



Long Term Manuring and Fertilization Effect on Soil Properties in Terrace Soil

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Authors' contributions

This work was carried out in collaboration among all authors. Author FA designed the study, performed the statistical analysis and wrote the protocol. Authors FA and MI wrote the first draft of the manuscript and managed the literature searches. Authors MMR and MSHB managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out the influence of long term manuring and fertilization on soil properties. Soil samples were collected in 2016 from a highly weathered terrace soil with rice-wheat cropping pattern at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) experimental farm having five OM (control, cow dung, green manure, rice straw and compost) treatments combined with three mineral N fertilizer (control, 155 kg ha⁻¹, 220 kg ha⁻¹) levels. Long term (28 years) application of mineral fertilizers and manure resulted in significant differences in soil organic carbon, total N content, C:N ratio of soil and soil pH_{KCl} between the treatments. The soil organic carbon content varied among the different treatments from 6.11 g OC kg⁻¹ (application of rice straw and no N) to 9.43 g OC kg⁻¹ (application of compost and 220 kg N ha⁻¹ yr⁻¹). The total soil N content varied among the different treatments from 0.41 g N kg⁻¹ (application of rice straw and no N) to 0.73 g N kg⁻¹ (application of compost and 220 kg N ha⁻¹ yr⁻¹). The C:N ratios of the soil varied among the

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different treatments from 13.3 (application of no exogenous OM and no N) to 15.1(application of green manure and no N). The soil pH varied among the different treatments from 4.42 (application of cow dung and 220 kg N ha⁻¹ yr⁻¹) to 4.89 (application of compost/cow dung and no N). So, long term fertilization and manuring undoubtedly bring some changes in the physicochemical soil properties of terrace soil.

Keywords: Long-term fertilization; soil properties; terrace soil.

1. INTRODUCTION

Integrated nutrient management practices are effective methods for maintaining the soil physical, chemical and biological properties as well as improving soil health [1-2]. Over use of chemical fertilizers with agriculture intensification can have negative effect on properties [3]. The outcome of over use of mineral fertilizers adversely affected soil physicochemical properties of soil under rice-wheat cropping system [4]. Soil's physicochemical properties can be modified by organic fertilizer as a result of its comprehensive nutrients [5-6]. Moreover, the fertilizer efficiency of organic factors is more lasting when compared with inorganic fertilizers [7-9]. According to the properties of chemical fertilizers and organic fertilizers the combined application of chemical fertilizers and organic fertilizers would be a preferable strategy for maintaining the soil sustainability in comparison with the application of either of them alone [10-12]. Application of organic and chemical fertilizer in terrace soil could logically enhance soil productivity and have had positive effects on rice yields [13-15]. However, recent studies with the application of either manure or straw did not improve grain yields statistically after analyzing 25 long term field experiments with rice-rice and rice-wheat systems in Asia instead of soil organic carbon and total soil N [16]. They further observed that long term experiments under rice-cropping system with low fertility indicated prominent positive effects of organic amendments on rice yields. After 17 years of cultivation and fertilization management of a barren land, rice yield reached a high level equivalent to the average yield of local high productivity paddy soils and still responding positively, whereas SOC and total N content were still less than half of those in high productivity paddy soils [17]. Therefore, hypothesized that SOM quality, rather than content can play a vital role in fertility of subtropical paddy soils [18].

Terrace soil of Bangladesh is an unfertile, highly weathered soil dominated with kaolinitic clay

having very low organic matter content. It covers 8% of the total surface of Bangladesh distributed mainly in madhupur tract, barind tract primarily and a small area in Akhaura. Growing demand for food in the country due to rapid growing human population on one hand and environmental vulnerability in another hand bring this unfertile land under intensive cultivation. Therefore, it is high time to develop proper management system for sustainable utilization of terrace soil under the present progressive shrinking of agricultural land available per capita. So, the present research work has been carried out to study the effect of long term fertilization and manuring on soil properties.

