Catena 172 (2019) 753–763

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Effects of vegetation and slope aspect on soil nitrogen mineralization during the growing season in sloping lands of the Loess Plateau

Weibo Kong[a,c], Yufei Yao[a,c], Zhongna Zhao[b], Xin Qin[b], Hansong Zhu[b], Xiaorong Wei[a,b,*], Mingan Shao[a], Zhao Wang[b], Kaiqiang Bao[b], Min Su[b]

[a] State Key Laboratory of Soil Erosion and Dryland Farming on the Loess Plateau, Research Center of Soil and Water Conservation and Ecological Environment, Ministry of Education, Chinese Academy of Sciences, Yangling 712100, China

[b] College of Natural Resources and Environment, Northwest A&F University, Yangling 712100, China

[c] University of Chinese Academy of Sciences, Beijing 100049, China

ARTICLE INFO

Keywords:
Mineral N pool
Net N mineralization
Vegetation presence
Grassland
Woodland
Slope aspect

ABSTRACT

The presence of vegetation has significant effects on soil nitrogen (N) turnover. However, whether these effects vary with slope aspect, vegetation type and time of season were not understood in previous studies, precluding our ability to understand how vegetation affects soil N cycling in sloping land. In this study, we investigated the effects of vegetation presence (plots with vs. without vegetation), vegetation type (grassland vs. woodland) and slope aspect (east vs. west slope) on soil N turnover during the growing season in sloping lands of the Loess Plateau, China. Soil metrics measured included concentrations of ammonium (NH_4^+), nitrate (NO_3^-) and total mineral N (Min-N) in soil solution and rates of ammonification (R_a), nitrification (R_n) and net N mineralization (R_m). We hypothesized that the presence of vegetation would deplete the soil Min-N pool and decrease R_m and that these effects would be greater in east slopes and woodlands than in west slopes and grasslands. In partial support of these hypotheses, vegetation presence decreased soil Min-N concentration but did not affect R_m. NH_4^+ and NO_3^- contributed similarly to Min-N, while R_n dominated R_m. The effects of vegetation presence on soil mineral N and N mineralization varied with the time of the season but were not related to the vegetation type and slope aspect. The soil Min-N and R_m were significantly higher in woodlands, east slopes and 0–10 cm depth than grasslands, west slopes and 10–20 cm depth, respectively. The R_a and NH_4^+ increased, while the R_n, R_m, NO_3^- and Min-N decreased with increasing soil moisture. These results indicated that soil Min-N and R_m in the sloping lands of the Loess Plateau consistently respond to vegetation presence across slope aspect and vegetation type, and were regulated by soil moisture.

1. Introduction

Sloping land is an important land position of the terrestrial ecosystem and is often used for agricultural production. Soil erosion due to tillage is the most important driver of land degradation in slopes (Basic et al., 2004; Wezel et al., 2002). Globally, the land area affected by soil erosion reached 1.643×10^7 km^2 (Lal, 2003), particularly in arid and semiarid climates (e.g., China's Loess Plateau, semiarid rangelands of Argentina) (Busso and Fernández, 2018; Fu et al., 2005). Generally, erosion results in the loss of nutrients and fine particles (Lal, 2003; Doetterl et al., 2016), leading to decreases in soil fertility and thus productivity of the ecosystem (Wezel et al., 2002). Establishing natural vegetation (grass or forest) is proven an effective way to prevent erosion and to improve soil quality of the slopes (Bennett, 2008). For example, the Grain for Green Program, aimed at rehabilitating the eroded lands in China, has decreased the sediment load from the Loess Plateau into the Yellow River from 1.34 ± 0.64 Gt yr^{-1} during the 1951–1979 period to 0.73 ± 0.28 Gt yr^{-1} during the 1980–1999 period, and further down to 0.32 ± 0.24 Gt yr^{-1} during the 2000–2010 period (Wang et al., 2016). In addition, this practice significantly increases soil organic carbon (C) and total nitrogen (N) concentrations in the Loess Plateau, with increasing rates of 0.23 and 0.03 g kg^{-1} yr^{-1}, respectively (Deng and Shangguan, 2017). The accumulation of soil organic matter and the reservation of soil nutrients could either increase N mineralization and availability due to the priming effects of the increased input of soil organic materials (Berhe et al., 2014; Doetterl et al., 2016) or decrease them due to the immobilization effect of increased microbial biomass and activities

* Corresponding author at: College of Natural Resources and Environment, Northwest A&F University, Yangling 712100, China.
E-mail address: xrwei78@163.com (X. Wei).

https://doi.org/10.1016/j.catena.2018.09.037
Received 4 March 2018; Received in revised form 11 September 2018; Accepted 19 September 2018

