Original Research Article

Soil chemical properties as influenced by long term manuring and nitrogen fertilization in Bangladesh

ABSTRACT

Organic fertilizers are enriched inplant nutrients whichmay enhance the soil chemical properties.However,studies on the effect of long term fertilization on soil chemical attributesis yet lacking in Bangladesh. Therefore, an experiment was conducted to assess the changes of soil chemical properties as influenced by long term manuring and nitrogen fertilizer in silt clay loam soil under rice-wheat cropping system. The experimental plot received different organic materials for the last 26 years (1988-2014). Five types of organic materials treatments such as control (no manure), cowdung, compost, green manure and rice straw were applied at the rate of 0, 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 in this study. Long term application of different organic materials positively increased soil organic carbon and total N, P, S and decreased pH and K, Ca and Mg availability. Increase in soil organic carbon was found maximum under green manure and lowest in rice straw applied soil. The green manure contributed to the maximum accumulation of soil nitrogen. N dose of 80 kg ha^{-1} was found effective in increasing availability of soil nutrients.

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, excessive crop cultivation with high yielding varieties , minimal use of organic materials and improper soil management practice, causes nutrients deficiency in soil (Lal, 2008). Consequently plants suffer from unavailability of essential nutrients which results in slow crop performance. So, there is a need for addition of nutrients from the external source for better plant growth and higher yield. Organic materials (OM) amendments influence significant increase of soil organic carbon (SOC) content, which demonstrates a positive role of OM in soil conservation especially in tropical and subtropical climatic conditions stated by Alam*et al.,* (2019).

But use of only inorganic fertilizer for longer period causes deterioration of physical properties, OM status and reduces crop yield. In such case, the use of organic manure has greatest benefits in soil health. Continuous application of OM increases organic carbon, total nitrogen, available phosphorus, exchangeable Ca, K and improves soil conditions and productivity. The available P, S and exchangeable K contents in post-harvest soil increase positivelyas 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 theapplication of chemical fertilizers such as N, P and K. Moreover the warm climate and intensity of cultivation increase the decomposition of OM (Montemurro et al., 2007).By contrast, the buildup of OM in soils is a slower process 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 loss of SOC 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 for ensuring food for ever growing population. 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 ofOM for maintaining soil fertility. In this perspective, continuous applications of OM areperhaps the best way to maintain the soil health in our climatic conditions. But such a step in Bangladesh is still meager. Considering the above factsan experiment was initiated in 1988 to study the effects 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 area

The current study is a part of long-term manuring experiment that started in July, 1988 with T. aman rice-wheat cropping sequence at the research field of Soil Science Deparment, Bangabandhu Sheikh MujiburRahman Agricultural University, Gazipur-1706, Bangladesh. The experimental site is located in the center of the Agro-Ecological Zone (AEZ) of Madhupur tract (AEZ-28) at about 24.23^0 N latitude and 90.08^0 E longitudes having a mean elevation of 8.4 m above from the sea level. The climate of the location is tropical monsoon. In the present experiment, soil properties were studied after 26 years of the long term manuring and studied data was compared with data obtained in 2003 as initial data. The land selected for the long-term experiment had been a virgin land where no crop was grown before. The soil belongs to Salna soil series representing the shallow red brown terrace soil and classified as Inceptisols according to USDA classification (Brammer 1978). The soil is characterized as heavy clay within 50cm from the surface and acidic in nature. Some basic chemical properties of the soil prior to set the long term experiment are presented in table 1.

