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Soil Organic Carbon Stocks as Influenced by Topography and Vegetation Cover Types at Different Soil Depths

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Abstract

Data on soil organic carbon stock in wooded grassland is important for assessing its contribution towards offsetting greenhouse gas emissions through carbon sequestration. Understanding the effect of topography and vegetation cover types on soil organic carbon stocks is therefore essential for adopting suitable strategies for reducing greenhouse gases emissions but little has been done to ascertain this. This study was conducted during the long (LRS) and short rainy seasons (SRS) of 2016 in Ilmotiok to determine the effects of topography and vegetation cover at different depths in the wooded grasslands of Laikipia County, Kenya. Randomized completely block design was used; the main plot was topographical zones (TZ); mid slopes (MS), foot slope (FS), toe slope (TS) and subplots vegetation cover (VC); tree (T), grass (G), bare (B). Soil samples were collected to a depth of 50 cm at an interval of 10 cm using soil auger. The samples were analyzed for texture, bulk density (BD) and soil organic carbon. The bulk density was highest under FS*B at 0-10 cm with a mean of (0.88gcm^{-3} and 0.97 gcm^{-3}) for LRS and SRS respectively as compared to other TZ. The lowest bulk density was observed for MS*GR at 0-10 cm (0.78 gcm^{-3} SRS and 0.86 gcm^{-3} LRS) in comparison to the other VC. Highest SOC concentration (1.21 MgHa^{-1} and 1.10 MgHa^{-1}) was recorded under TS*G at 0-10 as compared to 40-50 (0.52 MgHa^{-1} and 0.40 MgHa^{-1}) whereas the lowest (0.92 MgHa^{-1} and 0.91 MgHa^{-1}) was recorded on MS*B at 0-10 cm and 0.39 MgHa^{-1} and 0.28 MgHa^{-1} and at 40-50 for the LRS and SRS respectively. The same trend was observed for SOCs highest (9.72 MgHa^{-1} and 9.90 MgHa^{-1}) for TS*G at 0-10 cm and (5.11 MgHa^{-1} and 5.66 MgHa^{-1}) at 40-50 cm and lowest under SU*B at 0-10 (7.66 and 7.11 MgHa^{-1}.) and (3.19 and 2.60) MgHa^{-1} LRS and SRS respectively. The results from this study indicates that topography and vegetation cover of the wooded grassland has an influence on soil organic carbon stocks. Grass vegetation act as a sink to carbon stock therefore revegetation using grass is highly recommended.

Keywords: carbon sequestration; topographical zones; vegetation cover; wooded grassland savanna.

INTRODUCTION

Wooded grassland hold great potential for carbon sequestration that is vital in global climate change mitigation through removal of atmospherically carbon by higher than ground biomass and transferred into vegetation and soil pool for future storage (Yafeng et al., 2011). In Kenya, wooded grasslands savanna are primarily placed within the arid and semi-arid lands (ASALs) that represent over 80%of the entire area (UNDP, 2009). They therefore are vital in mitigating global climate change. Currently there is a widespread acknowledgement that maximizing storage of C in the soils offers a theoretically essential avenue to offset increasing atmospheric C levels and thus help alleviate the effects of anthropological induced climate change (Smith, 2012; IPCC, 2014). However, their potential has not been totally assessed because wooded grasslands are heterogeneous, each in temporal and spatial dimensions (Yafeng et al., 2011). The spatial heterogeneousness results from the changes in micro-climate, physical landforms and precipitation this creates an inclined distribution of soil wetness and nutrients that influence carbon sequestration whereas time-based heterogeneousness arises from seasonal distinction in productivity influenced by variation in vegetation patterns (Nori 2006).

