

Effect of grazing on soil fertility and trace elements of temperate desert steppe in Northwestern China

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Introduction

Grazing is the dominant land use of temperate desert steppe in northwestern China. It is well established that the grazing process has impacts on plant production and biodiversity (Li 1997), but less is known about the effects of grazing chemical characteristics of grassland soils. Livestock feeding activities, especially the provision of supplementary sources, may influence pasture nutrient cycle, and in turn change the chemical composition of the grassland soil (Rong *et al.* 2001). Soil fertility may be affected by the type use and grazing intensities because these may cause alterations in soil physical and chemical properties as well as the soil biota (Marzaioli *et al.* 2010; Caravaca *et al.* 2002). The combination of these factors can reduce pasture productivity (Islam and Weil 2000; Sánchez-Marañón *et al.* 2002). Soil was the nutrient carrier to forage and livestock.

Since changes in soil property will be reflected in both forage and livestock production directly or indirectly, it was important to study the effect of soil on grassland and grazing (Zhang *et al.* 2002), especially trace elements such as iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn). In Alxa (Inner Mongolia), for example, Wu *et al.* (2008) reported a difference in the accumulation of these elements due to grassland type with a sequence of Fe>Mn>Zn>Cu in alpine meadow soil compared to a sequence of Fe > Mn>Cu>Zn in mountainous steppe and desert steppe soils. The objective of this study is to investigate the effect of grazing on the concentrations of Fe, Mn, Cu and Zn in temperate desert steppe in Gansu Province.

Materials and Methods

The experiment was conducted on a farm of Xin Dun Wan village (103°31'-103°38'E, 37°06'-37°13'N), Si Tan Xiang, southwest of Jingtai County, Gansu Province. The experi-

mental area is characterized by a temperate arid continental climate with warm and arid summers (annual sunshine 2658 h) and cold winters (annual mean temperature 8.3°C) with some snow. There were the main types of temperate desert steppe and alpine shrub meadow. The pasture had been maintained relative stable grazing intensity since 2003 and based on forage yield and livestock census they are considered to be in reasonable condition according to Li's (1997) method to classify grassland degradation. Since changes in both plant and soil are related to grazing intensity, we established monitoring sites within four levels of grazing identified in the Xin Dun Wan village grassland. These were: (1) light grazing (LG, 0.45 sheep unit (SU)/ha); (2) moderate grazing (MG, 0.75 SU/ha); (3) heavy grazing (HG, 1.50 SU/ha); and (4) ungrazed grassland enclosed as control area (CK).

Soil was collected in five different locations (20 m × 20 m large) within each stocking rate treatment to provide five replicates of soil data. Soil samples (0-30 cm depth) were extracted using a soil auger July 2010. Samples were dried, sieved and analyzed for chemical [pH, organic matter (OM), total nitrogen (N_T), available nitrogen (N_A), potassium (K_A), and phosphorus (P_A); and total Cu, Mn, Fe and Zn] and biological [urease, catalase and alkaline phosphatase activity] properties. Statistical analysis was made by SPSS software.

Results

Soil fertility

OM, N_T, P_A and K_A in the LG area were higher ($P<0.05$) than those of other grazing areas whereas N_A was higher ($P<0.05$) in the CK (Table 1). Soil bulk density of HG and CK were higher ($P<0.05$) than that of LG and MG. There was no difference in pH between treatments (Table 1).

Table 1. The influence of grazing on the soil fertilities

Grazing intensity	pH	N _T (%)	N _A (mg/kg)	OM (%)	P _A (mg/kg)	K _A (mg/kg)
CK	8.6	0.19b	240a	4.0b	6.4b	105d
LG	8.8	0.32a	228b	7.3a	7.0a	196a
MG	8.6	0.17c	112c	3.6c	3.3c	117c
HG	8.9	0.13d	82d	2.6d	1.5d	133b

Note: Means within columns followed by a different letters are significantly different at $P<0.05$. LG - light grazing; MG - moderate grazing and HG - heavy grazing and CK - no grazing grassland enclosed as control area.

Table 2. The influence of the grazing on the soil enzyme activity

Grazing intensity	Urease (NH ₃ -N mg/g soil)	Catalase (ml0.1KMnO ₄ /g soil)	Alkaline phosphatase (mg phenol/g soil)
CK	2.09b	0.23c	1.92b
LG	2.31a	0.29a	2.10a
MG	1.95c	0.27b	1.71d
HG	1.84d	0.21d	1.85c

Note: Means within columns followed by a different letters are significantly different at $P < 0.05$. LG - light grazing; MG - moderate grazing and HG - heavy grazing and CK - no grazing grassland enclosed as control area.

Table 3. Influence of the grazing intensity on the soil trace elements

Grazing intensity	Cu (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
CK	1.57	12.35	32.56a	0.74
LG	2.07	12.66	28.86b	0.82
MG	2.01	13.37	19.36c	1.13
HG	1.72	12.52	11.60d	0.85

Note: Means within columns followed by a different letters are significantly different at $P < 0.05$. LG - light grazing; MG - moderate grazing and HG - heavy grazing and CK - no grazing grassland enclosed as control area.

Soil enzymes

The soil urease and catalase activity decreased ($P < 0.05$) with the increase of grazing intensity whereas the pattern for alkaline phosphatase was more variable (Table 2).

Soil Trace elements

There was no difference in Cu, Mn or Zn content in soil of the differently grazed areas (Table 3). However, a Fe content was strongly correlated to grazing intensity with a higher ($P < 0.05$) concentration measured in the CK and the lowest at the highest stocking rate.

Discussion

N_T, P_A, K_A and OM in soil of light grazing site were higher ($P < 0.05$) than that of control area which suggests that grazing at an appropriate intensity may provide some benefit to soil fertility. Since soil organic matter is recognized as a key indicator of soil health (Hou et al. 2002), it is important for monitoring to continue to assess the long-term potential for improvement in temperate desert steppe. The trends observed could certainly reflect the impacts of these grazing intensities with continuous heavy grazing reducing the amount of biomass returned as organic matter to the soil.

Kandeler et al. (1999) suggested that soil ecosystem degradation was accompanied by a decrease in soil enzyme activity decreased. Urease and catalase and alkaline phosphatase activity were higher ($P < 0.05$) in light grazing area. This possibly reflects the abundance of organic residues in the lightly grazed grassland (Table 1) which provided ample energy to soil microbes which in turn increased the quantity and activity of soil enzyme secreted by microorganism. However, low concentrations of Cu and Zn may impose a constraint on biological processes. These preliminary showed that the soil was deficient in Cu, Mn and Zn, where as Fe levels were adequate.

Conclusion

Grazing practices are known to affect soil fertility and enzyme activity. Concentrations of Cu, Mn and Zn in Xin

Dun Wan village soil were lower than the critical values required for both plant and livestock production. Further monitoring is needed to delineate the effect of grazing from the background nutrient levels for the temperate desert steppe and their possible implication for herbage growth and livestock production.

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