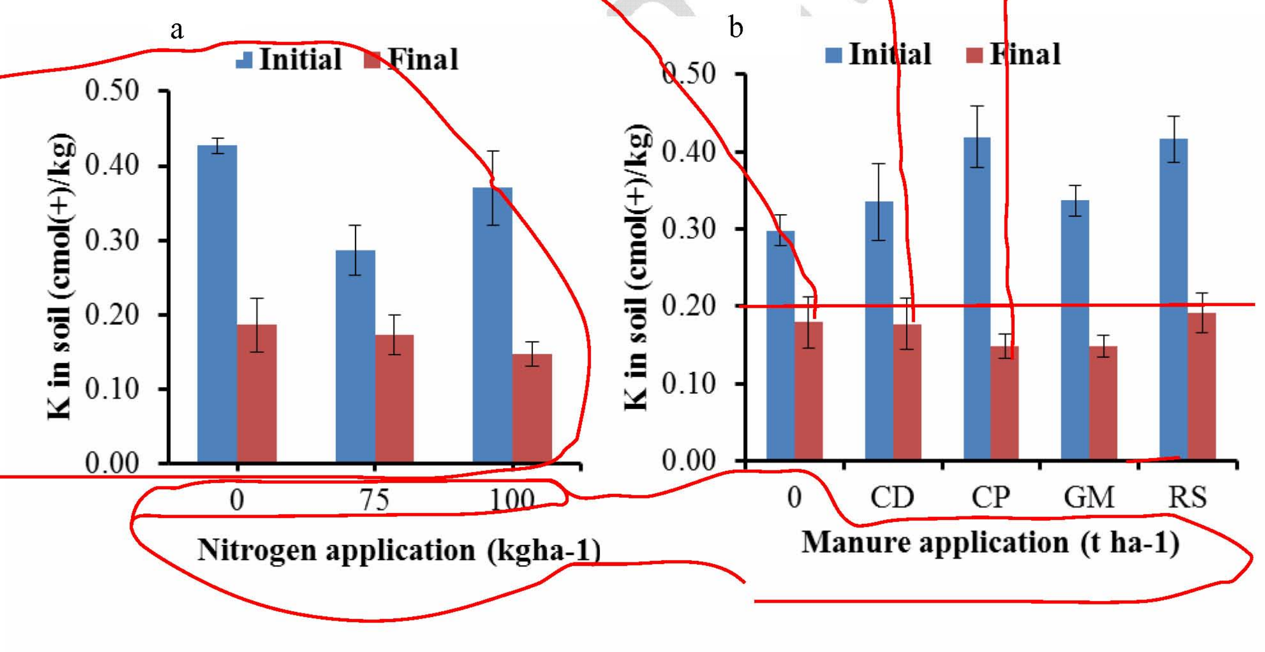


Figure 5. Combined effect of long-term application of N and OM on K content of soil

This showed that due to 26 years of long-term fertilization and cropping, the status of potash decreased than the initial value. Mian (1991) found that the NH_4^+ formed due to hydrolysis of urea displaced K^+ from exchange sites. As a consequence, K^+ content decreased. A nutrient balance indicated a severe loss of K^+ from BAU farm soil each year due to weathering of soil material (Mian and Moslehuddin, 1999). The decrease in K^+ content over the initial status might be the effect of luxury consumption of K^+ by the crops from the experimental field. Crop removal accounts for the largest loss of K from the soil.

3.6 Exchangeable calcium

The effect of long-term manure application was more pronounced in case of Ca availability in soil (Figure 6). The initial soil (2003) contained 3.06 cmol kg^{-1} Ca in control plot and 4.04 to 4.33 cmol kg^{-1} in cowdung, compost and green manure plot. After long-term fertilization the available Ca content increased from 7.88 to 8.82 cmol kg^{-1} in all the treatments over the initial value. Results of four year experiment studied by Patiram and Singh (1993) depicted that exchangeable Ca^{+2} of soil were increased and the exchangeable Al^{+3} decreased by the application of manure.