The spatial pattern of soil organic carbon concentration are influenced by topography as a results of its influence on the distribution of soil and vegetation cover (Nori 2006). Topographic positions (aspect and slope) are therefore necessary factors for precise estimates of C stocks in wooded grassland savanna. In addition, vegetation is taken into account as a main factor regulating SOC stocks in arid and semi-arid wooded grasslands savanna. In wooded grasslands savanna, the type and variety of plant species play a key role in carbon transfer into the soil (Steinbeiss et al., 2008). Often estimations of soil carbon stocks in wooded grassland savanna seldom take into account the difficulties ensuing from wooded grassland non-uniformity and therefore adopt homogeneity (Dabasso et al. 2014). Past studies dispensed in wooded grasslands of arid and semi-arid areas thought of them as solid zones aside from heterogeneous zones with completely different geographic zones and vegetation cover types (Dabasso et al. 2014). Thus far, field measurements of soil organic carbon changes area unit restricted and underprivileged by the inherently high spatial variability of SOC stocks at varied scales. Therefore, most analysis has been done at numerous scales to estimate SOC exploitation simply obtained parameters, i.e. environmental condition parameters, and remotely perceived information. This thus results in inaccurate reporting of the carbon sequestration and false illustration of the wooded grasslands savanna. Additionally, most analysis has primarily targeted on the relation of SOC stocks to environmental conditions, changes of SOC stocks underneath ever-changing climate conditions and management (Don et al. 2011). To enhance on the accurate value of regional carbon budgets to help within the development of effective ecological restoration measures thus it is necessity to include and perceive wooded grassland as non-uniformity and thus have different spatial pattern characteristics (Wang et al., 2018). Therefore, this study determined the influence of topography and vegetation cover of wooded grassland savannah on soil organic carbon stocks at different soil depths.

Materials and method

Site description

The study was conducted at Ilmotiok Group Ranch in Laikipia County which lies between latitudes 0° 18″ south and 0° 51″ north and between longitudes 36° 11″ and 37°24′ east with an elevation ranging from 1,550 to 1,700 m, with gentle undulating terrain. It covers an area of 9,462 km^2. Rainfall is highly variable both in space and time with an annual range of 400–800 mm. The long rains occur between March and May, while short rains fall in October to November (Odadi 2010). Mean monthly maximum temperature range from 25 to 30 °C, while minimum temperature ranges from 12 to 17 °C with July and August being the coldest and windiest months (Odadi 2010). Ilmotiok group ranch are dominated by red soils with black cotton soils found in some areas. Vegetation in the study area is largely classified as wooded grasslands comprising of *Themenda–pennisetum* grassland, *Acacia* bushland, and leafy bushlands. *Acacia brevispica* dominates the open thickets, while *Acacia mellifera* and *Acacia nilotica* mainly occur in arid zones. *Acacia* bushlands are commonly found on the well-drained red soils in the AEZ VI (Odadi 2010). Cattle are the dominant livestock comprising 85 % of total livestock biomass density (Georgiadis et al. 2007). Other livestock species in the study site include sheep, goats, camels, and donkeys. Nomadic pastoralism are the main economic activity and land is communally owned.