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

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

Factorial experiment comprising two factors (organic materials and nitrogen fertilizer) was laid out in a randomized complete block design with two replications and unitplot size was 12m × 7m. Experiment comprised eight treatment viz. five different organic materials(OM) treatment (application of cow-dung (CD) @ 25 t/ha, compost (CP) @ 25 t/ha, green manure (GM) @ 7.5 t/ha, rice straw (RS) @ 1.5 t/ha, no manure application(CK) and three level of nitrogen viz. N0, N1 and N2 (For rice 0, 75, and 100 kg ha^{-1} and for wheat 0, 80, and 120 kg ha^{-1}).Organic materials were applied in well before final land preparation and incorporated them through repeated ploughing. The high yielding rice variety BRRI dhan39 and wheat variety BARI Gom 24 were used as the test crops. Seeds were collected from Bangladesh Agricultural Development Corporation (BADC).After one week proper paddling the field, twenty-five-days old seedlings of BRRI dhan39 were transplanted maintaining 25 cm × 20 cm spacing and wheat seeds were directly sown in18th November 2013 in continuous lines having theline-linedistance of 20 cm. Fertilizer 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 (S containing fertilizer) were applied during final land preparation. Urea was applied in three equal split dose, at final land preparation, 15 days after transplanting 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 cropusing sampling augur composite (four samples were collected from unit plot and then mixed homogenously to have a single sample) soil samples from each plot were collected from 0-15 cm depth at 20th March 2014. 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 %OC was estimated by wet oxidation method as described by Walkley and Black (1935), %TN was determined by Kjeldhal method according to Jackson(1973). Available phosphorus was determined by Bray andCurtz (1945) method, Exchangeable potassium was determined by Jackson (1973), Exchangeable calcium and magnesium was determined by ammonium acetate extraction method described by Black (1965) and available S was determined by turbidimetric method by Black (1965).

2.4 Statistical analysis

Data were statistically analyzed using statistics10.0 version software and univariate analysis was performed to test all parameters. Mean data and standard deviation were used to prepare different graphs using Microsoft Excel (Office 2007 version).

3. RESULTS AND DISCUSSION

3.1 Soil pH

Initial (2003) soil pH was5.88 in control plot (CK), 5.40 in CD treated plot, 5.38 in CP treated plot, 5.40 in GM treated plot and 5.22 in RS treated plot (Figure 1). After long-term application of OM, soil pH decreased in CK (5.42), CP (5.16) and GM (5.33) treatments over the initial value. The pH value of CD and RS treated plot was more or less unchanged. Whereas in N treated plot pH value was found almost similar in initial and final samples.

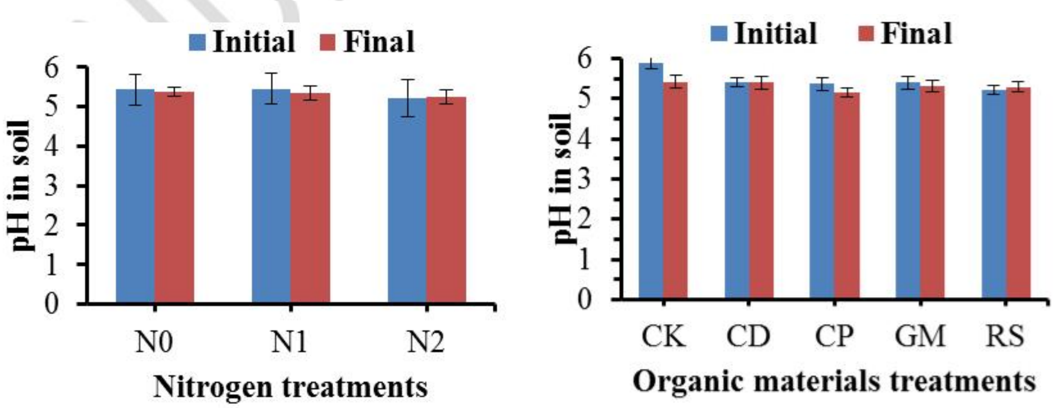


Figure 1.Effect of long-term application of N and OM on soil pH; vertical bar indicates Standard deviation (SD) of mean

Chang *et al.* (1991) found that soil pH decreased with increasing manure application as organic materials produce organic acid. Ghuman and Sur (2006) studied the effect of manuring on soil properties and yield of wheat andobtained significant decrease of 3.0 units in soil pH in theplots 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 (%OC)

