2015 International Conference on Advances in Environment Research
Volume 87 of IPCBEE (2015)
DOI: 10.7763/IPCBEE. 2015. V87. 7

Soil Carbon and Nitrogen Ratio in Different Land Use

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Abstract. Carbon and nitrogen ratio is important factor for both soil capability and carbon storage. This study aims to analyse the relationships of soil properties and the carbon and nitrogen ratio in different land use. Ninety-six soil samples in different land use, including paddy field, horticulture, field crop and mangrove forest soils in the central plain of Thailand are sampling. The results were found that total carbon and nitrogen ratios were significantly correlated with bulk density in crop fields and with pH for horticulture and mangrove soils. Whereas the ratios of organic carbon and nitrogen contents showed statistical significance with clay separate content and moisture for horticulture soils, with clay separate content and pH for mangrove forest soils. The findings of this study support appropriate soil management in agricultural land use, together with the sustainability in mangrove forest.

Keywords: Carbon and nitrogen ratio, paddy field, horticulture, field crop, mangrove forest, soil, Thailand

1. Introduction

Carbon (C) and nitrogen (N) in soils are the main component of organic content which known as soil fertility. However, the biogeochemical cycles of C and N also play an important role in global warming [1], [2]. Both C and N status associated with C:N ratio may play a key role in regulating soil organic matter mineralization. The ratio of C:N indicates the rate of decomposition of organic matter and this results in the release (mineralization) or immobilization of soil nitrogen. [3] pointed out that the greatest SOM mineralization would occur at substrate C:N ration of 25. If the ratio is less than 20, mineral N is released in the early of decomposition process. The dividing line between immobilization and release of N is about 20:1. The change of soil C:N could lead to significant declines in carbon storage [4]. Many factors, including are land use, climate, topography and some basic soil properties [5], influence the biogeochemical cycle in soil which further the change of C and N storage. Significantly, land use is the most importance among those factors [1].

The ratio of carbon and nitrogen shows the degradation rate of organic matter which is the main source of carbon in soil. Soil organic carbon reservoir in tropical ecosystem is an important component of global terrestrial ecosystem [6] since climate factors affect the rate and magnitude of change of soil mechanism [7].

The objective of this study was to assess the relationship of the C and N ratio with related to their basic soil properties in different land use. Agricultural land use was our interested. Within the agricultural areas themselves, cropping practices have been different depending on agricultural types. Those are divided into three main crops, including horticulture, field crops and paddy fields. The dissimilar patterns of each agricultural crop bring to the alterations of land cover, soil properties and further effect to biogeochemical cycle in soils. Mangrove forest nearby agricultural areas was another land use selected. The reasons were that (1) the difference of soil parent materials could be controlled and (2) the basic of land use is similar, as the natural areas.

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2. Materials and Methods

2.1. Study Area

The study was conducted in three provinces, including Nakorn Pathom, Samut Sakorn and Samut Songkram. These locations are known as one of the main agricultural area in the central part of Thailand. The agricultural types are mixed and covered all main agricultural products, mentioned above. Within these areas, mangrove areas are also significant. Hence, four soil types according to their land uses, including paddy field, horticulture, field crop and mangrove forest, were selected to sampling. The soils in the depth of 20 cm were taken, according to soil sampling methods [8]. Total samples were ninety-six.

2.2. Soil Sampling and Analysis

Soil samples were sieved through 212 μm and the selected soil properties were analyzed. These are included total carbon (TC) by Total Organic Carbon Analyzer of Teckmar-Dohrmann series Phoenix 8000, organic carbon content (OC) by Walkley-Black wet combustion, total nitrogen (TN) by Macro Kjeldahl digestion, Cation Exchange Capacity (CEC) by compulsive exchange method, soil texture by hydrometer methods, moisture by alternative method and pH by pH meter [8].

The soil OC:N and TC:N ratio was calculated by dividing the SOC and TC concentration, respectively, by the TN concentration. Statistical analysis was performed with the software SPSS 18.0 for Windows to access the variability of the C:N ratio due to five soil factors.