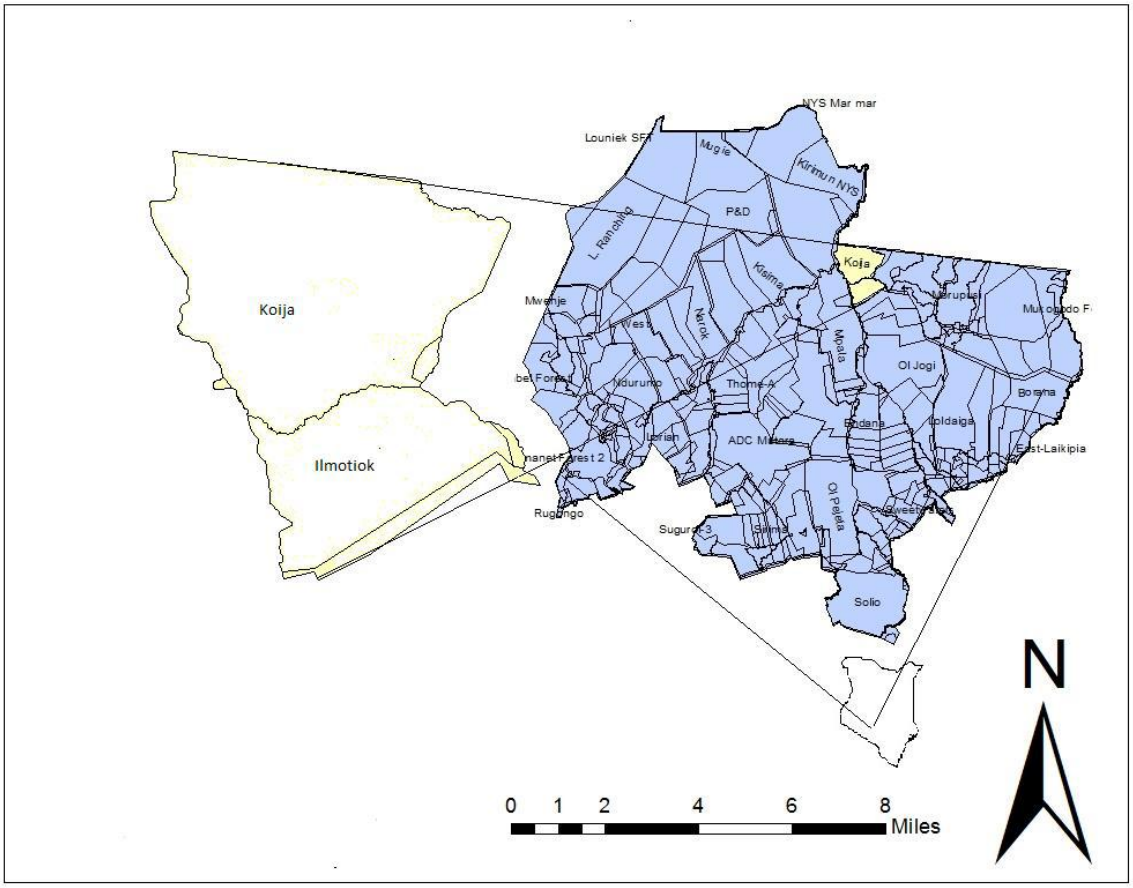

Figure 1: Map showing the location of Laikipia County and Ilmotiok community ranch

Soil Physical-chemical Properties

The soil pH varied in all the topographical zones ranging 5.23-6.83pH (H2O). Soils in the toe slope zone was slightly acidic with mean pH of 5.23. Soil texture ranged from sandy clay loam to loamy sand. It varied with topographical zone (Table 1) where the mid slope and foot slope had sandy clay loam texture but summit and toe slope had a loamy sand texture.

Table 1: Physical characteristics of soil at different topographical zone (TZ) at Ilmotiok community Ranch, Laikipia County, Kenya

Topographical Zone	pH (H_2O)	Sand (%)	Clay (%)	Silt (%)	Textural class
Mid slope	6.24	69.72	19.12	11.16	Sandy clay loam
Foot slope	6.83	71.72	15.12	13.16	Sandy clay loam
Toe slope	5.23	76.92	10.72	12.36	Loamy sandy

The highest level of sand in the toe slope could be attributed to erosion down the slope from foot slope. Lalampa et al., 2016 reported that there are mainly sandy and well drained red soils on toe slopes.

Experimental layout and sampling

Randomized Completely Block Design (RCBD) with split plot arrangement was used; the main plot was variation in topographical levels; mid slope (MS), foot slope (FS) and toe slope(TS) and the subplots were the vegetation cover types; Tree (T), Grass (G) and Bare (B) as the control (Table 2). The assessments of soil organic carbon stocks were done for two consecutive rainy seasons of long (LRS) and short rain seasons (SRS) in of 2016.

Table 2: Experimental layout

Topographical zones →	Mid slope	Foot slope	Toe slope
Vegetation cover types ↕	Tree (T)	Grass (G)	Bare (B)
	Grass (G)	Bare (B)	Tree (T)
	Bare (B)	Tree (T)	Grass (G)

Soil sampling and analysis

Sampling of soils was done at intervals of 50 m along the transect line. Soil samples were collected to a depth of 0-50 cm at an interval of 10 cm in an area of 1 m^2 in a Z pattern using a soil auger. Three sub-samples of soil were collected at every corner of the 1 m^2

mixed in a larger plastic bucket, and 500 g sample was pooled into a small paper bag and labeled to indicate vegetation cover type and sample ID number. The samples were analyzed for soil texture, pH and Soil Organic Carbon (SOC).