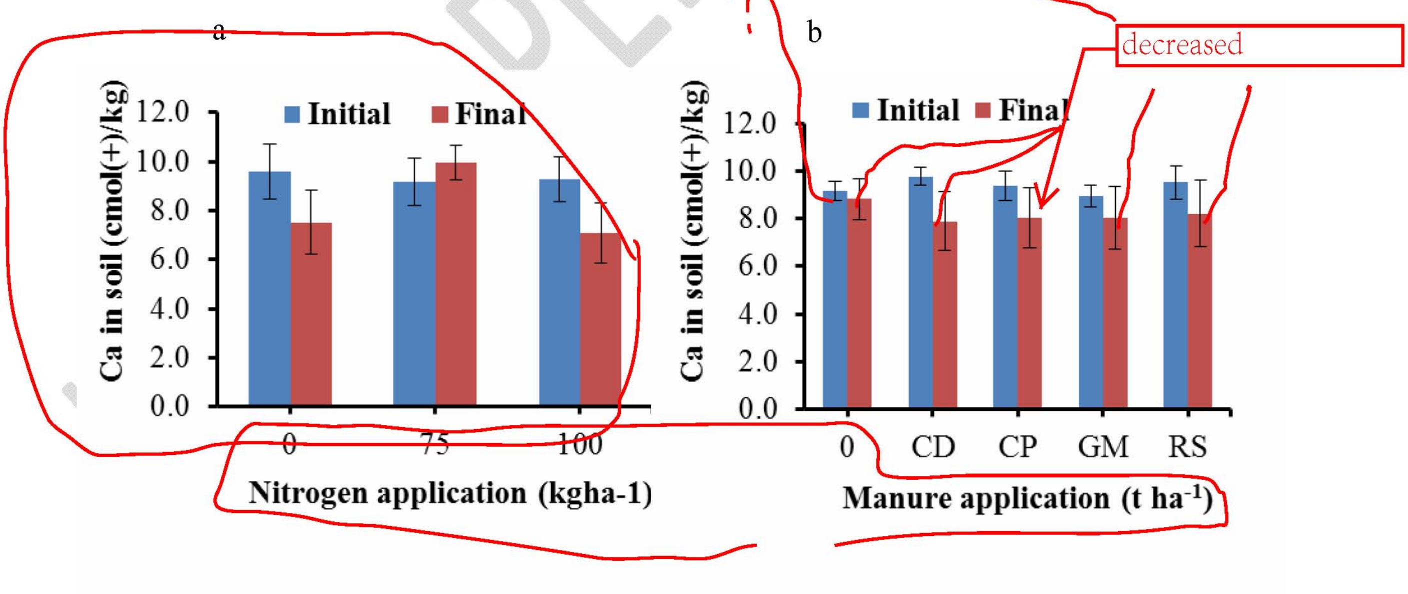


Figure 6. Combined effect of long-term application of N and OM on Ca content of soil

3.7 Exchangeable magnesium

The exchangeable Mg content of soil was slightly decreased over the initial value after long-term fertilization. Exchangeable Mg content was increased in control plot. But in cowdung, compost and green manure treated plot the exchangeable Mg was 1.97 to 2.09 cmol kg^{-1} which slightly decreased from 1.83 to 1.86 cmol Kg^{-1} (Figure 7). In contrast, Wong *et al.* (2001) found that addition of manure compost increased exchangeable Mg content in the amended soil.