3. Results and Discussion

3.1. Soil Properties

Soil properties in Table I illustrate some different. Physical properties were influenced by their raw materials whereas chemical properties were affected by conventional tillage. Clay material is dominant in all soil types. These are depending on their soil series which appropriate for the specific cropping types. The values of pH, bulk density and CEC were also analyzed to further consider their relations to the ratio of carbon and nitrogen. The pH values of three agricultural crop types and, surprisingly, mangrove soils were less than 7. According to [9], the efficiency of nitrogen storage of soils which pH less than 5 is increased since they affect the reduction of denitrification process. The CEC levels of agricultural crops were significantly varied and these are not happen for mangrove soils.

The values of C and N were also showed in Table I. C and N contents in mangrove soils presented the highest value. For agricultural land use, both C and N contents in field crop soils were the least and the most values were in paddy field soils. The main reason is the characteristics of soil management which is different in each cropping system. Usually, harvest together with land opening for field crops have been taken the most frequencies, comparing with horticulture and paddy fields.

Table I: Soil properties of different land use

Soil properties	Horticulture	paddy field	field crop	Mangrove
Soil textures(%)				
-clay	61.21-84.99	35.22-87.20	38.49-78.35	42.53-73.04
-silt	22.93-43.55	20.16-41.71	11.42-42.36	16.40-38.76
-sand	Nd-24.59	Nd-44.60	Nd-51.57	Nd-43.50
Bulk density(g/cc)	1.03-1.36	1.00-1.28	1.19-1.45	0.45-1.18
Moisture (%)	15.40-47.86	3.79-89.20	9.30-33.01	63.47-136.30
pH	4.10-8.22	4.51-6.98	5.81-6.96	3.54-6.78
CEC (meq/100g)	13.98-46.11	4.03-37.34	5.86-30.70	12.56-35.17
Total carbon (%)	0.89-3.01	1.37-4.20	0.94-1.85	2.01-6.33
Organic carbon (%)	0.63-4.20	0.90-3.69	0.49-2.01	1.34-6.64
Total nitrogen (%)	0.08-0.25	0.08-0.32	0.05-0.14	0.13-0.32

3.2. The Ratio of Carbon and Nitrogen

The ratio of C and N illustrates the appropriateness of soil to supply the nutrients and the capability of carbon storage. For agricultural soil, low C:N ratio (20:1 or less) is sufficient. The higher C:N ratio in

mangrove forest affect the decreasing of N pool [10]. The ratio of OC:N and TC:N in Table II were found that horticulture and paddy field soils were not different whereas field crop soils were slightly higher. For mangrove soil, the ratio of C:N showed the degradation rate of soil which affect C storage influencing by vegetation types. The ratio of C:N in mangrove soils was slightly higher than in agricultural soils. However, the result of mangrove C:N ratio in this study was lower than the study of [5] in similar ecosystem which illustrated the range of ratio from 24.96 to 32.40.

Table II: The ratio of OC:N and TC:N

Soil properties	Horticulture	paddy field	field crop	Mangrove
OC/N				
Minimum	7.60	6.77	7.22	9.03
Maximum	21.71	18.01	25.65	20.65
Mean	10.90	10.65	11.32	14.22
STDEV	2.88	2.04	4.02	3.41
TC/N				
Minimum	9.68	6.88	12.27	11.01
Maximum	18.08	29.50	17.78	19.70
Mean	13.08	13.57	14.10	14.86
STDEV	2.08	3.66	1.70	2.86

3.3. Statistical Association of Soil Properties and the Ratio of Carbon and Nitrogen

Table III showed the results of multiple linear regression equations for the OC:N and TC:N to five soil factors of four soil groups. For horticulture soil, regression models explain the variation of five soil factors to the OC:N and TC:N with 30.2% and 30.6% accounted in Equations 1 and 2, respectively. Only clay content and moisture showed statistical significance ($P < 0.10$) for OC:N. As to TC:N, only pH can explain the variability with significance value ($P < 0.10$).