The initial OC of soil (2003) in long-term experimental plot was 0.30% in control plot (CK), 0.76% in CD treated plot, 0.68% in CP treated plot, 0.80% in GM treated plot and 0.78% in RS treated plot while in case of N fertilizer received plots %OC was N0 (0.84%) , N1(0.59%) and N2(0.66%).Due to application of fertilizer and manure during the last 11 years, the amount of SOC increased in all treatments over the initial value except in N0 treated plot. In case OM the highest OC was found in GM treated plot which was 0.95% followed by CP (0.90%) treated plot and N1 treated plot shows maximum %OC followed by N2 plot receiving different level of N doses (figure 2).

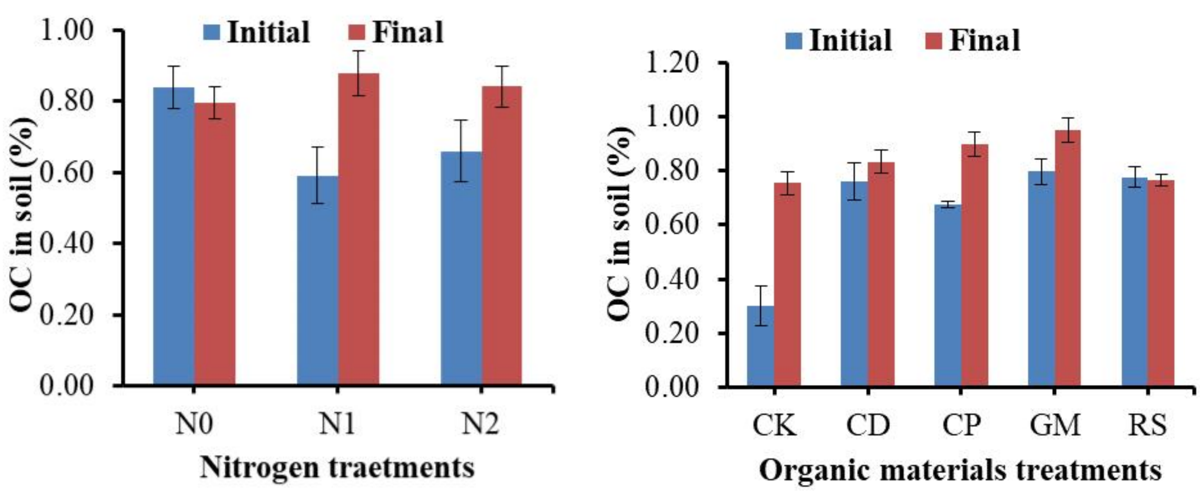


Figure 2.Effect of long-term application of N and OM on OC content of soil; vertical bar indicates SD of mean

The reason 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 results indicated that the long-term application of organic manure enrich total organic carbon of soil. Mandal*et el.,*(2003) found that the total organic carbon was higher under green manuring treated plots than fallow. Similar results were also found by Mehla*et el.,*(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 0.06% N in the control plot CK (No manure), 0.07% in cowdung and compost, 0.06% in green manure and 0.08% in rice straw treated plots. In the present study, the total N percentage increased over the initial value due to fertilization and long-term manuringfor the last 11 years.