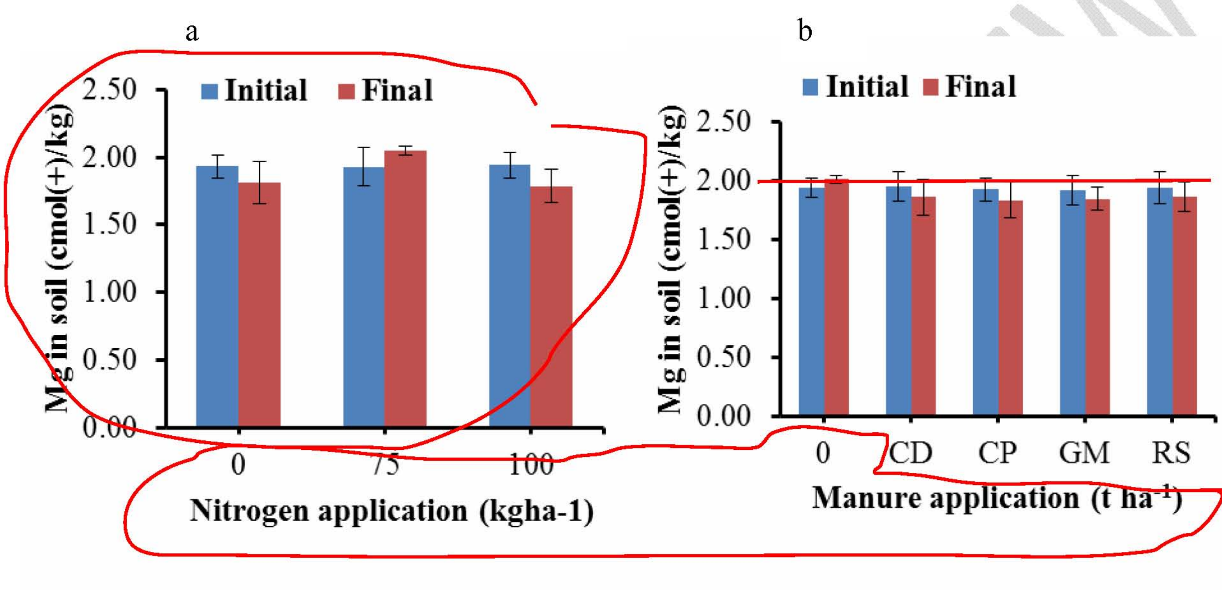


Figure 7. Combined effect of long-term application of N and OM on Mg content of soil

3.8 Available sulphur

Long-term application of manure increased sulphur content in soil (Figure 8). Sulphur contents initial soil (2003), cowdung, compost and green manure treated plots ranged from contained 21.07 to 27.79 mg kg^{-1}. After 26 years of long-term manuring S contents increased,which ranged from 28.87 to 33.38 mg kg^{-1}. The highest available S content (33.38 mg kg^{-1}) was recorded in rice straw treated plot and lowest in the control plot. As about 90% of the soil sulphur is derived from organic source, which might be the major reason for the development of the sulphur content in organic manure treated plots. The result obtained in this study was supported by the findings of Sherchan and Gurung (1998).