2. MATERIALS AND METHODS

This experiment was established since 1989. The site of the experiment was the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) farm located in salna, Gazipur district, 40 km north of Dhaka, and situated in the center of the Madhupur Tract(24°05' N, 90°16' E), at 8.4m above MSL. The experiment was laid out in a 5 x 3 factorial design with two replications. Five treatments of organic residues and three levels of nitrogen were arranged randomly in each replication. All treatments followed a yearly wheat-fallow-rice cropping pattern and involved 5 OM application treatments (1° no-application (M0), 2° cowdung at 25 Mg ha⁻¹ as fresh manure (CD), 3° compost at 25 Mg ha⁻¹ made from cowdung and rice straw (CP), 4° green manure at 7.5 Mg ha⁻¹ fresh biomass of Sesbania Rostrata (GM), and 5° rice straw at 2 Mg ha⁻¹(ML). These were combined with 3 levels of inorganic N fertilizer dressing (0, 75 and 100 kg N ha⁻¹ for rice and 0 (N0), 80 (N1) and 120 (N2) kg N ha⁻¹ for wheat). Organic residues were applied to the soil once (June) a year 20-25 days before rice transplanting. Organic residues and amendments were incorporated by a power tiller to a maximum depth of 10 cm. Every year a high-yielding variety of T. Aman 'BR 14' was

transplanted in July and harvested in October. 'Akbar', a high-yielding variety of wheat, was sown between mid-November and December and harvested in March. Surface soil samples (0-15 cm) were collected in 2016 from each replicated plot. The field moist soil was gently broken apart by hand and was air-dried and ground to pass a 2-mm sieve prior to soil incubations and determination of soil properties.

2.1 Carbon and Nitrogen Analysis of the Soils

The total carbon and nitrogen content of soil samples were analysed with a Variomax CNS-analyzer (Elementar Analysensysteme, Germany). Sub-samples of 0.8 g were used for analysis. The CNS analyser works according to the principle of catalytic tube combustion under excess oxygen supply and high temperatures (850°C to 1150°C). The combustion gases are transported by He as a carrier gas and the oxygen dosing amount is adjusted via a dosing parameter selected for the sample. As general rule, each 350 mg organic substance with a medium carbon content requires approximately 0.30-0.35 L O₂ for combustion. In the CNS analyzer, the organic matter in the samples is converted to NO_x, CO₂, H₂O and SO₂. Each gas is adsorbed by means of specific traps and then subsequently released by thermal desorption and measured quantitatively with a thermo conductivity detector (TCD).

2.2 pH

The pH (KCl) was determined for all soils. To determine the pH, 10 g of air-dried and sieved (<2 mm) soil was weighed in a 50 ml glass vase, 25 ml KCl 1 M was added and the suspension was well-mixed with the aid of a glass bar. After waiting for 10 min, the suspension was mixed again. Afterwards, pH-KCl was measured with a pH-electrode.

2.3 Statistical Analysis

Non-linear least-square regression analysis was used to calculate parameters from cumulative C mineralization data in SPSS. Two-way ANOVA (with mineral N levels and OM application treatments as fixed factors) with Duncan's multiple range post-hoc test was used for statistical analysis of the BSMRAU experiment. All statistical analyses were carried out with SPSS 15.

3. RESULTS AND DISCUSSION

3.1 Organic Carbon

The soil organic carbon content varied among the different treatments from 6.11 g OC kg⁻¹ (application of rice straw and no N) to 9.43 g OC kg⁻¹ (application of compost and 220 kg N ha⁻¹ yr⁻¹). Organic carbon content was only significantly different between the rice straw and cow dung application treatments (Fig. 1). The highest SOC content was observed in green manure applied plot followed by compost, cow dung, control (i.e. no organic matter application) and the lowest in rice straw treated plot. The increased accumulation of organic carbon in green manure, compost and cowdung applied plots over control (only N fertilizer applied plots) is logical and in line with many others [19-21].

Irrespective of the OM application, addition of N fertilizer (155 and 220 kg N ha⁻¹) resulted in a significantly accumulation of SOC compared to the control (Table 1, Fig. 2). Fig. 2 shows that, soil organic carbon increases with the increase of N-fertilizer application. Long term (33 years) application of fertilizers and manure resulted in significant differences in the annual carbon mineralization. NP has the effect to soil for the purpose of carbon sequestration in floodplain soil compared to other fertilizer [22]. Soil organic carbon influenced by manure application [23]. However, in few experiments soil organic C did not increase until N was applied at rates in excess of that required for maximum yield [24].