Soil texture determination Soil texture was determined by the hydrometer method. The samples was shaken for 6 hours with calgon solution in a mechanical shaker**.** Measurement of silt plus clay was done after 40 seconds and clay after 2 hours, all with a soil hydrometer. Sand fraction will be obtained by the difference. Textural classes was then be read directly from USDA textural triangle.

Bulk Density determination

Coring rings of known volume was used to collect the samples. Sampling was done carefully by driving the coring ring into the soil using hand sledge and a block of wood. Analysis of soil bulk density was done using the methodology described by Cresswell and Hamilton (2002). Oven proof container was weighed first before the soil is transferred. The soil and the container was oven dried at 105^{o} C for 24 hours. The soil and container was removed from the oven and left to cool in a desiccator then weighed and recorded. C. Soil bulk density (g cm-^{3}) was then be calculated as shown (Equation 1):

$$\text{BD Sample} = \frac{\text{ODW Sample}}{\text{CV Sample}} \quad \text{(Equation 1)}$$

Where;

BD Sample is the bulk density (g cm-^{3}) of the soil sample, ODW Sample the mass (g) of oven dried soil core and CV Sample core volume (cm^{3}) of the soil sample.

Soil reaction (pH) determination

The pH was measured with a glass electrode pH meter on 1: 2.5 ($^{w}/_{v}$) suspension of soil in water, and on 0.01M $CaCl_2$ solution, in all cases after shaking for 30 minutes (Okalebo et al., 2002).

Organic carbon (%C) determination

The organic carbon was estimated by the Walkley-Black method (Black, 1965). 1 g of ground soil sieved through 0.5mm was weighed into a labeled 100 ml digestion tube. 10

ml 5% potassium dichromate solution was added and allowed to completely wet the soil or dissolve the standards. Slowly and carefully 5 ml H_2SO_4 will be added from a slow burette and the mixture will be swirled gently to mix. The mixture will be digested at 150 ^{O}C for 30 min. It was allowed to cool, then 50 ml 0.4% barium chloride will be added, swirled to mix thoroughly, and the volume was made to 100 ml mark. An aliquot of the supernatant solution will be transferred into a colorimeter cuvette, absorbance of the standard, the sample and blank was measured. Total organic carbon was calculated as follows equation 2;

$$\text{Total Organic carbon \%} = \frac{(a-b) \times 0.10)}{W} \quad \text{(Equation 2)}$$

W - Weight of Sample, a - Blank Titre value, b - Titre value of the Sample

Statistical analysis

Data from soil analysis was subjected to analysis of variance (ANOVA) using General Statistics (GENSTAT) package. The differences among the treatment means of the interaction of different topographical zones and vegetation cover types was compared using Fisher's Protected LSD test at 5% probability level.

Results and discussion

Influenced of vegetation cover types and topography on soil bulk density (BD)

There was significant ($P < 0.05$) effect of topography and vegetation cover on soil bulk density (Table 4). The bulk density was highest under foot slope with bare VC at 0-10 cm with a mean of (0.88gcm^{-3} and 0.97 gcm^{-3}) for long and short rain season respectively as compared to other topographical zones. The lowest bulk density was observed for MS*G vegetation cover for 0-10 cm (0.78 gcm^{-3} SRS and 0.86 gcm^{-3} LRS) in comparison to the other vegetation cover types. There was also a significant ($P<0.05$) difference in bulk density between top depth of the soil and bottom depth of soil with the top depth having lower bulk density than the bottom depth in all TZ and VC.

