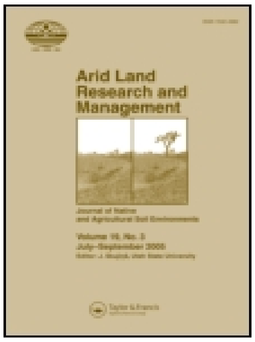

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Distinguishing Carbon and Nitrogen Storage in Plant and Soil of Grassland Under Different Climates in the Loess Plateau, China

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Grassland covers approximately one-third of the area of the Loess Plateau and plays an important role in the carbon (C) and nitrogen (N) cycles. This study was conducted to estimate the C and N storage of grassland ecosystems under different climates (semi-humid, semi-arid and arid). Results indicated that about 90% of the ecosystem C and N were stored in the soil. Soil organic carbon (SOC) density of grasslands in different climatic zones decreased in the order, semi-humid (53.34 Mg C ha^{-1}) > semi-arid (50.22 Mg C ha^{-1}) > arid (19.13 Mg C ha^{-1}) climatic zone. Also, grassland in the semi-humid climatic zone had the highest belowground biomass C (1.01 Mg C ha^{-1}) and N (0.25 Mg N ha^{-1}) density; whereas grassland in the semi-arid climatic zone had the highest aboveground biomass C (1.06 Mg C ha^{-1}) and N (0.26 Mg N ha^{-1}) density. C and N storage of grassland ecosystem in the arid climatic zone was significantly lower than that in the other two climatic zones ($p < 0.05$). The vegetation community density, cover, and richness, above- and belowground biomass, and climatic factors significantly influenced the C and N distribution in this region ($p < 0.05$). The mean annual precipitation emerged as the most important variable for C and N accumulation. Grassland with mean annual precipitation of 350–630 mm might have high C and N sequestration potential. Results of this study provide reliable reference information for predicting C and N dynamics in similar agroecological systems.

Keywords carbon/nitrogen storage, climatic factors, community characteristics, grassland soil, plant biomass

Introduction

Grassland is one of the most widely distributed terrestrial ecosystems and plays a crucial role in husbandry and soil water conservation (Cheng, 1993). Grassland

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ecosystems also have high potential of carbon (C) and nitrogen (N) sequestration, contributing >10% of the total biosphere C and N store (Jones and Donnelly, 2004; Heimann and Reichstein, 2008). The quantity and quality of grassland ecosystem C and N sequestration are reported to be affected by multiple factors, causing unstable and more variable C and N cycling in grassland ecosystems (see Table 1). Climatic factors are the most decisive ones, which influence both the above- and belowground processes of the C and N cycles and ultimately determine the quantity of C and N sequestrations in grassland soil (Weltzin et al., 2003). It is demonstrated that precipitation and temperature are the most important climate variables for C and N accumulation (Brandt et al., 2007). Vegetation biomass and C and N cycling

Table 1. Factors and their effects on grassland C and N accumulation in the Loess Plateau

Affecting factor	Effect on C and N accumulation		Source
	Result	Mechanism	
Precipitation	Increase	Increase carbon fixation of plant	Ise and Moorcroft, 2006; Ford et al., 2012
	Decrease	Run off or leach soil C and N	Chen et al., 2012
Temperature	Increase	Increase the carbon fixation by plant	Cao and Woodward, 1998; Dalgleish et al., 2011
	Decrease	Increase the decomposition of organic matter	Parton et al., 1995
Grazing	Decrease (under overgrazing)	Decrease C and N input to the soil	Derner et al., 2006
	Increase (under light grazing)	Accelerate the litterfall decomposition by livestock stomp	Reeder et al., 2004
Grazing exclusion	Increase	Increase carbon fixation by plant	Gao and Cheng, 2013
Grassland reclamation	Decrease	Decrease C and N input to the soil; destroy the stability of soil aggregates; increase organic matter decomposition and soil erosion	Jones and Donnelly, 2004
Introduction of suitable grass cultivar	Increase	High above- and belowground biomass and carbon concentration	Ma et al., 2000

are closely related to the amount and seasonal distribution of precipitation and temperature in arid and semiarid ecosystems (Carrera et al., 2009).

