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The Effects of Land Management and Slope on Mineralize Carbon and Nitrogen Contents

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Abstract: Mineralize C and N contents and organic matter quality can be influenced by soil management, and vary by the slope of sampling location. Soil organic matter quality can impact mineralization of organic matter and eventually C sequestration. The objective of this study was to determine the effects of land management and different slopes on mineralizable C and N contents at high elevated location. The study was conducted on three different adjacent land uses (agricultural, grassland and forest) at 1500 m elevation in Tokat, Çamlıbel province. Soil samples were taken from 0-10, 10-20, and 20-40 cm depths and also soil samples were taken through slope in agricultural field. The greatest mineralizable C was measured in forest and followed by grassland and agricultural field. The mineralizable N content was similar in the three land uses. Mineralizable C content increased from upland to lowland. However, mineralizable N content was similar through the slope.

Keywords: Land management, mineralize carbon, mineralize nitrogen.

Arazi Kullanımı ve Eğimin Mineralize Karbon ve Azot İçeriğine Etkisi

Öz: Farklı kullanımlar altındaki topraklarda mineralize C ve N içeriği organik maddenin kalitesi ve amanejman sistemine bağlı olarak değişkenlik gösterebilir. Toprağa ilave olan organik maddenin kalitesi organik karbonun mineralizasyonunu ve karbon depolanmasını etkilemektedir. Çalışmanın amacı yüksek rakımlı faklı kullanımlar altında (Tarım, mera ve orman) ve eğime bağlı olarak mineralize C ve N içeriğindeki değişimin belirlenmesi. Çalışma 1500 m rakımda bir birine komşu üç farklı kullanımda yürütülmüştür. Çalışmada toprak örnekleri 0-10, 10-20 ve 20-40 cm derinliklerden alınmış ve ayrıca tarım toprağında eğim boyunca da bir örnekleme yapılmıştır. Mineralize C en yüksek ormanda ölçülürken bunu mera ve tarım toprağı takip etmiştir. Farklı kullanımla altında mineralize N içeriğinde önemli bir değişim gözlenmemiştir. Eğime bağlı olarak mineralize C içeriği en yüksek taban arazide belirlenmiştir. Mineralize N içeriğinde önemli bir değişim tespit edilmemiştir.

Anahtar Kelimeler: Tokat Zile Akdoğan, Watershed, Rainfall, Precipitation, Hydrology

1. Introduction

Soil organic matter is a component of plant materials growing in soil and residue of soil organisms. Soil organic matter in soil has significant impact on soil physical, chemical and biological properties and also stimulates plant productivity. The amount of organic carbon held in soils worldwide is more than two or three times in terrestrial biomass (Jacobson et al. 2000). Soil organic matter can be regarded as a potentially important C sink and mitigation global worming by sequestering C requires removal of C from atmosphere by plant (Bolin and Sukumar, 2000). Environmental changes can influence CO_2 emission and global climate change, determining the factors that manage soil respiration is critical for ecosystem management. Soil pressure coexists with a renewed interest in the capacity of agricultural soils to sequester the historically lost soil organic carbon, contribute to mitigate annual greenhouse gas emissions to the atmosphere, and reduce soil degradation (Smith et al. 2005; Lal, 2004). Soil organic carbon sequestration preserves soil resources for food production and buffers against global environmental threats (Mcbratney et al. 2012, 2014). Therefore, agricultural management has become a significant issue to improve soil functions and sequester atmospheric carbon and its impact on soil organic carbon stocks is crucial for global C cycle (Quinton et al. 2010). The quality of soil organic matter and soil microorganisms play a significant role in mineralization of soil organic matter and respiration of microbial community is generally limited by the bioavailability of organic substrate (Raich and Tufekcioğlu, 2000). The bioavailability of substrata is generally the ability of microbial exoenzymes to break organic polymers into smaller units that it can pass through microbial cell walls. Labile compounds are considered as carbohydrates and proteins, but lipids, lignin and humic substances are relatively chemical resistant. Physical availability of soil organic carbon is the location of soil organic matter within mineral aggregates (Jastrow and Miller, 1997).