Table 3: Soil bulk density (BD) as influenced by vegetation cover types (VC) and topographical zone (TZ) down the soil profile

		LRS 2016					SRS 2016				
TZ	VC	0-10	10-20	*20-30*	*30-40*	*40-50*	*0-10*	*10-20*	*20-30*	*30-40*	*40-50*
FS	BR	0.88^{ab}	0.91^{a}	1.10^{c}	1.12^{b}	1.15^{b}	0.97^{c}	1.01^{b}	1.13^{c}	1.22^{c}	1.24^{c}
	GR	0.77^{a}	0.81^{a}	0.83^{a}	0.87^{a}	0.89^{a}	0.86^{a}	0.90^{a}	1.02^{b}	1.11^{b}	1.13^{b}
	TR	0.83^{b}	0.87^{b}	0.94^{b}	0.98^{b}	1.06^{b}	0.84^{a}	0.88^{a}	0.97^{a}	1.03^{a}	1.11^{b}
MS	BR	0.83^{b}	0.93^{c}	0.96^{b}	1.02^{b}	1.07^{ab}	0.94^{ab}	1.04^{c}	1.08^{c}	1.14^{b}	1.19^{b}
	GR	0.78^{a}	0.81^{a}	0.87^{a}	0.92^{a}	0.96^{a}	0.89^{a}	0.92^{a}	0.98^{a}	1.03^{a}	1.07^{a}
	TR	0.79^{a}	0.86^{b}	0.93^{b}	0.98^{b}	1.03^{a}	0.91^{a}	0.97^{b}	1.04^{b}	1.10^{b}	1.14^{b}
TS	BR	0.80^{a}	0.87^{a}	0.90^{a}	0.94^{a}	0.97^{a}	0.96^{ab}	1.00^{a}	1.07^{ab}	1.12^{a}	1.15^{a}
	GR	0.76^{a}	0.81^{a}	0.89^{a}	0.94^{a}	0.99^{a}	0.88^{a}	0.94^{a}	0.99^{a}	1.03^{a}	1.10^{a}
	TR	0.81^{a}	0.84^{a}	0.87^{a}	0.91^{a}	0.95^{a}	0.92^{a}	0.95^{a}	1.04^{a}	1.06^{a}	1.13^{a}

FS-foot slope, MS-Mid slope SU-summit, TS-toe slope BR-bare GR-grass TR-tree LRS-long rain season SRS-short rain season

Means followed by the same superscript letter (within a column for each season separately) are not significantly different ($p \leq 0.05$) by Fisher LSD test

The lower soil bulk density values under grass cover may be due to enhanced soil micro porosity, soil aggregate and microclimate, higher SOC concentration input and improved soil structure comparative to bare land and tree cover. The same observations were made in Kenya by (Muya et al 2011) who reported lower bulk density in soils with a ground cover. The higher soil BD density under bare cover is accredited to low assimilation of organic matter in the soil, loss of vegetative and litter cover permitting direct impact of rain drops on bare soils resulting to greater splash impacts, hard layer formation, superficial sealing that moderate water infiltration in to soil. Lack of plant growth on the bare ground can also result in reduced bulk density due to a decrease in root density whereas the presence of vegetation cover results into an increase in the presence of root channels resulting into the build-up of unconsolidated organic material on the soil surface, results in lower bulk density values at the surface, as was noted in the vegetated cover with grass and tree cover. The input of organic matter from vegetation also improves soil aggregation, resulting in an improvement in soil structure and, hence, a reduced bulk density (Muya et al 2011).

The differences in bulk density across the seasons can be attributed to low vegetation cover during the short rain season as compared long rain season this results into moderate water infiltration this thus indicates higher root biomass which in turn makes the soil porous thus reducing compaction by raindrops during the long rain season hence reduced bulk density as compared to short rain season. Donkor et al. (2002) also found bulk density was lowest in the long rain season. Several researchers have also found that the amount of compaction is reliant on soil water content at the time of contact (Donkor et al. 2002), with more compaction occurring under less wetter conditions. Soil bulk density changes demonstrate that bulk density can't be considered as a static soil property. It can likewise be seen that there is an expansion of its mean a reason during the low precipitation period as an outcome of contracting soil changes as contradicted in high precipitation period. The soil presents swelling and contracting developments amid the wetting and drying cycles along the diverse rainy and dry periods of the year. As stated by Timm *et al ., 2006* that the reality can be related with the presence of soil cracks because of wetting and drying cycles, causing a soil mass contracting and increasing bulk density of the soil between cracks.