For paddy field, soil properties have negligible effect on OC:N and TC:N. There are no any statistical associations and only small account to OC:N and TC:N as presented in Equations 3 and 4, respectively.

As to field crop soil, five soil factors can explain OC:N variation at 27.9%, with no statistical significance. The association of TC:N (78.3%) was dramatically higher than OC:N (27.9%). Bulk density was only soil property that was significantly correlated. Equations 5 and 6 explained the relations of OC:N and TC:N with their basic soil properties.

Regression model explaining the greatest variation in the OC:N ratio for mangrove soils with clay accounted for 56.5%. The values of pH of mangrove soil were significant correlated ($P < 0.10$) with both OC:N and TC:N, respectively, however, the relations presented in negative direction. Equations 7 and 8 explained 93.5 % and 76.0% of the variation accounted for OC:N and TC:N, respectively.

Table III: Equation models of OC:N and TC:N

Soil types	Equation models	R^2
Horticulture	*1.OC:N=18.323-0.605bulk-0.232clay+0.089CEC+0.117moist+0.613pH* *2.TC:N= 12.385-3.037bulk-0.083clay+0.075CEC+0.060moist+0.948pH*	0.302 0.306
Paddy field	*3.OC:N=6.731+2.351bulk-0.021clay+0.044CEC+0.000moist+0.29pH* *4.TC:N= 8.624+6.835bulk-0.149clay-0.009CEC+0.036moist+1.026pH*	0.024 0.259
Field crop	*5.OC:N=53.41-7.786bulk-0.203clay+0.174CEC-0.196moist-2.934pH* *6.TC:N= -5.072+17.048bulk-0.057clay-0.044CEC+0.075moist-0.04pH*	0.279 0.783
Mangrove forest	*7.OC:N=18.279-3.185bulk+0.565clay-0.531CEC-0.011moist-3.249pH* *8.TC:N= 29.836-4.577bulk+0.539clay-0.612CEC-0.065moist-3.314pH*	0.935 0.760

4. Conclusion

The results of statistical association can conclude in which factors of soil properties that affect OC/N and TC/N in Table IV.

Table IV: Soil properties correlated to the ratio of OC:N and TC:N

Soil types	OC/N	TC/N
Horticulture soil	Clay contents, moisture	pH
Paddy field soil	None	None
Field crop soil	None	Bulk density
Mangrove soil	pH, clay contents	pH

This study can illustrate overall pictures for both soil management and environmental sustainability. For soil management, bulk density, one of soil physical properties, affects TC:N for field crop soils. Hence, appropriate tillage practice should improve soil polarity. Many agricultural soils have lost 30-50% of their original SOC pool. However, management practice could recapture those SOC lost, like the study of [11] in pastures at the Northeast USA. In contrast, OC:N in horticulture soil is influenced by their clay and moisture contents. According to [12], finer-textured soils, like clay, had greater SOC. This is positive related to SOC at both global and landscape scale [13]. Usually, clay is the soil properties affected by their soil parent materials. The way to enhance should focus on water maintained in soil. These should consider the pH factor for cropping system since it also affects TC:N. However, the values of C:N ratio in each cropping system is important for practical farming by adding organic materials to decrease (immobilization) or an increase (release) soil nitrogen [14]. Soil management, itself, also affects carbon and nitrogen distribution in soil and further soil resource sustainability [15], [16].

For global warming, the attention is on mangrove soil since carbon stores in them could decrease carbon and further greenhouse gas in the environment [17]. Clay texture in mangrove soil influenced by their parent raw materials has an effect on the ratio of C and N.

Soil sustainability should balance between agricultural products and global carbon cycle in ecosystem. The linear relationship presented here could predict the effect of factors influencing on C:N ratio in different land use.

5. Acknowledgments

The authors would like to acknowledge the contribution of the financial support from Office of National Research Council of Thailand, together with Silpakorn University Research and Development Institute, for granting this research project.