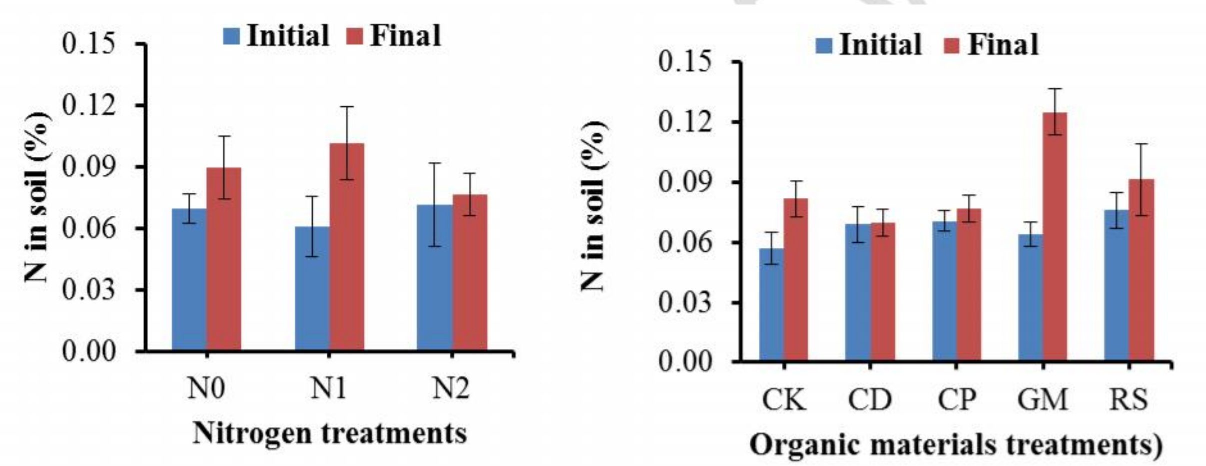


Figure 3. Effect of long term application of N and OM on Total N content of soil;vertical bar indicates SD of mean

The highest value of nitrogen (0.13%) was found in the green manure treated plot and lowest (0.07) in the CD treated plot after long-term manuring in final soil samples. In case of plots treated with doses % TN increased in all doses over initial value. Maximum TN was found in plot received N2 (0.10%) treatment followed by N0 in the final sample where in the initial sample TN was more or similar ranging from 0.06-0.07%. Long term fertilizer experiment conducted bySanthy*et al.,* (1998) at Tamil Nadu, India, since 1972 found 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 amendments increased the available N status of soil over their initial status. Nitrogen is the most limitingplant nutrient in nutrient 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.

3.4 Available phosphorus

Long-term manuring significantly affects the available P content (ppm) in soil (Figure 4). In case of OM treatments initial soil P in the CK (19.07 ppm) plot, CD (20.14 ppm), CP (15.19 ppm), GM (15.37 ppm) and RS (19.73 ppm) was found. While in the final sample most of case P content decrease except in plot having GM (22.27 ppm) treatment and in the control plot (CK) which was 23.80 ppm which might due to application of OM an important source of soil P. In case of N treatment P content also decreased in N0 and N2 treated plot but increased in plot received N1 treatment over the initial values. Highest P content was recorded in N0 (21.60ppm) treated plot in the initial sample whereas N1 (24.66ppm) treatment occupied the maximum P content in the final samples.