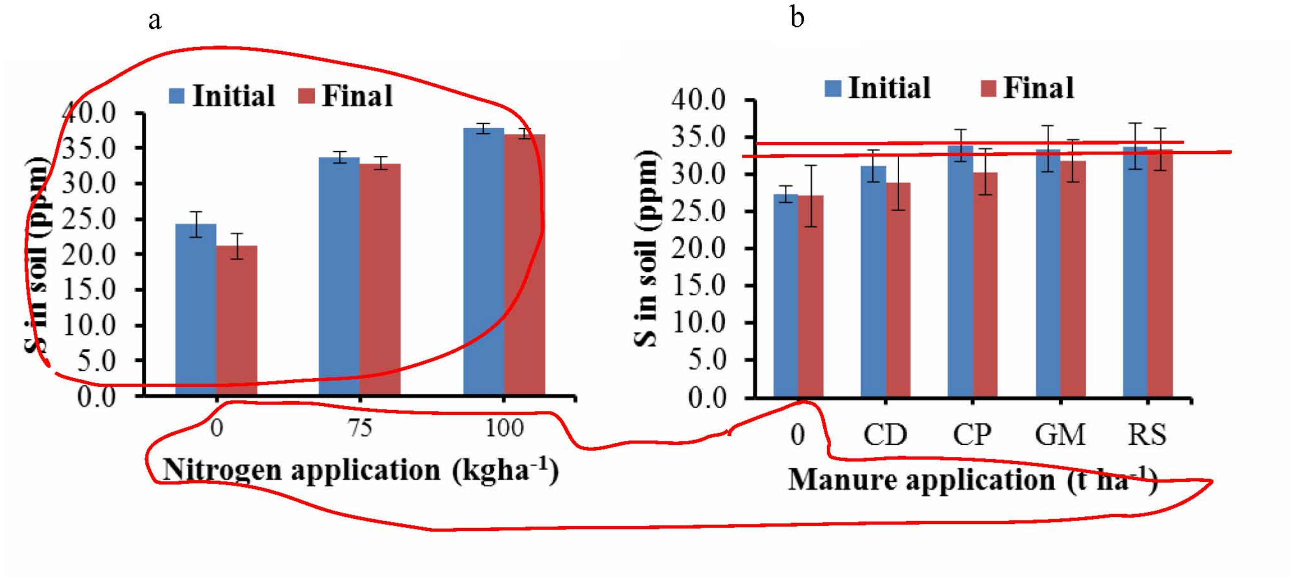


Figure 8. Combined effect of long-term application of N and OM on S content of soil

No any support ?

except RS, and why? and why increased in CK

4. CONCLUSIONS

Long-term application of organic manure significantly increased total organic carbon, nitrogen in soil, exchangeable Ca, available S. GM plays a significant role in increasing organic carbon and nitrogen in soil. Whereas, nitrogen and organic carbon content in soil was found the highest when soil was treated with green manure. Significant amount of available sulphur was found in rice straw applied soil. But soil pH lowered and P availability decreased due to long-term manuring. Combined application of inorganic and organic fertilizer might improve soil health and show positive impact on ecosystems and environment.

CK also increased,why?

REFERENCES

Black, C.A. 1965. Methods of Soil Science Analysis Part I and II. *J.Am. Agron.Soc. Ins.*Publisher Madison. Wiscon. U.S.A. 57(7): 472-475.

Brammer, H. 1978. Rice Soils of Bangladesh. *In:*Soils and Rice. Manila, Philippines. The IRRI. pp. 35-55.

Bray, R.H. and Kurtz, L.T. 1945. Determination of total, organic and available forms of phosphorus in soils. *J.Soil. Sci.*59:39-45.

Chang, C., Sommerfeldt, T.G. and Entz, T. 1991. Soil chemistry after eleven annual applications of cattle feedlot manure. *J. Environ. Qual.* 20: 475-480.

Davies, G. and Lennartsson, M. 2005. Organic vegetable production. A complete guide, Henry Doubleday Research Association, The Crowood Press Ldt.

FAO. 1988. Agro-ecological regions of Bangladesh. Technical report 2. FAO of the United Nations, Rome, Italy.pp.476-492.

Ghuman, B. S. and Sur, H. R. 2006. Effect of manuring on soil properties and yield of rainfed wheat. *J. Indian Soil Sci. Soc.* 54(1): 6-11.

Islam, M. S. 2003. Impact of long-term application of organic matter on soil properties and crop production. Anun published Ph.D. Dissertation. Department of Soil Science. BSMRAU, Salna, Gazipur-1701, Bangladesh.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi. pp. 498.

Karim, A. J. M., Egashira, K., Yamada, Y., Haider, J., & Nahar, K. (1995). Long-term application of organic residues to improve soil properties and to increase crop yield in terrace soil of Bangladesh.

Komatsuzaki, M. and Ohta, H. 2007. Soil management practices for sustainable agroecosystems, *Sustain. Sci.* 2: 103–120.

Kumar, K., Gupta, S.C. Baidoo, S.K., Chander, Y. and Rosen, C.J. 2006. Antibiotic uptake of plants from soil fertilized with animal manure . *J. Environ. Qua.* 34: 2082-2085.