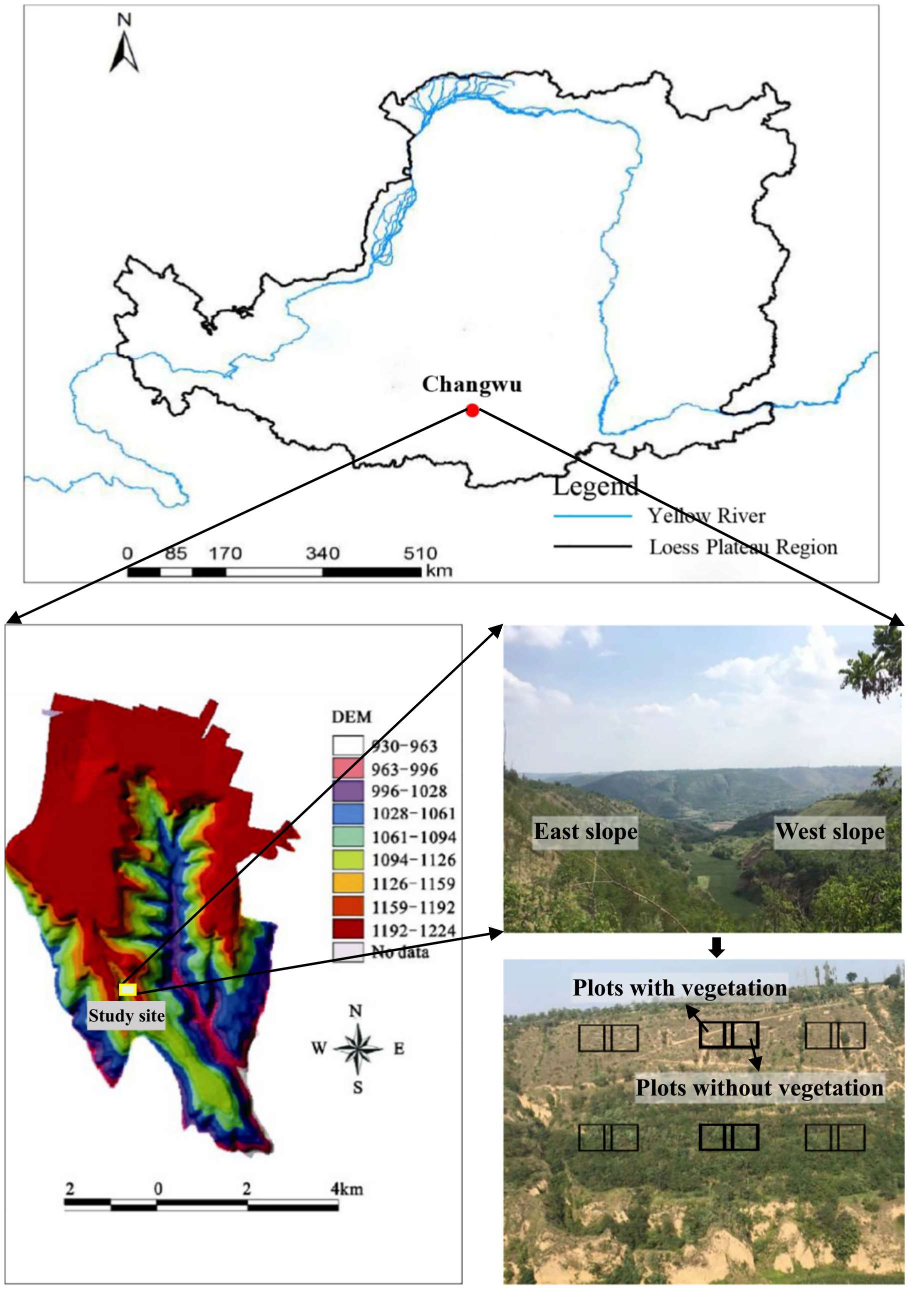

Fig. 1. Location of the study site and sampling scheme.

(Seagle et al., 1992; Wang et al., 2010; Guo et al., 2018). The response of land surface processes to vegetation establishment would thus provide important regulation on biogeochemical cycles in the sloping lands.

The slope aspect plays a vital role in determining soil moisture and solar radiation and thus soil heat flux between the soil and atmosphere (Bennie et al., 2008; Chesson et al., 2004). Generally, the slope aspect alters radiation and soil evaporation, and thus influences plant composition (Clifford et al., 2013; Deák et al., 2017). These variations considerably affect soil biogeochemical cycles and vegetation patterns (Zhao and Li, 2017). For instance, Hishi et al. (2017) observed higher rate of net N nitrification in the north facing slopes than in the south facing slopes in the Ashoro Research Forest on the east side of inland Hokkaido, Japan. They attributed this effect to the differences in the C/N ratio, acidity and soil moisture between the two slopes. Gilliam et al. (2015) showed that N mineralization was dominated by ammonification in the southwest slopes but by nitrification in the northeast slopes at two forested sites of West Virginia. However, Westerband et al. (2015) and Zak et al. (1991) reported no response in nitrification and N mineralization with respect to the slope aspect in semiarid pinyon-juniper woodlands and upland pin oak forest, respectively. This inconsistency in the response of soil cycles to the slope aspect might be due to the variations in vegetation coverage and type. For example, Hishi et al. (2014) revealed that the rates of N mineralization and nitrification were higher in larch plantations than in natural broad-leaved forests, especially on south facing slopes. Although the effects of the slope aspect and the presence of vegetation were described in previous studies, the interaction of the two factors was rarely examined.

The turnover and the availability of soil N have important influence on terrestrial ecosystems, with higher soil N availability contributing to higher plant C assimilation and productivity (Vitousek and Howarth, 1991; Reich et al., 1997) but lower species diversity (Stevens et al., 2004; Isbell et al., 2013). In this study, we present the results of soil N mineralization during the growing season as affected by vegetation