Precipitation and temperature can influence the C and N storage not only directly by affecting the flux rates but also indirectly by affecting both the grassland species composition and vegetation characteristics. Due to the different adaptations to various climate conditions, some plant species disappear or some others occur. In the northwest China, hygrophytes and mesophytes are rare whereas xerophytes dominate the vegetation community with decreasing precipitations and temperatures (Cheng, 1993). Some species tend to have more stress-tolerant morphological and physiological traits, such as small stature, low nutrient concentrations, assimilation rate, adaptation to the unfavorable environment (Chapin et al., 1993). The apparent changes in vegetation community are usually low plant cover and productivity (Weltzin et al., 2003). Shifts in species composition and vegetation characteristics may alter the quantity and quality of plant C and N inputs to soil via leaf litterfall and root turnover (Schlesinger and Pilmanis, 1998). For example, sagebrush, one of the dominant species in arid environment, has slower root turnover towards the soil than perennial grasses and forbs (Dalgleish et al., 2011). Moreover, the differences in biomass allocation (i.e., shoot: root ratio) of vegetation types not only determine the quality of C input, but also influence soil C mineralization rate (Vinton and Burke, 1995).

There are three typical climatic zones (semi-humid, semi-arid, and arid) from southeast to northwest in the Loess Plateau, which provides us with an opportunity to investigate the spatially heterogeneous C and N content of grasslands under different climates. Previous studies about soil C and N storage of grassland in this region mainly focus on small catchments (Fu et al., 2010; Han et al., 2010). The C and N storage and distribution of grassland at regional scale is poorly understood. Additionally, the C and N are stored in discrete pools, plant C and N should be taken into consideration (Ostle et al., 2009). The objectives of this study are (1) to estimate the C and N storage in plant biomass and soil of grassland, (2) to explore C and N distribution of grassland ecosystems in different climatic zones, and (3) to evaluate the effects of climatic factors (precipitation and temperature) and vegetation characteristics on C and N storage. This study will provide a more accurate quantification of grassland ecosystem C and N storage in the Loess Plateau, and will contribute significantly to the prediction of C and N dynamics with climate changes.

Materials and Methods

Study Area

The Loess Plateau (latitude 33°41′–41°16′N, longitude 100°52′–114°33′E), with a total area of 6,238,000 km^2 and a elevation range of 300–2000 m, is located in the northwest of China. About 1/3 of the region is grassland, the remaining land is divided into forests and agriculture land. The Loess Plateau is the transitional belt area between humid and arid regions of China. The mean annual temperature ranges between 3.6°C and 13.6°C, and the mean annual precipitation is typically between 150 mm and 800 mm. In the test area, there are three major climatic zones (Figure 1), they are semi-humid (mean annual precipitation >600 mm), semi-arid (mean annual precipitation ranging from 250 mm to 600 mm), and arid (mean annual precipitation <250 mm) (Cheng, 1993; Wang et al., 2011). The grassland soil is classified as Cal-Orthic Aridisol or Cinnamon Spodosol according to the Chinese

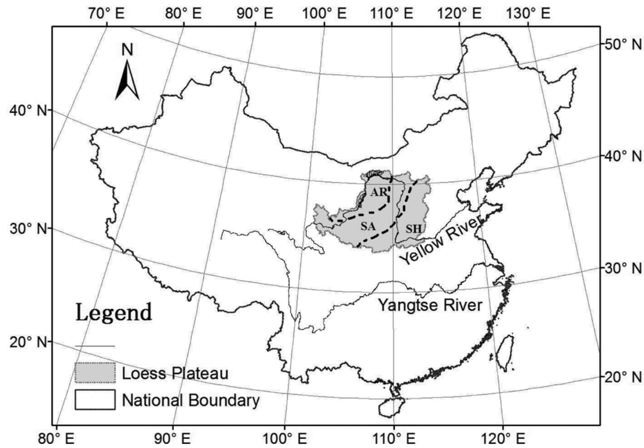

Figure 1. Location of the study area.

taxonomic system and is developed from wind-accumulated loess parent material with uniform silt loam texture (Cheng, 1993). The soil's average pH ranges from 6.5 to 8.5. The dominant species are needlegrass (*Stipa bungeana* Trin. and *Stipa grandis* P. Smirn.) and sagebrush (*Artemisia sacrorum* Ledeb. ex Hook.f., *Artemisia capillaris* Thunb., and *Artemisia scoparia* Waldst. et Kit.).