3.2 Total N

The total soil N content varied among the different treatments from 0.41 g N kg⁻¹ (application of rice straw and no N) to 0.73 g N kg⁻¹ (application of compost and 220 kg N ha⁻¹ yr⁻¹). N content was only significantly different between the rice straw, cowdung and green manure application treatments (Fig. 1). The order of total N in different organic matter application plots were as follows: green manure > cowdung > compost > control (i.e. no organic matter application) > rice straw. This is in line with continuous addition of manures for 20 years increased the soil total and available nitrogen content significantly from 0.05 to 0.083 per cent, while increase was only 0.005 per cent in N fertilizer applied plots as large portion of N was removed by the crop [25].

Irrespective of the OM application, addition of N fertilizer (155 and 220 kg N ha⁻¹) resulted in a

significantly higher N content compared to the control (Table 1, Fig. 2). Total N content of soil was significantly increased with the increase of N-fertilizer application. This result is consistent with Raun et al, (1998) who reported that N fertilization significantly increased (linear and/or quadratic) total soil N in the surface 30 cm and this was most apparent when the high rate of N applied compared to the check (no N fertilization) [26]. The long term (33 years) application of fertilizers and manure resulted in significant differences in soil total N content between the treatments of floodplain soil [27]. Most of this immobilized N remain in the soil profile and contribute to the build up of soil total N.

3.3 C: N Ratio

The C:N ratios of the soil varied among the different treatments from 13.3 (application of no exogenous OM and no N) to 15.1(application of green manure and no N). C:N ratios of rice straw and green manure applied soils were significantly higher than the compost, cowdung and control soil (Fig. 3). C:N ratios of compost, cowdung and control soil were statistically similar but the C:N ratio of rice straw applied soils was significantly higher than the green manure applied soils (Fig. 3). The variation of soil C:N ratios in different exogenous OM treated soils resulted from the variation in C:N ratios of different applied exogenous OM.

Irrespective of the OM application, addition of N fertilizer (155 and 220 kg N ha⁻¹) resulted in a decline in soil C:N ratios compared to the control (Fig. 4) but the differences were insignificant (Table 1). This result is fit with addition of fertilizer & manure resulted in a decline in soil C: N ratios compared to the control but the differences were insignificant [28].

3.4 Soil pH

The soil pH varied among the different treatments from 4.42 (application of cow dung and 220 kg N ha⁻¹ yr⁻¹) to 4.89 (application of compost/cow dung and no N). The pH of soil was not significantly influenced by the application of different exogenous organic matter treatments instead of remarkable differences between the treatments (Fig. 5). The highest soil pH was observed with the application of compost followed by rice straw, cowdung, control and green manure. However, application of manure or FYM continuously to the soil reduced the soil pH [29]. It is hypothesized that application of exogenous organic matter to the soil decreases the pH due to production of organic acids during decomposition of organic matter [30]. This hypothesize was partly true for this experiment where sufficient N (220 kg N ha⁻¹) was applied (Table 1). It suggest that sufficient N (220 kg N ha⁻¹) application decreases the soil pH by enhancing organic acid production through the decomposition of applied exogenous organic matter.

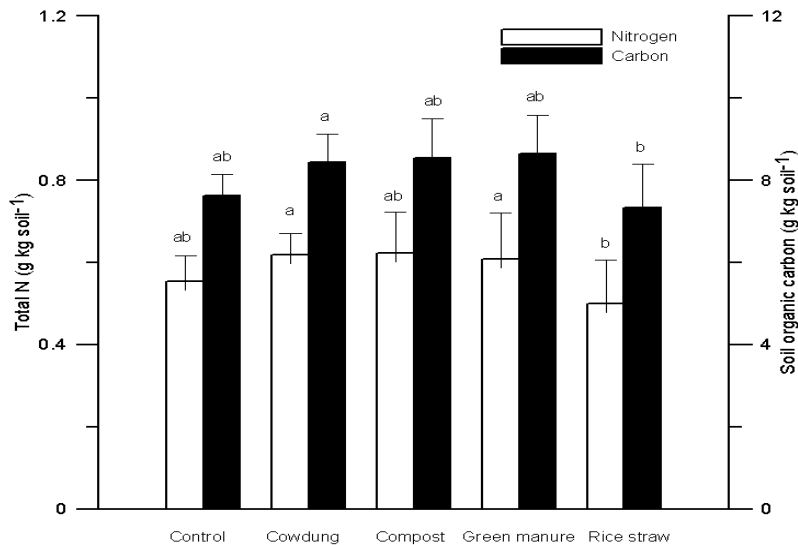


Fig. 1. Soil organic carbon and total N content (g kg⁻¹) as influenced by exogenous OM application in a highly weathered terrace soil field experiment (BSMRAU) (averages of the 3 N fertilizer application treatments)