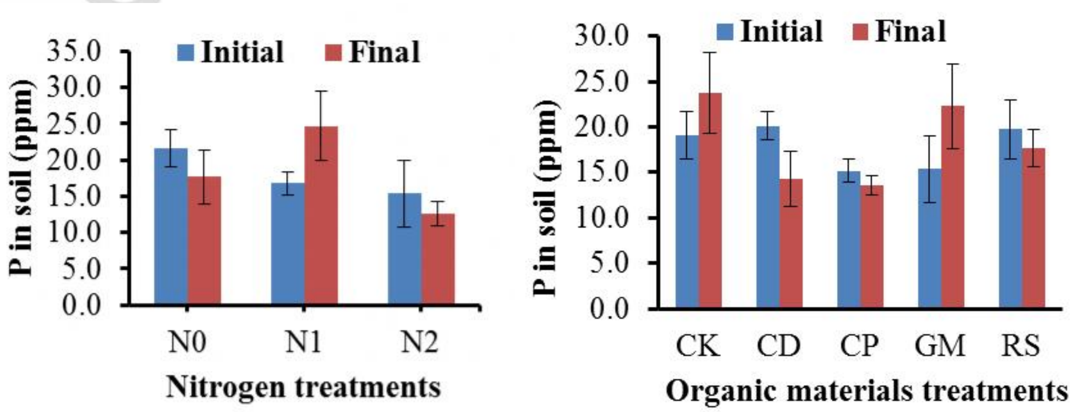
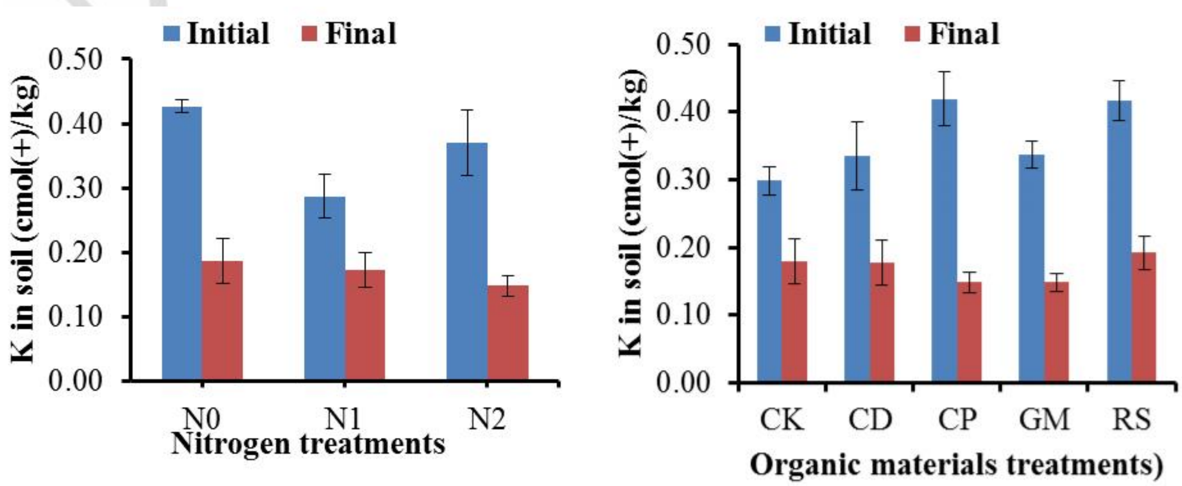


Figure 4. Effect of long-term application of N and OM on P content of soil;vertical bar indicates SD of mean

After long-term manuring the available P content decreased in the treatments over the initial value in most of the cases. 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 ofbeafcattle 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 11 years(figure 5).Exchangeable K^+ content was increased in the control plot. In case of OM treatments initial K content was more or less similar in CP (0.418 cmol kg^{-1}) and RS (0.416 cmol kg^{-1}) treated plots and CD and GM were also similar. Lowest K content was recorded in control plot CK (0.297 cmol kg^{-1}). In the final sample highest K value was found in RS (0.191 cmol kg^{-1}) treated plot followed by CK and CD treated plots which are statistically similar. CP and GM were also in similar range of 0.14 cmol kg^{-1}. In case of N fertilizer treatments K



content was also found decreased in the final sample over initial value. N0 treated plot showed highest K contents the soil in the both initial (0.43 cmol kg^{-1}) and final (0.19 cmol kg^{-1}) soil samples. Findings showed that due to 11 years of long-term fertilization and cropping, the status of potash decreased thanthe 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 (MianandMoslehuddin, 1999). The decrese in K^+ content over the initial status might be the effect ofluxury 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

Theeffect of long-term manure application was more not pronounced in case of Ca

Figure 5.Effect of long-term application of N and OM on K content of soil; vertical bar indicates SD of mean

availability in soil (Figure 6). In the initial soil (2003) highest Ca was found in RS (9.77cmol kg^-1) treated plot.Ca contents in others plot were in the range of 8.95-9.52 cmol kg^-1 in case of OM treatments. After long-term fertilization the available Ca content was decreased over initial value and found in the range of 7.88to 8.82 cmol kg^-1 in the final samples.