Experimental Details

This study was conducted in October 2011. There were 24 grassland sites with grazing exclusion for 12 years along the precipitation and temperature gradient (8 sites for each climatic zone). The grassland sites were grazed by goats before grazing exclusion. The intensity of grazing had varied over the years. We randomly selected three test plots (50 m $\times$ 50 m) in each site. In each plot, five plant quadrats (1 m $\times$ 1 m) were set. Plant species, community cover, density, and richness were recorded. The live and dead aboveground biomass was harvested at the ground level. The live and dead roots in soil (1 m depth) were collected. Above- and belowground biomass (AGB and BGB) were measured after the plant materials were dried at 65°C to constant weight. Series of soil samples to a 1 m depth were collected at 20 cm intervals using a soil core (5 cm diameter). The soil samples from the same layer in each plot were mixed for a more representative sample for lab analysis. Another set of soil samples to the same depth were taken from all of the plots in order to determine the bulk density using the core method with a 100-cm^3 sampler (Gao and Cheng, 2013). The total number of soil and plant (above- and belowground) samples was 120 and 240, respectively. Each soil or plant sample was replicated for 3 times.

Soil and plant samples were ground and passed through a 0.25 mm sieve before testing. Organic C concentration was measured by $K_2Cr_2O_7$ external heating method, and N concentration was measured by Kjeldahl method (Fu et al., 2010). Climatic data were collected from local weather stations.

Data Analysis

The organic carbon density of above- and belowground biomass [ABOCD and BBOCD, (Mg C ha^{-1})], the nitrogen density of above- and belowground biomass

[ABND and BBND, (Mg N ha^{-1})], SOC density [SOCD, (Mg C ha^{-1})], and STN density [STND, (Mg N ha^{-1})] in 1 m depth are calculated as follows:

$$\text{ABOCD} = \text{AGB} \times \text{ABOC}/10000 \tag{1}$$

$$\text{BBOCD} = \text{BGB} \times \text{BBOC}/10000 \tag{2}$$

$$\text{ABND} = \text{AGB} \times \text{ABN}/10000 \tag{3}$$

$$\text{BBND} = \text{BGB} \times \text{BBN}/10000 \tag{4}$$

$$\text{SOCD} = \sum \text{SOC}_i \times \text{B}_i \times \text{H}_i/10 \tag{5}$$

$$\text{STND} = \sum \text{STN}_i \times \text{B}_i \times \text{H}_i/10 \tag{6}$$

where AGB and BGB are the above- and belowground biomass (g m^{-2}), ABOC and BBOC are the organic carbon concentrations (g C kg^{-1}) of above- and belowground biomass, ABN and BBN are the nitrogen concentrations (g N kg^{-1}) of above- and belowground biomass, SOC_i, STN_i, B_i, and H_i are the SOC concentration (g C kg^{-1}), STN concentration (g N kg^{-1}), soil bulk density (g cm^{-3}), and thickness (cm) of soil layer i ($i = 1, 2, 3, 4, 5$), respectively.

The grassland ecosystem C storage is the sum of ABOCD, BBOCD, and SOCD; the grassland ecosystem N storage is the sum of ABND, BBND, and STND.

Statistical analysis was performed by the software SPSS, ver. 16.0 (SPSS Inc., Chicago, IL, USA). One-way ANOVA for plant and soil C and N storage of grasslands in climatic zones was conducted and multiple comparisons were carried out by Duncan's method. Correlation and regression analyses between C and N storage and climate factors and vegetation community characteristics were performed.

Basing on the values of C and N storage in each sampled site, the inverse distance weighted approach (IDW) was used to map the spatial distribution of grassland C and N storage in the Loess Plateau. These maps were produced with the GIS software ArcView (version 3.1).

Results

Dominant Species and Vegetation Community Characteristics

There were significant differences in the dominant species of grasslands among climatic zones (Table 2). The most important species were mesophyte grasses in the semi-humid climatic zone, mesophyte grasses and forbs in the semi-arid climatic zone, and xerophytic suffrutex in the arid climatic zone. The values of AGB (187.62–237.17 g m^{-2}), community density (24.01–43.90 plants m^{-2}), cover (25.51–41.02%) and richness (12.75–19.62 species m^{-2}) decreased as semi-arid, semi-humid > arid climatic zone ($p < 0.05$) (Table 3). However, BGBs of grasslands in semiarid and arid climatic zones was significantly lower than that in the semi-humid climatic zone ($p < 0.05$).