6. References

[1] Y. H. Yang, J. Y. Fang, D. L. Guo, C. J. Ji. Vertical patterns of soil carbon, nitrogen and carbon: nitrogen stoichiometry in Tibetan grasslands. *Biogeosciences Discuss*. 2010, 7: 1-24.

[2] P. Johanna, Y. Kuzyakov. Soil organic carbon decomposition from recently added and older sources estimated by $\delta^{13}C$ values of CO_2 and organic matter. Soil Biology & Biochemistry. 2012, 55: 40-47.

[3] Q. Deng, X. Cheng, G. Zhou, J. Liu, S. Liu, Q. Zhang, D. Zhang, D. Seasonal responses of soil respiration to elevated CO_2 and N addition in young subtropical forest ecosystems in young subtropical forest ecosystems in Southern China. *Ecological Engineering*. 2013, 61: 65-73.

[4] J. A. Aitkenhead, W. H. McDowell. Soil C:N ratio as a predictor of annual riverine DOC flux at local and global scales. *Global Biogeochemical Cycles*. 2000, 14(1): 127-138.

[5] H. B. Zhang, H. B., Lou, Y. M., Wong, M. H., Zhao, Q. G., Zhang, G. L. Soil organic carbon storage and change with reduction in agricultural activities in Hong Kong, *Geoderma*. 2007, 139: 412-419.

[6] E. Sakin, A. Deliboran, E. D. Sakin, H. Aslan. Carbon and nitrogen stocks and C:N ratio of Harran plain soils. *Not Sci Biol*. 2010, 2(4): 104-110.

[7] B. Lozano-Garcia, L. Parras-Alcantara. Land use and management effects on carbon and nitrogen in Mediterranean Cambisols. *Agriculture, Ecosystems and Environment*. 2013, 179: 208-214.

[8] K. H. Tan, *Soil sampling preparation and analysis*, New York: Marcel Dekker, 1996.

[9] J. Silva and R. S. Uchida. Plant nutrient management in Hawaii's soils. University of Minnesota. Accessed January 15 20150. *http://www.ctahr.hawaii.edu*

[10] I. Callesen, K. Raulund-Rasmussen, C. J. Westman, L. Tau-Strand. Nitrogen pools and C:N ratios in well-drained Nordic forest soils related to climate and soil texture. *Boreal Environment Research*. 2007, 12: 681-692.

[11] R. H. Skinner, C. J. Dell. Comparing pasture C sequestration estimates from eddy covariance and soil cores. *Agriculture, Ecosystems and Environment*. 2014, 199: 52-57.

[12] A. C. Procter, R. A. Gill, P. A. Fay, H. W. Polley. Soil carbon responses to past and future CO2 in three Texas

prairie soils. *Soil Biology & Biochemistry*. 2015, 83: 66-75.

[13] E. Jobbagy, R. Jackson. The vertical distribution of soil organic carbon and its relation to climate and vegetation. *Ecological Application*. 2000, 10: 423-436.

[14] X. Xiong, S. Grunwald, B. Myers, C. W. Ross, W. G. Harris, N. B. Comerford. Interaction effects of climate and land use/land cover change on soil organic carbon sequestration, *Science of the Total Environment*. 2014, 493: 974-982.

[15] M. A. G. Galeote, S. Trigalet, B. V. Wesemael. Soil organic carbon evolution after land abandonment along a precipitation gradient in Southern Spain. *Agriculture, Ecosystems and Environment*. 2014, 199: 114-123.

[16] M. R. Masnavi. Environmental sustainability and ecological complexity: developing on integrated approach to analyse the environment and landscape potential to promote sustainable development. *Int. J. Environ. Res*. 2013, 7(4): 995-1006.

[17] H. Fang, S. Cheng, G. Yu, M. Xu, Y. Wang, L. Li, X. Dang, L. Wang, Y. Li. Experimental nitrogen deposition alters the quantity and quality of soil dissolved organic carbon in an alpine meadow on the Qinghai-Tibetan Plateau. *Applied Soil Ecology*. 2014, 81: 1-11.