In case of N treatments Ca

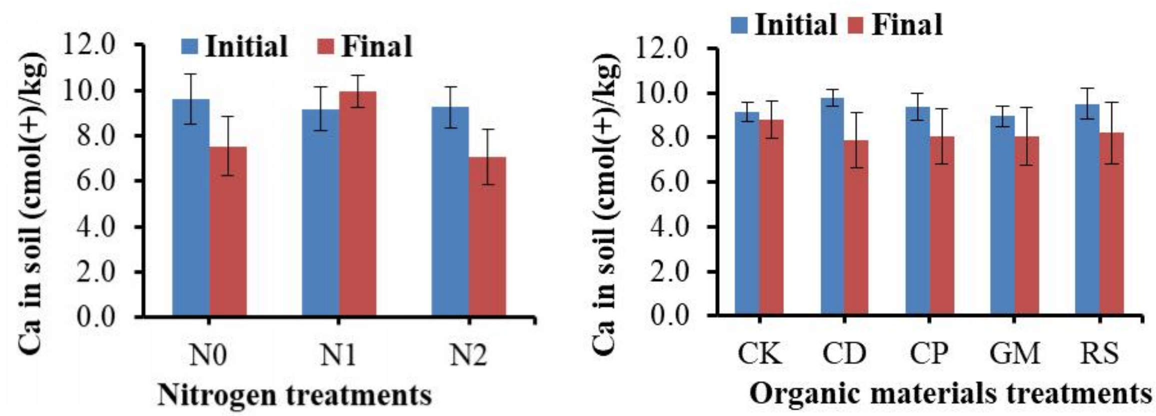


Figure 6.Effect of long-term application of N and OM on Ca content of soil;vertical bar indicates SD of mean

content of soil was also found in decreasing except in N1 treated plot over the initial samples. Highest Ca was found in the initial soil with N0 (9.61 cmol kg^{-1}) treated plot. While N1 (9.98 cmol kg^{-1}) gives the highest Ca value in the final sample. This result might be due to absence of Ca bearing minerals in the soil as Ca is not applied in the form of fertilizers. 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.

3.7 Exchangeable magnesium

The exchangeable Mg content of soil was slightly decreased over the initial value after long-term fertilization (figure 7). Exchangeable Mg content was increased only in control plot CK (2.01 cmol kg^{-1}) but decreased in case of all OM treatments over the initial value. Mg value was found the range of 1.83 to 2.01 cmol kg^{-1} in final soil sample treated with OM. In case N treatments Mg content of initial sample was found highest in N2 treated plot which was 1.94 cmol kg^{-1} and in the final sample N1 treated plot showed highest Mg content which was 2.05 cmol kg^{-1}. Normally applications of organic materials enhance the availability of Mg but in this study scenario are quite different and this might be due to slow mineralization process or less cation exchange capacity of soil. In contrast, Wong *et al.*(2001) found that addition of manure compost increased exchangeable Mg content in the amended soil.