Table 2. Dominant species and their characteristics of grasslands in different climatic zones

Climatic zone	Dominant species	Growth form	Life cycle	Ecotype
Semi-humid				
	Bothriochloa ischaemum (Linn.) Keng	Grass	Perennial	Mesophyte
	Setaria viridis (Linn.) Beauv.	Grass	Annual	Mesophyte
	Rubia cordifolia Linn.	Herbaceous vine	Perennial	Mesophyte
	Stipa bungeana Trin.	Grass	Perennial	Mesophyte
	Artemisia sacrorum Ledeb. ex Hook.f.	Suffrutex	Perennial	Mesophyte
Semi-arid				
	Stipa bungeana Trin.	Grass	Perennial	Mesophyte
	Heteropappus altaicus (Willd.) Novopokr.	Forb	Perennial	Mesophyte
	Poa sphondylodes Trin.	Grass	Perennial	Mesophyte
	Ixeris polycephala Cass. ex DC.	Forb	Annual	Mesophyte
	Artemisia giraldii Pamp.	Suffrutex	Perennial	Mesophyte
Arid				
	Artemisia capillaris Thunb.	Suffrutex	Perennial	Mesophyte
	Agropyron cristatum Beauv.	Grass	Perennial	Xerophyte
	Sophora alopecuroides Linn.	Suffrutex	Perennial	Xerophyte
	Salsolapasserina Bunge	Suffrutex	Perennial	Xerophyte
	Kochia prostrate (Linn.) Schrad.	Suffrutex	Perennial	Xerophyte

Plant Biomass C and N Storage

The concentrations of ABOC and BBOC were 426.43–446.33 g C kg^{-1} and 396.38–406.62 g C kg^{-1} and the concentrations of ABN and BBN were 11.52–11.74 g N kg^{-1} and 9.77–9.87 g N kg^{-1}. There was no significant difference in ABOC, BBOC, ABN, or BBN concentration among the different climatic zones. Within the variation of AGB and BGB (Table 3), the biomass C and N density was also various (Table 4). The order of ABOCD and ABND was semi-arid>semi-humid>arid climatic zones. However, semi-humid climatic zone had higher BBOCD and BBND than the other two zones.

SOC and STN Storage

The SOC concentrations in the 0–20 cm layer were 10.72 ± 0.89 g C kg^{-1} in semi-humid zone, 7.02 ± 0.76 g C kg^{-1} in semi-arid zone, and 2.27 ± 0.58 g C kg^{-1} in arid zone, respectively. However, SOC concentrations in the deeper soil layers of the semi-arid climatic zone were the highest among zones (Figure 2). In contrast, grassland in arid climatic zone had the lowest level of SOC concentration for each soil layer. Throughout the soil profile, STN concentration presented a prominent

Table 3. Vegetation community characteristics of grasslands in different climatic zones

Vegetation community characteristics	Climatic zone			
	Semi-humid	Semi-arid	Arid	*F* (Sig.)
AGB (g m^{-2})	224.08 ± 5.80^a	237.17 ± 6.63^a	187.62 ± 3.91^b	21.31 (<0.001)
BGB (g m^{-2})	655.91 ± 13.06^a	621.17 ± 9.29^b	604.25 ± 4.26^b	7.81 (0.003)
Community density (plants m^{-2})	43.45 ± 4.14^a	43.90 ± 2.90^a	28.01 ± 4.07^b	5.83 (0.010)
Community cover (%)	36.03 ± 4.32^a	41.02 ± 3.06^a	25.51 ± 2.13^b	5.78 (0.010)
Community richness (species m^{-2})	17.82 ± 1.59^a	19.62 ± 1.45^a	12.75 ± 1.16^b	26.87 (<0.001)

Note: Data represent the mean ± standard deviation (N = 120). AGB is the aboveground biomass, BGB is the belowground biomass. Significant differences ($\alpha = 0.05$) among climatic zones are indicated with lowercase superscript letters.

consistent trend with SOC concentration, and their relationship fit a linear equation ($y = 0.0761x + 0.0823$, $R^2 = 0.857$, $p < 0.001$) (Figure 3). SOC and STN concentrations decreased sharply at the 20–40 cm layer in semi-humid and semi-arid climatic zones, indicating that more C and N input from organisms to the soil in the surface layer. Due to the lowest SOC and STN concentrations, grassland in the arid climatic zone had significantly lower SOCD and STND than those in the semi-humid and semi-arid climatic zones ($p < 0.001$) (Table 4).