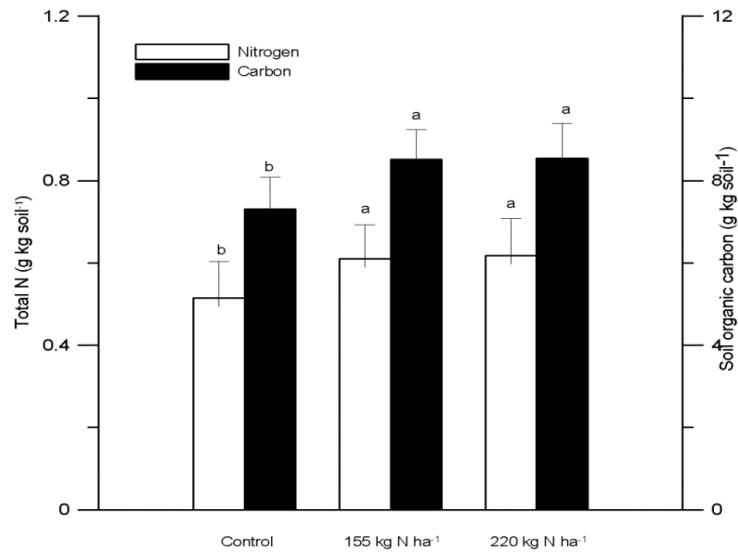


Fig. 2. Soil organic carbon and total N content (g kg⁻¹) as influenced by N fertilization in a highly weathered terrace soil field experiment (BSMRAU) (averages of the 5 OM application treatments)

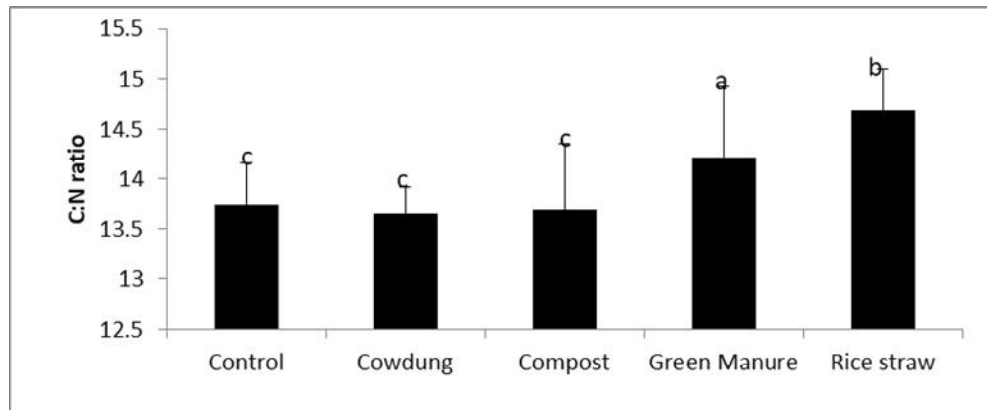


Fig 3. C: N ratio as influenced by exogenous OM application in a highly weathered terrace soil field experiment (BSMRAU) (averages of the 3 N fertilizer application treatments)