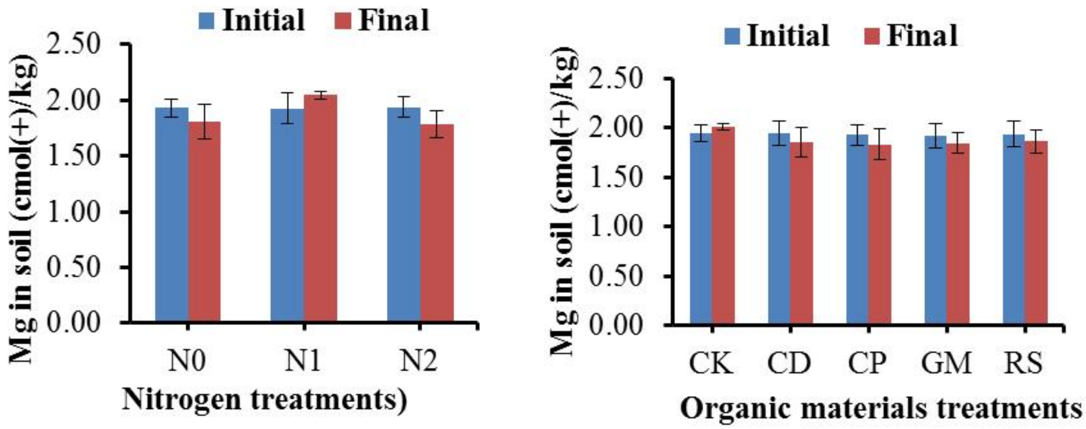


Figure 7.Effect of long-term application of N and OM on Mg content of soil;vertical bar indicates SD of mean

3.8 Available sulphur

Application of manure increased sulphur content in soil(Figure 8). Sulphur contents of initial soil (2003), ranged from 27.17 to 31.83 ppmin different OM treated plots. Highest S was found in GM treated plot which was 31.83 ppm followed by RS treatment in initial sample. After long-term manuring S contents increased,which ranged from 28.37 to 33.84 ppm in case of OM treatments. Lowest Swas recorded in the control plot in both cases of initial and final samples. In case of different N dose application S content was almost similar in initial and final sample. Plot received N2 treatment comprised highest S (37.79 and 36.95 ppm) content in both initial and final sample respectively. S content was found decreased in N0 treated plot over the initial value.

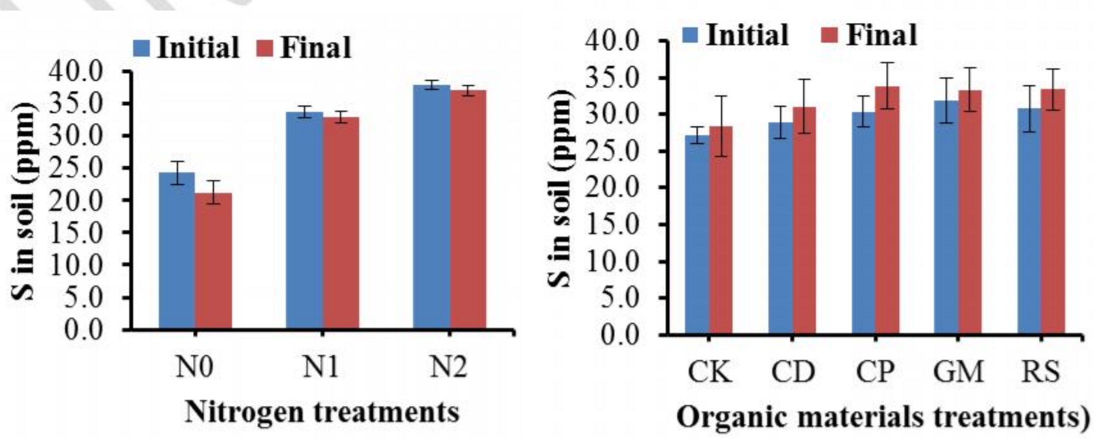


Figure 8.Effect of long-term application of N and OM on S content of soil; vertical bar indicates SD of mean

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).

4. CONCLUSIONS

Long term application of organic manure increased %OC, %TN and available S and available phosphorus slightly in soil while soil pH, Ca, Mg and K was found decreased. GM plays a significant role in increasing organic carbon, nitrogent and P in soil. N1 treatment mostly contributed for increasing the amount of %OC, TN and P . Rice straw (RS) was found effective in increasing availabe S and N2 dose in case of N fertilizer treatments. But soil pH lowered and Ca, Mg and K availability decreased due to long-term manuring. Further studies are needed to observe the combined effect of inorganic and organic fertilizers which might improve soil health and show positive impact on ecosystems and environment.

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CONFLICT OF INTEREST

The authors declare there are no conflicts of interest.

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