Table 4. Organic carbon and nitrogen density in biomass and soil of grasslands in different climatic zones

	Climatic zone			
	Semi-humid	Semi-arid	Arid	*F* (Sig.)
ABOCD (Mg C ha^{-1})	0.99 ± 0.03^a	1.06 ± 0.03^a	0.80 ± 0.03^b	20.96 (<0.001)
BBOCD (Mg C ha^{-1})	2.60 ± 0.03^a	$2.53 \pm 0.06^{a,b}$	2.42 ± 0.04^b	6.62 (0.006)
SOCD (Mg C ha^{-1})	53.34 ± 1.42^a	50.22 ± 3.67^a	19.13 ± 1.73^b	58.06 (<0.001)
ABND (Mg N ha^{-1})	0.03 ± 0.00^a	0.03 ± 0.00^a	0.02 ± 0.00^a	1.79 (0.192)
BBND (Mg N ha^{-1})	0.07 ± 0.00^a	0.06 ± 0.00^b	0.06 ± 0.00^b	6.66 (0.006)
STND (Mg N ha^{-1})	5.03 ± 0.26^a	5.17 ± 0.39^a	2.00 ± 0.024^b	33.94 (<0.001)

Note: Data represent the mean ± standard deviation ($N = 24$). ABOCD is the aboveground biomass organic carbon density, BBOCD is the belowground biomass organic carbon density, SOCD is the soil organic carbon density, ABND is the aboveground biomass nitrogen density, and BBND is the belowground biomass nitrogen density and STND is the soil total nitrogen density. Significant differences ($\alpha = 0.05$) among climatic zones are indicated with lowercase superscript letters.

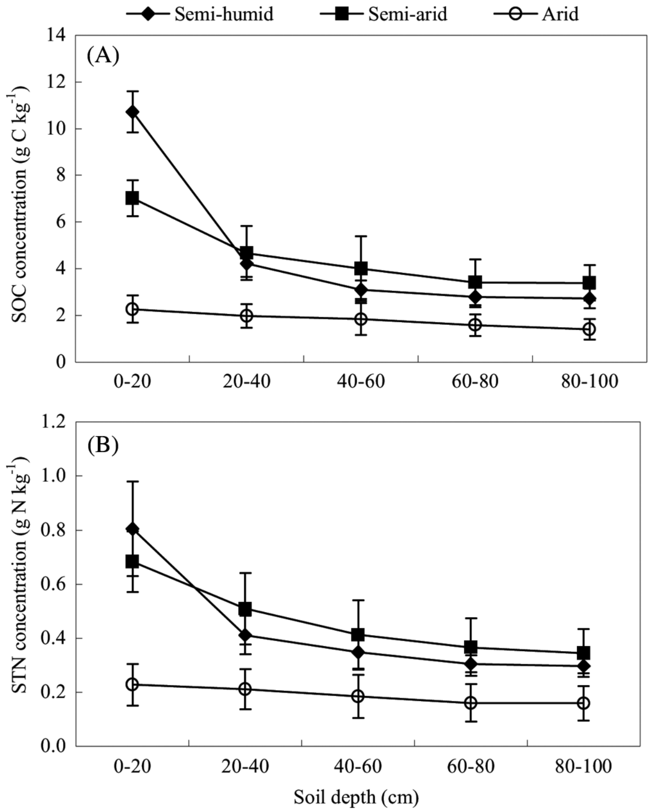

Figure 2. SOC (A) and STN (B) concentration of grassland in the three climatic zones.

Distribution of Grassland C and N Storage

The average grassland ecosystem C storages were 56.94 Mg C ha^{-1} in the semi-humid zone, 53.81 Mg C ha^{-1} in the semi-arid zone, and 22.35 Mg C ha^{-1} in

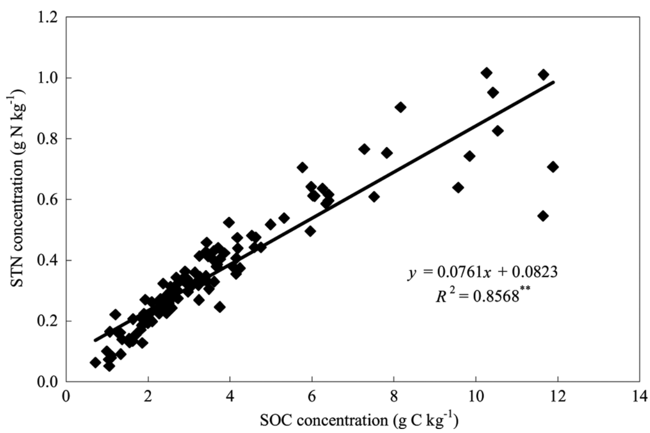

Figure 3. Linear regression between SOC and STN concentration throughout the profile.