Lal, R. 2008. Soils and sustainable agriculture. A review, *J. Agron. Sustain. Dev.* 28:57–64.

Mandal,U.K.,Singh,G.,Victor,U.S.andSharma,K.L.2003. Green manuring: its effect on soil properties and crop growth under rice rice-wheat cropping system. *J. European Agron.*19(2): 225-237.

Mehla, D. S., Singh, J. P., Sekhon, K. S., Sihag, D. and Bhardwaj, K. K. 2008. Long-term effects of inorganic and organic inputs on yield and soil fertility in the rice-wheat cropping system in India.

Mian, M. J. A. 1991. Air, Water and Nutrient Dynamics in paddy soils. PhD Thesis, Dept. of Soil Science, BAU, Mymensingh.

Mian, M. J. A. and Moslehuddin, A. Z. M. 1999. Soil fertility changes under different cropping patterns in long term fertility trials. Proc. Workshop long term expt. Soil Pert. Rice based cropping systems, BRRI, Gazipur, March 8-10.

Montemurro, F., Maiorana, M., Convertini, G. and Ferri, D. 2007. Alternative sugar beet production using shallow tillage and municipal solid waste fertilizer. *J. Agron. Sustain. Dev.* 27: 129-137.

Murphy, D.V., Stockdale, E.A., Brookes, P.C. and Goulding, K.W.T. 2007. Impact of microorganisms on chemical transformation in soil, *In*: Abbott L.K., Murphy D.V. (Eds.), Soil biological fertility – A key to sustainable land use in agriculture, Springer, pp. 37–59.

Patiram and Singh, K. A. 1993. Effect of continuous application of manures and nitrogenous fertilizer on some properties of acid Inceptisols. *J. Indian. Soil Sci. Soc.* 3: 430-433.

Salam M U, Hossain SMA, Biswas JK and Mridha AJ. 2014. Managing the unmanageable: rice variety technology for future challenging food security in Bangladesh. Extended abstract in the "Agronomic visions in challenging future", the proceedings of the 13th conference of the Bangladesh Society of Agronomy, 20 September 2014, Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.

Santhy, P., Sankar, S. J., Muthuvel, P. and Selvi, D. 1998. Long term fertilizer experiments: status of N, P and K fractions in soil. *J. Indian. Soil Sci. Soc* 46(3): 395-398.

Schlegel, A.J. 1992. Effect of composted manure on soil chemical propoerties and nitrogen use by grain sorghum. J. Prod. Agric. 5: 153-157.

Sherchan, D.P. and Gurung, G.B. 1998. Effect of long-term application of chemical fertilizer and manure on crop yields and soil chemical properties under rice-wheat cropping pattern. PAC Technical Paper. Pakhribas Agricultural Centre. No. 183. pp. 20.

Singh, G., Jalotas, K. and Singh, Y.2007. Manuring and residue management effects on physical properties of a soil under the rice-wheat system in Punjab, India. *Soil Tillage Research*. 94(1): 229-238.

Van-Camp, L., Bujarrabal, B., Gentile, A. R., Jones, R. J. A., Montanarella, L., Olazabal, C. and Selvaradjou, S.K. 2004. Reports of the technical working groups established under the thematic strategy for soil protection, EUR 21319 EN/3, 872 p., Office for Official Publications of the European Communities, Luxembourg.

Walkley, A.C. and Black, T.A. 1935.Estimation of soil organic carbon by chromic acid titrationmethod.*SoilSci.* 47: 29-38.

Wong, J. W. C., Fang, K. M. and Cheung, C. 2001. Utilization of manure compost for organic farming in Hong-Kong. *Bio-resource Technology*. 67(1): 43-46.

Zuazo, V. H. D. and Pleguezuelo, C. R. R. 2008. Soil-erosion and runoff prevention by plant covers. *J. A review. Agron. Sustain. Dev.* 28:65-86.