Bulk density usually increases with soil depth since subsurface layers are more condensed and have less organic matter, less aggregation, and less root penetration compared to surface layers, therefore contain less pore space. Trükmann et al. 2008 observed more root growth in the top layer of compacted soil with improved total root length concentrated in the top 12 cm depth Soil compaction has been shown to increase bulk density. Thus, the significantly higher bulk density down the soil profile at 50 cm can be attributed to direct effect of soil compaction. At depth, however, there are few roots and, hence, very little improvement in soil structure. This is also reflected in the bulk density values at depth, which increase with increasing soil depth. As noted by Erick *et al*. 2015, the comparable bulk density with increasing soil depth reflect the relatively homogenous soil physical conditions with depth and presumably indicate that the degree of soil compaction. The same was also reported by Pande and Yamamoto 2006 who reported that loss of top soil through erosion escalates soil compaction and it, potentially increases the for severe run-off and erosion during rainy events.

The bulk density was significantly lower in the toe slope than other slopes. The toe slope areas, have a better soil water content, be richer in clay and organic matter, and successively have a better water holding capability than the upslope regions. The bulk density of the toe slope is decreases due to a rise in clay deposition and organic matter and therefore the ensuing increase in pore area. Stavi et al., 2008 showed decreased bulk density in toe slope is attributed to increased clay content and as a result of the downward movement of water and organic matter from the higher zones.

Soil organic carbon concentration (%) and soil organic carbon stocks (Mg/ha) as influenced by vegetation cover types (VC) and topographical zone (TZ) down the soil profile

At all topographical zones, the SOC concentration decreased across vegetation types in the order (grass>tree>bare. The SOC concentrations were lowest in the summit, but higher at the toe slope compared to other topographical positions in all vegetation cover types and depths. Soil organic carbon concentration varied across the seasons at all interaction of TZ*VC*D with the highest values recorded during the LRS. Topographical zones, vegetation cover types and depth significantly affected ($p < 0.05$) the SOC stocks. The mean SOC stocks ranged from (2.98-9.72) and (3.15-9.90) $Mgha^{-1}$ for the 2016 LRS and SRS respectively (Table 5). SOC stocks varied for the different vegetation cover types in the order: grass > tree >bare soil in all the topographical zones. SOC stocks under grass in all topographical level were slightly higher in all topographical zones. Highest SOC concentration (1.21 $MgHa^{-1}$ and 1.10 $MgHa^{-1}$) was recorded under TS*G at 0-10 as compared to 40-50 (0.52 $MgHa^{-1}$ and 0.40 $MgHa^{-1}$) whereas the lowest (0.92 $MgHa^{-1}$ and 0.91 $MgHa^{-1}$) was recorded on MS*B at 0-10 cm and 0.39 $MgHa^{-1}$ and 0.28 $MgHa^{-1}$ and at 40-50 for the LRS and SRS respectively. The same trend was observed for SOCs highest (9.72 $MgHa^{-1}$ and 9.90 $MgHa^{-1}$) for TS*G at 0-10 cm and (5.11 $MgHa^{-1}$ and 5.66 $MgHa^{-1}$) at 40-50 cm and lowest under SU*B at 0-10 (7.66 and 7.11 $MgHa^{-1}$.) and (3.19 and 2.60) $MgHa^{-1}$ LRS and SRS respectively. With regards to soil depth, the total soil organic carbon stock content varied considerably. SOC stocks decreased with depth in all topographical zones and vegetation cover type. The upper soil depth (0-10) had higher soil organic carbon stock compared to the lower depth (40-50) in all topographical zones and vegetation cover types. SOC stock mean decreased as the depth increased from (9.72 Mg ha^{-1}, and 9.90) in the upper 0- 10 cm to 5.11 Mg ha^{-1} and 5.42) at the 40-50 cm soil depth under the interaction of toe slope and grass cover during the long and short rain season respectively (Table 4).