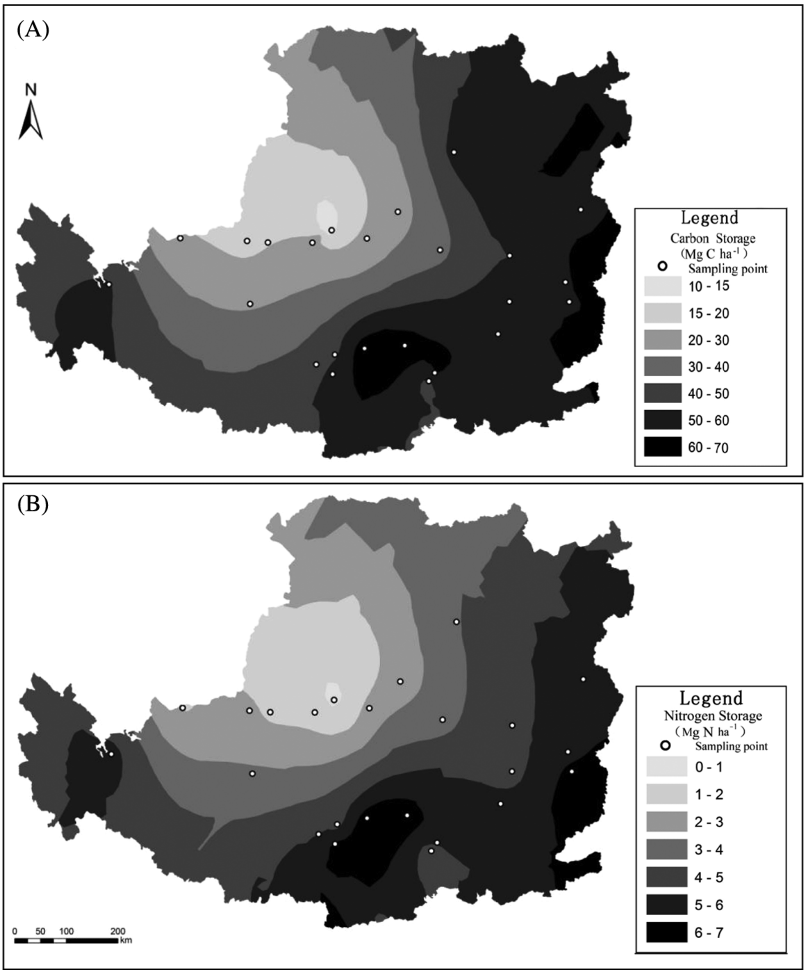

Figure 4. Spatial distribution of the grassland ecosystem C (A) and N (B) storage in the Loess Plateau.

the arid zone. The corresponding N storages were 5.13 Mg N ha^{-1}, 5.28 Mg N ha^{-1}, and 2.08 Mg N ha^{-1}, respectively. About 90% of C and N were contained in the grassland soil, whereas the C and N in biomass were relatively lower. The spatial distribution of C and N storage of grassland was in accordance with the climosequence across the Loess Plateau, decreasing from southeast to northwest (Figure 4).