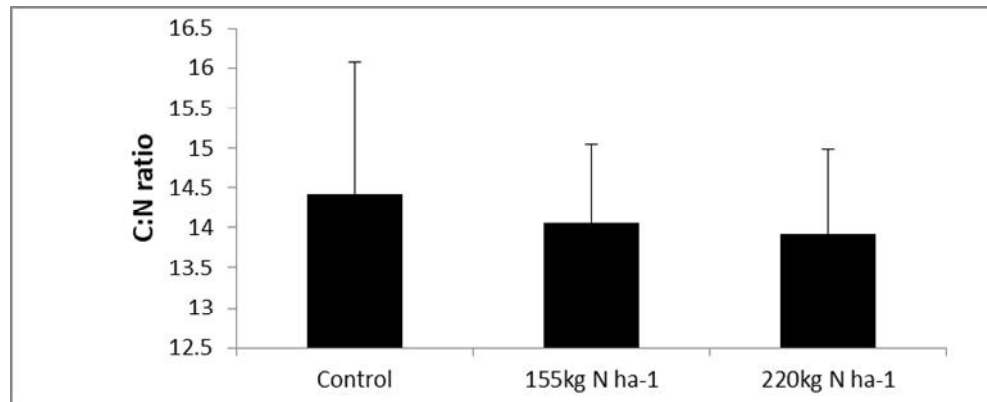
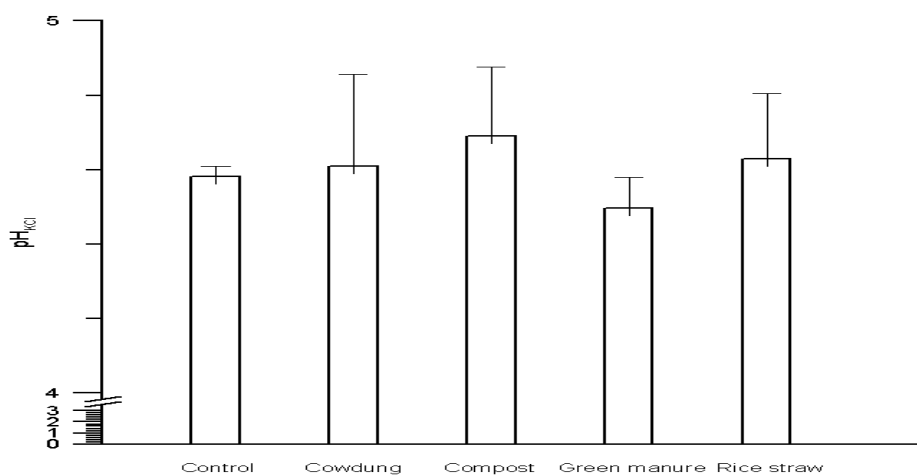


Fig. 4. C: N ratio as influenced by N fertilization in a highly weathered terrace soil field experiment (BSMRAU) (averages of the 5 OM application treatments)

Table 1. Soil properties and N mineralization in highly weathered terrace soil (BSMRAU) of Bangladesh as influenced by long term organic amendment in combination with mineral fertilization

Treatments	Organic carbon (g kg ⁻¹)	Total N (g kg ⁻¹)	C:N ratio (-)	pH _{KCl} (-)
0 kg N ha ⁻¹ yr ⁻¹				
Control	7.57	0.57	13.3	4.60
Cowdung	7.72	0.56	13.8	4.89
Compost	7.37	0.52	14.2	4.89
Green manure	7.76	0.52	15.1	4.59
Rice straw	6.11	0.41	14.9	4.77
155 kg N ha ⁻¹ yr ⁻¹				
Control	7.79	0.56	13.9	4.55
Cowdung	8.88	0.67	13.4	4.52
Compost	8.81	0.63	14.1	4.67
Green manure	9.20	0.68	13.6	4.47
Rice straw	7.88	0.53	15.0	4.69
220 kg N ha ⁻¹ yr ⁻¹				
Control	7.53	0.54	14.1	4.60
Cowdung	8.73	0.63	13.0	4.42
Compost	9.43	0.73	13.9	4.52
Green manure	8.98	0.64	14.1	4.43
Rice straw	8.04	0.57	14.2	4.43
ANOVA				
OM treatment	*	*	*	NS
N level	**	*	NS	*
OMxN level	NS	NS	NS	NS

** , * Significant at $P \leq 0.01$ and $P \leq 0.05$, respectively; NS, not significant

**Fig. 5 pH_{KCl} of soil as influenced by different exogenous OM application in a highly weathered terrace soil field experiment (BSMRAU) (averages of the 3 N fertilizer application treatments)**