Table 4: Soil organic carbon concentration (%) and soil organic carbon stocks (Mg/ha) as influenced by vegetation cover types (VC) and topographical zone (TZ) down the soil profile

			Long rain season 2016					Short rain season 2016				
	TZ	VC	0-10	10-20	20-30	30-40	40-50	0-10	10-20	20-30	30-40	40-50
Organic Carbon concentration (%)	FS	BR	0.91^{a}	0.71^{a}	0.53^{a}	0.34^{a}	0.28^{a}	0.92^{b}	0.73^{ab}	0.66^{b}	0.55^{b}	0.39^{b}
		GR	1.13^{b}	0.84^{b}	0.67^{b}	0.50^{c}	0.36^{a}	1.01^{c}	0.69^{a}	0.54^{a}	0.39^{ab}	0.27^{a}
		TR	1.04^{a}	0.77^{a}	0.59^{a}	0.42^{b}	0.29^{a}	0.83^{a}	0.66^{a}	0.47^{a}	0.32^{a}	0.21^{a}
	MS	BR	1.04^{a}	0.79^{a}	0.69^{a}	0.58^{a}	0.36^{a}	0.93^{a}	0.68^{a}	0.58^{a}	0.47^{a}	0.27^{a}
		GR	1.11^{b}	0.90^{b}	0.766	0.60^{b}	0.54^{c}	1.00^{b}	0.79^{b}	0.65^{b}	0.49^{b}	0.43^{b}
		TR	0.93^{a}	0.75^{a}	0.60^{a}	0.43^{a}	0.34^{a}	0.82^{a}	0.64^{a}	0.49^{a}	0.32^{a}	0.25^{a}
	TS	BR	1.04^{a}	0.83^{a}	0.69^{a}	0.53^{a}	0.47^{a}	0.93^{a}	0.72^{a}	0.58^{a}	0.41^{a}	0.36^{a}
		GR	1.21^{c}	1.00^{b}	0.81^{b}	0.63^{b}	0.52^{a}	1.10^{c}	0.89^{b}	0.70^{b}	0.52^{b}	0.40^{b}
		TR	1.12^{b}	0.84^{a}	0.66^{a}	0.54^{a}	0.44^{a}	1.01^{b}	0.73^{a}	0.55^{a}	0.42^{a}	0.33^{a}
Soil organic carbon stocks (Mg/ha)	FS	BR	7.66^{a}	6.49^{a}	5.86^{a}	3.77^{a}	3.19^{a}	7.11^{a}	5.90^{a}	5.24^{ab}	3.83^{a}	2.60^{a}
		GR	9.12^{c}	7.46^{b}	6.46^{a}	5.12^{b}	3.78^{a}	9.63^{b}	6.60^{a}	5.50^{ab}	4.73^{b}	3.39^{b}
		TR	8.84^{b}	6.87^{a}	5.85^{b}	4.54^{b}	3.28^{a}	6.88^{a}	5.93^{a}	4.98^{a}	3.66^{a}	3.04^{a}
	MS	BR	8.74^{a}	7.37^{b}	6.64^{a}	5.95^{a}	3.80^{a}	8.85^{a}	7.07^{b}	6.23^{a}	5.32^{ab}	3.22^{a}
		GR	8.86^{a}	7.52^{b}	6.43^{a}	5.10^{a}	4.31^{a}	9.13^{b}	7.52^{b}	6.16^{a}	4.57^{a}	3.73^{a}
		TR	8.37^{a}	6.88^{a}	6.72^{a}	5.75^{a}	4.49^{a}	8.53^{a}	6.71^{a}	6.37^{a}	5.18^{a}	3.70^{a}
	TS	BR	8.44^{a}	6.99^{a}	6.08^{a}	4.82^{a}	4.46^{a}	8.57^{a}	6.85^{a}	5.75^{a}	4.27^{a}	3.80^{a}
		GR	9.72^{b}	8.13^{b}	7.22^{b}	5.88^{b}	5.11^{a}	9.90^{b}	8.31^{b}	7.28^{b}	5.66^{b}	5.52^{b}
		TR	8.91^{a}	7.27^{a}	5.90^{a}	5.01^{a}	4.27^{a}	9.66^{b}	7.25^{a}	5.96^{a}	4.81^{a}	3.71^{a}