Discussion

Effects of Climatic Factors on Plant Biomass C and N Storage

Previous studies demonstrated that C and N cycles in plant-soil ecosystems can be notably affected by the mean annual precipitation and temperature (e.g., Chen et al., 2013; Chang et al., 2014). Thus, we tested the relationship between the two climatic factors and C and N storages in plant biomass and soil. The mean annual precipitation had a significantly positive correlation with ABOCD, BBOCD, and BBND ($p < 0.05$) (Table 5). The mean annual temperature had a significant positive correlation with BBOCD and BBND ($p < 0.05$). The results indicated that both the two climatic factors impacted the biomass C and N storage profoundly. These impacts were mainly accomplished via affecting the quantity and allocation of plant biomass. Increasing aridity could reduce the live and dead biomass though suppressing plant growth (Fan et al., 2008). Low soil water availability also removed some species that inhabited the most productive areas and responded to climate variability sensitively (Craine et al., 2013). In contrast, positive effects of increasing soil water on plant above- and belowground growth could be rapidly observed in semiarid and arid grassland ecosystems (Fan et al., 2008). Therefore, the AGB, community density, cover were higher in the semi-humid and semi-arid grasslands than those in arid grassland (Table 3). In addition, laboratory studies demonstrated that root growth rates were sensitive to or even determined by temperature (Sanaullah et al., 2012). Cold stress slowed down carbohydrate synthesis, weakened microbial activity and then reduced plant growth and soil nutrient availability (Mitchell and Csillag, 2001). Moderate increases in temperature and precipitation could accelerate plant shoot and root growth (Dalgleish et al., 2011).

Effects of Climatic Factors on SOC and STN Storage

There were substantial variations of grassland SOC and STN storage among climatic zones (Table 5). The STN concentration exhibited a similar tendency with SOC concentration. This result was consistent with the earlier findings which suggested STN was highly related to SOC (Yimer et al., 2006; Fu et al., 2010). Both the SOC and STN density had significant positive correlations with the mean annual precipitation ($p < 0.01$) (Table 5). Also, the SOC density was significantly correlated with the mean annual temperature ($p < 0.01$). These results indicated that SOC and STN were increased with the precipitation or temperature increasing. In spite of C loss caused by faster decomposition rates under such a warm and humid condition, it could be compensated by the C input from increasing plant productivity (Jones and Donnelly, 2004). The mean annual precipitation had more significant

Table 5. Correlations between mean annual precipitation, mean annual temperature and C and N density

	Mean annual precipitation		Mean annual temperature	
	r	Sig.	*r*	Sig.
ABOCD	+0.56	<0.01	+0.31	0.15
BBOCD	+0.53	<0.01	+0.67	<0.01
ABND	+0.26	0.21	+0.07	0.76
BBND	+0.48	0.02	+0.60	<0.01
SOCD	+0.85	<0.01	+0.52	<0.01
STND	+0.76	<0.01	+0.40	0.06

Note: ABOCD is the aboveground biomass organic carbon density, BBOCD is the belowground biomass organic carbon density, ABND is the aboveground biomass nitrogen density, BBND is the belowground biomass nitrogen density, SOCD is the soil organic carbon density, STND is the soil total nitrogen density, and *r* is the Pearson correlation coefficient.

correlations with SOC and STN density than the mean annual temperature did. This indicated that precipitation regime was the most important factor influencing soil C and N cycles in arid regions (Burke et al., 1998; Ise and Moorcroft, 2006). Precipitation exerted various impacts on C and N cycles. The fluctuation in precipitation caused the variations in plant productivity and litter decomposition rate (Brandt et al., 2007). Additionally, precipitation could affect the allocation of active and inert SOC and then influenced the stability of SOC storage. Under higher precipitation condition, active SOC including particulate organic carbon and light fraction organic carbon were infiltrated to deeper soil layers, providing an ideal condition for SOC accumulation (Chen et al., 2010). Furthermore, relationship between SOC, STN density, and the mean annual precipitation fit an "S" model, indicating that they had been allometrically increasing with the increase of precipitation. Grassland with moderate mean annual precipitation (350–630 mm) might have high potential in C and N accumulation (Figure 5). To explain this, too low precipitation