Soil organic matter content and availability vary with land use type and soil management (Lorenz et al. 2006; Pouyat et al. 2007). Since, land use can be determining C release from soils and change long-term soil C stocks by ±50% (Searchinger et al. 2008). Most of the lost soil organic carbon occurs during the transition from forest or pasture to annual crops with the largest C increases the converse land use conversion (Gua and Gifford, 2002). Soil erosion and the associated redistribution export soil organic carbon, particularly in agricultural lands and have important controls on changes in soil C storage (Sanderman and Chappel, 2013). The controls of soil erosion on soil organic C is redistribution, which affects spatial and vertical of variability of both soil organic C quality and storage (De Gryze et al. 2008; Doetterl et al. 2012). In addition, mineralizable C pool of soil organic C is essential and important component of soil C dynamics and a significant component of ecosystem responses to changing environmental factors (Stewart et al. 2008). Environmental factors such as temperature and moisture control mineralization of soil organic C in many ecosystems (Pan et al., 2010). Soil organic C and mineralizable C and N content may change depending on land use and sampling location in field. The objective of this study was to determine soil organic C and mineralizable C and N content at high elevated different land uses (forest, grassland, and agricultural field) and sampling slopes.

2. Materials and Methods

The study was conducted on native grassland, forest and agricultural fields, which was located at 1500 m elevation. The average annual temperature and precipitation were 9.7 ^{o}C and 423 mm, respectively. Most of the precipitation occurred on winter and spring. Three adjacent land uses (forest, grassland, and agricultural field) were chosen in this study and soil samples were taken from 0-20 and 20-40 cm depths at three randomly selected locations in each land use. In addition, a group of soil samples were taken through the slope in agricultural field from 0-10, 10-20, and 20-30 cm depth in order to measure the effect of sampling location on soil organic C and N. Soil samples were stored at 4 ^{o}C until analysis.

Some soil physical and chemical properties were determined in the samples. Soil particle distribution was measured by Bouyocous hydrometer method (Bouyoucous, 1951). Soil reaction was determined 1:2.5 soil water mixture (Richards, 1954). Soil organic C content was measured by Walkey-Black wet oxidation procedure (Nelson and Sommer, 1982). Mineralizable C and N contents was determined in the soil samples after adjusting moisture content to 60% of water holding capacity at 25 ^{o}C for 28 days incubation. The CO_2-C produced during incubation was trapped in 5 mL of 1 M sodium hydroxide (NaOH) solution, and the extra OH^- was titrated using 0.05 N HCl solutions. After incubation soil samples were extracted using 2 M KCl. The extract were analyzed for mineralizable N (ammonium (NH^+_4) N and nitrate (NO^-_3) N) with a distillation procedure (Keeney and Nelson 1982). The experimental design was randomized block design with three replications. Analysis of variance was performed for analyzing management and slope effects on soil organic C, mineralizable C and N contents at α = 0.05 probability level.

3. Results and Discussion

Soil particle distribution was presented in Table 1. The highest clay content was observed in forest (%52) and clay content was similar through soil depth in forest and grassland. Clay content slightly increased below the surface soil in agricultural field. The increase in clay content below the surface soil could be the result of clay translocation from surface soil. Silt content was similar in all land uses. However, sand content was greater in agriculture and grassland. Changes in land use significantly affected some soil chemical properties ($p<0.05$) (Table 2). Soil pH ranged from 7.4 to 8.1 and the greatest pH was obtained in grassland while the lowest pH was in agricultural field. Soil pH significantly decreased in agricultural field ($p<0.05$) which could be the result of chemical fertilizers and leaching of basic cations from surface to the deeper depth.

Land management and soil depth significantly affected soil organic C content ($p<0.05$) (Table 2). The greatest soil organic carbon content was obtained in grassland and fallowed by forest and agricultural field. Generally, soil organic carbon content decreased from surface to the deeper depths, but soil organic C content was similar up to 40 cm depth. This can be attributed to the translocation of surface residue to subsurface soil by plowing. Soil organic C content 90% decreased under long-term cultivation compared to grassland and native forest.

Table 1. Soil particle distribution of forest, grassland and agricultural fields.