Irrespective of the OM application, addition of no N fertilizer (control) resulted in a significantly decreased soil pH compared to the addition of N fertilizer (155 and 220 kg N ha⁻¹) (Table 1, Fig. 6). There is a significance variation between control

and 220 kg N ha⁻¹ application but the variation was insignificant between two different dose of N fertilizer application (155 and 220 kg N ha⁻¹) and between control and 155 kg N ha⁻¹. Soil pH decreases with the increase of N fertilizer

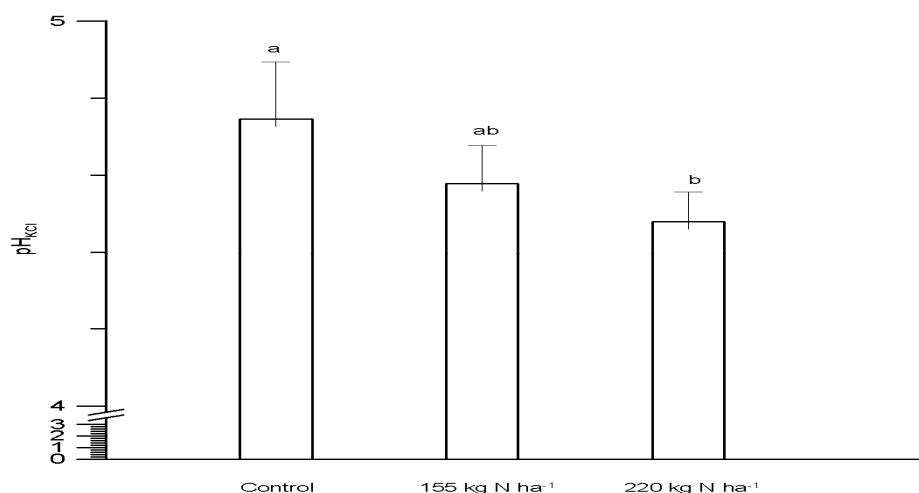


Fig. 6. pH_{KCl} of soil as influenced by mineral N fertilizer application in a highly weathered terrace soil field experiment (BSMRAU) (averages of the 5 OM application treatments)

application. This findings is in line with a significant decrease in soil pH from 8.9 to 8.7 due to 15 years application of ammonical fertilizer. They suggested that the reduction of soil pH was mainly attributed due to the acidic residual effect of ammonical fertilizer [31]. Fertilizers that either contain ammonium (NH₄⁺) or convert to ammonium have an acid-forming nature because of the release of hydrogen (H⁺) during the nitrification of NH₄⁺ to nitrate (NO₃⁻) [32]. The long term application of mineral fertilizers and manure to floodplain soil resulted in significant differences which is varied among the different treatments from 5.65(application of NK) to 4.89 (application of N) [33].

4. CONCLUSION

Long term (28years) application of mineral fertilizers and manure to the BSMRAU terrace soil resulted in significant differences in soil organic carbon, total N content, C:N ratio of soil and soil pH_{KCl} between the treatments. Organic carbon content was only significantly different between the rice straw and cow dung application treatments. N content was only significantly different between the rice straw, cowdung and green manure application treatments. C:N ratios of rice straw and green manure applied soils were significantly higher than the compost, cowdung and control soil. The variation in organic carbon and total N accumulation with the C:N ratio of soils in different OM treated plots could be resulted from the variation in quality of the applied exogenous OM. The pH of soil was not significantly influenced by the application of

different exogenous organic matter treatments instead of remarkable differences between the treatments. The highest soil pH was observed with the application of compost followed by rice straw, cowdung, control and green manure.

Irrespective of the OM application, addition of N fertilizer (155 and 220 kg N ha⁻¹) resulted in a significantly accumulation of SOC and total N and decline in soil C:N ratios and soil pH compared to the control. Soil organic carbon and total N increases while the C:N ratio and soil pH decreases with the increase of N-fertilizer application. The reduction of soil pH in N fertilized treatments was mainly attributed due to the release of hydrogen (H⁺) during the nitrification of NH₄⁺ comes from ammonical fertilizer to nitrate (NO₃⁻). The result indicates that long term fertilization and manuring undoubtedly bring some changes in SOC and total N; C:N ratios and soil pH as physiochemical soil properties of terrace soil.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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