FS-foot slope, MS-Mid slope, TS-toe slope BR-bare GR-grass TR-tree LRS-long rain season SRS-short rain season

Means followed by the same superscript letter (within a column for each season separately) are not significantly different ($p \leq 0.05$) by Fisher LSD test

Higher soil organic carbon recorded within the toe slope zone was due to higher litter production that is assimilated into the soil resulting to greatest vegetation growth happening within the toe slope because of longer periods of saturation giving rise to high concentrations of organic matter therefore promoting rise of vegetation. Zhang et al. (2015) found that the changes in vegetation kind influences soil carbon accumulation. The upper soil organic carbon concentrations is owed to the improved vegetation production, litter quality and nutrient sport as indicated by Zhang (2015). Topography levels, defines the microclimate and therefore great determinant of vegetation distribution and therefore soil organic carbon concentration. Paul et al. (2016) also linked difference in SOC concentration at totally different topography zones to the heterogeneous nature of vegetation and microclimate at different topographical zones. Various vegetation on changeable topography zones even have distinct soil surface coverage that deeply impacts SOC input, hydrological processes and thus the effect on SOC distribution (Seibert et al., 2007).

The variation soil organic carbon concentration across the seasons is owed to changes in plant biomass throughout the long rain season as compared to short rain season. With increased biomass production throughout the LRS this translates to increased organic matter reservoir that holds the nutrients which can be decomposed by soil microorganisms therefore translating higher organic carbon content in the soil. Reeder *et al., 2004* reported that plant root residues supply of soil organic matter and thus increase of below ground biomass that enhance soil organic matter within the soil. Higher SOC stocks were ascertained at the toe slope than different topographic zones. This might result the deposition of eroded organic carbon from the mid slope and foot slope. Toe slope are water accumulating zone thus has deeper and porous soils that encourage faster vegetation growth and thus increased biomass production thus leading to increased SOC. Schwanghart and Jarmer (2011) showed that prime SOC stocks in toe slope is attributed to enlarged status and as a results of the downward movement of water from the higher zones. Romero et al., 2014 also reported that variation in topography means that totally different climate conditions, that hamper the vegetation cowl varieties, poignant productivity of vegetation, and more influence the organic carbon input quantity into the soil. On the one hand, it should result from the distribution of SOC because of erosion and deposition processes, depleting SOC from wearing sites on the topography, and depositing them at the toe slope zone (Seibert et al., 2007). On the contrary, the enrichment of SOC at the toe slope presumably promoting vegetation growth, and thus accessorial plentiful residues and root growth, eventually tributary to SOC accumulation there (Zhu et al., 2014).

The low mean values of SOC ascertained for vacant may be due to; vegetation loss ensuing to a low in carbon inputs from the roots and leaf litter, microorganism activity enlarged because of favourable soil temperature relative to tree and grass cover. Higher SOCS recorded below grass cover may also be coupled to higher litter production that is incorporated into the soil compared to bare ground. Wang *et al* ., 2018 reported that accumulative root biomass not simply will increase soil C inputs but also N retention inside the soil as a result of each organic N and C dynamics. Higher soil organic carbon stock within the higher (0-10 cm) is as a results of leaf litter decomposition. Moreover, as a result of most organic residues area unit incorporated in, or deposited on the surface, organic matter tends to accumulate within the higher layers. This conforms to the study by Yimer et al. (2006), who recorded a decrease in SOC stock with increasing of soil depth implying that a lot of carbon is sequestered within the prime 25 cm with a modification in vegetation varieties.

Conclusions

Results of this study have shown topography and vegetation cover of the wooded grassland had positive influence on soil organic carbon (SOCs). Soil organic carbon stocks are high within the toe slope topography and grass vegetation at totally different soil depths across the seasons. So efforts aimed toward rising SOCs at intervals the wooded grassland can improve on carbon sequestration and otherwise reverse degradation of the timbered parcel. The study recommends action on the grazing management ways to scale back land degradation to encourage soil organic carbon sequestration. Soil management plans ought to use within the summit and bare ground to extend soil organic carbon stocks.

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