Land use	Depth	Clay	Silt	Sand
	cm		%	
Forest	0-20	52.6	18.0	29.4
	20-40	52.6	17.6	29.8
Agriculture	0-20	38.0	19.3	42.7
	20-40	42.6	18.0	39.4
Grassland	0-20	37.3	25.3	37.4
	20-40	36.7	22.0	41.3

The lower organic C content in agricultural field also can be relate to lower organic residue input in where most of the harvest residue removed for animal feed. Mineralizable C content was significantly affected by land management ($p<0.05$). Mineralizable C content decreased from forest to agricultural field and the highest mineralizable C content was measured as 286.4 mg kg^{-1} at the surface soil of forest. Also, mineralizable C content significantly decreased from surface to subsurface soil in the all management. The difference in mineralizable C content between the depths was greater in native ecosystems compared to agricultural use. Many study indicated that microbial biomass and total enzyme activity has been correlated with soluble organic C content which can vary depending on management systems (Landgraf et al., 2003, 2005; Tirol-Padre et al., 2005).

Therefore, labile soil organic C has been used as a proxy for mineralizable C (Leinweber et al., 1995) and has been correlated with basal respiration in many circumstances (Tirol-Padre et al., 2005).

On the other hand, mineralizable N content was similar in the all management ($p>0.05$). Mineralizable N content significantly decreased from surface to the deeper depth ($p<0.05$). The interaction between management and soil depth was not significant for all soil properties ($p>0.05$). The sampling location in agricultural field significantly affected mineralizable C content ($p<0.05$) (Table 3). The greatest mineralizable C content was observed at lowland and followed by upland and slope. Similarly, the average soil organic C content was found lower in upland forest compared to lowland (Ahn et al., 2009).

Table 2. Soil pH, organic C, and mineralizable C and N contents of forest, grassland, and agricultural soils.

Land use	Depth	pH	Organic C	Mineralizable C	Mineralizable N
	cm		g kg^{-1}	mg kg^{-1}	mg kg^{-1}
Forest	0-20	7.67	46.4	286.4	25.3
	20-40	7.79	26.5	260.3	15.8
Agriculture	0-20	7.40	5.3	224.2	26.4
	20-40	7.59	6.3	214.1	18.6
Grassland	0-20	8.06	53.9	267.6	23.5
	20-40	8.18	49.4	226.4	20.7
			P value		
Land use		0.03	0.001	0.02	ns*
Depth		0.02	0.01	0.003	0.01
Land use *Depth		ns	ns	ns	ns

*not significant α = 0.05.

Table 3. The changes in mineralizable C and N contents depending on sampling locations on a straight line in agricultural field.

Sampling location	Depth	Mineralizable C	Mineralizable N
	cm	mg kg^{-1}	mg kg^{-1}
Upland	0-10	263.7	34.5
	10-20	260.8	33.5
	20-40	230.2	27.8
Slope	0-10	254.9	20.3
	10-20	256.7	41.5
	20-40	260.8	17.9
Lowland	0-10	307.7	30.4
	10-20	294.4	18.6
	20-40	300.3	22.0
		P value	
Location		0.03	ns*
Depth		ns	ns
Location*Depth		ns	ns

*not significant α=0.05.

However, the effect of soil depth on mineralizable C was not significant on this study ($p>0.05$). Mineralizable N was similar through the sampling locations and depths ($p<0.05$). This study indicated that sampling location in a land uses has important for estimation of mineralizable C. Therefore, soil organic C fractions in agricultural ecosystem can change depending sampling position.

4. Conclusion

Soil organic C and mineralizable C content was significantly affected by soil management systems. The greatest soil organic C content was observed in native grassland followed by forest and agriculture field. Soil organic C content was almost similar through soil depth in grassland and agricultural field while soil organic C decreased approximately 50% in subsoil of forest. The greatest mineralizable C content was measured at the surface of forest and mineralizable C content decreased with soil depth. The proportionally greater mineralizable C was observed in agricultural field, which indicates greater disturbance of agricultural practices which results lower physical protection of soil organic C. The sampling location significantly affected mineralizable C content in agricultural field. Lowland had greater mineralizable C content than upland and slope. Thus, sampling location in agricultural ecosystem is important for soil organic C and fractions.

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