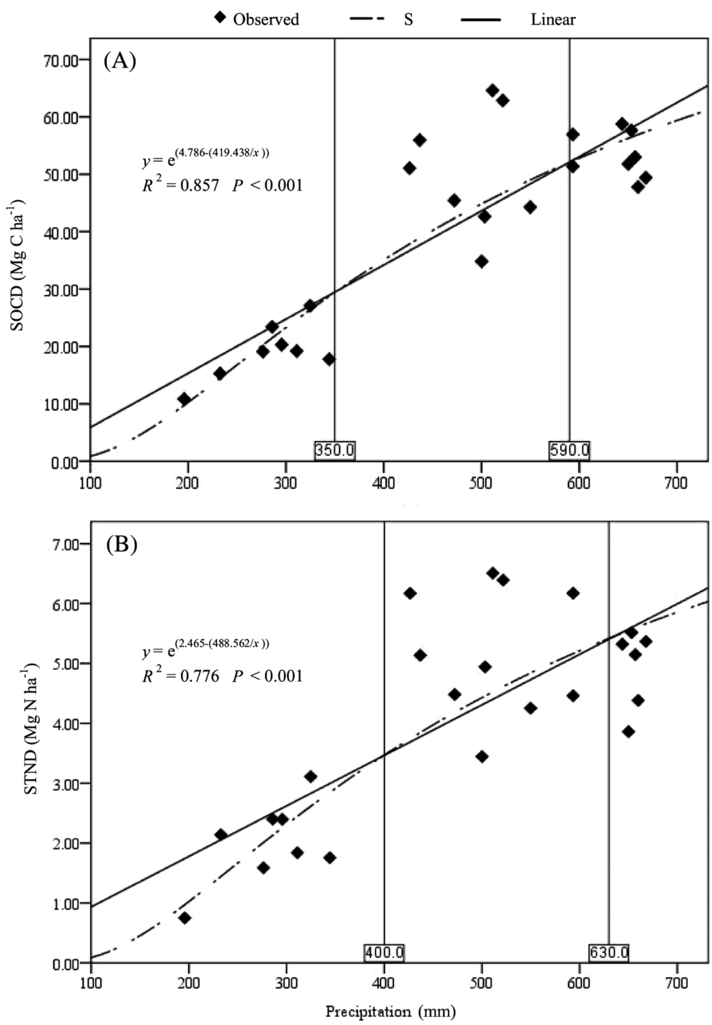

Figure 5. Regressions between mean annual precipitation and SOCD (A) and STND (B).

Table 6. Correlations between community characteristics and SOCD and STND

	Community density		Community cover		Community richness		AGB		BGB	
	r	Sig.	*r*	Sig.	*r*	Sig.	*r*	Sig.	*r*	Sig.
SOCD	+0.54	<0.01	+0.50	0.01	+0.69	<0.01	+0.67	<0.01	+0.48	0.02
STND	+0.45	0.03	+0.49	0.02	+0.66	<0.01	+0.68	<0.01	+0.40	0.05

Note: SOCD is the soil organic carbon density, STND is the soil total nitrogen density, AGB is the aboveground biomass, BGB is the belowground biomass, and *r* is the Pearson correlation coefficient.

reduced the input of C and N to soil, whereas too high precipitation runs off the surface soil and lead to C and N loss (Chen et al., 2012). It was reported that SOC, STN concentration in the top 0–3 cm decreased by 11% and 12% through soil loss (Roder et al., 1995). In the runoff soil, the C concentration reached 7.10–7.76 g C kg^{-1}, and the N concentration was 1.22–1.29 g N kg^{-1} (Liu et al., 1995).

Effects of Vegetation Community Characteristics on SOC and STN Storage

From our data, all the plant community characteristics had positive correlations with the SOC and STN storage (Table 6). This result was partly in accordance with previous findings which suggested that plant community distribution and species dominance had close relationships with the SOC and STN storage of grassland (Zuo et al., 2009; Peri and Lasagno, 2010). Former research even demonstrated that the effect of vegetation type on the SOC was much more important than the precipitation (Jobbágy and Jackson, 2000). High plant biomass resulted in greater litterfall and fine root turnover which lead to faster redistribution rates of C and N toward the soil (Hooker et al., 2008). In contrast, poor plant productivity was the main reason for lower SOC and STN storage of grassland in the arid climatic zone (Table 3 and Table 6). In arid climatic zone, xerophytic suffrutex were sparsely distributed. The small community density and cover limited the quantity of C and N input to the soil. In addition, litterfall of suffrutex decayed slower due to its high concentrations of lignin and low concentrations of soluble carbohydrates, slowing down the process of C input from litter to the soil (Schlesinger and Pilmanis, 1998).

Conclusion

Our work illustrates the distinguishing grassland biomass and soil C and N storage among climate types. Grassland in the semi-humid zone had the highest belowground C and N storage; whereas grassland in the semi-arid zone had the highest aboveground C and N storage. Moreover, our analysis emphasizes the impacts of vegetation community characteristics and climatic factors on C and N distribution. The mean annual precipitation emerged as the most important variable for C and N cycling in the region of Loess Plateau. The Loess Plateau is expected to experience significant climatic changes as anthropogenic forcing continues. Further studies are needed to fully evaluate the influence of climate variability on the grassland C and N sequestration.

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