Biochemical Systematics and Ecology 62 (2015) 58–65

Contents lists available at ScienceDirect

Biochemical Systematics and Ecology

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

The patterns of nitrogen and phosphorus stoichiometry across communities along altitudinal gradients in Qilian Mountains, China

Shi-Jian Xu*, Xiao-Yong Fan, Li-Long Wang, Xin-Fang Zhang, Li-Zhe An

MOE Key Laboratory of Cell Activities and Stress Adaptations, School of Life Sciences, Lanzhou University, Lanzhou 730000, China

ARTICLE INFO

Article history:
Received 23 January 2015
Received in revised form 30 July 2015
Accepted 31 July 2015
Available online 10 August 2015

Keywords:
Stoichiometry
Nitrogen
Phosphorus
Organs
Plant community
Altitude

ABSTRACT

Unraveling the distribution patterns of plant nitrogen (N), phosphorus (P) stoichiometry along the elevational gradients has been attracting growing scientific interests of ecologists. However, little is known about patterns of plant root N, P stoichiometry along elevation and the relationship between foliar and root. Here we determined the foliar and root N, P concentrations and clarified the patterns of N:P stoichiometry across functional groups and community types along a 2000 m altitudinal gradient in Qilian Mountains, China. Generally, foliar N remained constant but P increased, therefore foliar N:P ratio decreased against elevation. Foliar N, P and N:P were different considerably and correlated highly with that in root, respectively. One-way ANOVA demonstrated stable root N content across the communities, and remarkably higher root P at the higher rather than at the lower sites. For the foliar, the alpine bushwood had the lowest foliar P, but highest N content, whereas the alpine cold-desert presented the lowest foliar N, but higher P concentration. The well-constrained N:P ratios indicated no significant limitation in N or P in the study area. These results together suggest that plant foliar N, P contents do not simply increase with elevation, and the vegetation type, specifically at the arid and low temperature environments, may play crucial roles on patterns of plant N:P stoichiometry at alpine region.

1. Introduction

Ecological stoichiometry theory provides an integrative framework for studying biogeochemical patterns at regional and global scales (Sterner and Elser, 2002). Nitrogen (N) and phosphorus (P), as the most common nutrients, generally limit plant growth and functioning (Elser et al., 2000), affect intensively competition between plant species and drive ecosystem succession (Wright, 2004).

Plant N, P contents are affected by plant intrinsic properties and meteorological and pedologic factors jointly. Attentions have been paid to the relations between N:P stoichiometry and climate factors, and some general biogeographic patterns have been uncovered. However, the trends of plant N:P stoichiometry both on regional scale and on large scale of global flora have been demonstrated with the different reasons. For examples, the increasing N:P with temperature

* Corresponding author.
E-mail address: xushijian@lzu.edu.cn (S.-J. Xu).

http://dx.doi.org/10.1016/j.bse.2015.07.037
0305-1978/

had been attributed to increasing P and constant N concentration over latitudes (Reich and Oleksyn, 2004). By contrast, no trend in neither N nor P but the same trend in N:P was observed across global scale temperature gradients (Kerkhoff et al., 2005). Even, no obvious correlation between N:P ratios and latitude or mean annual precipitation was detected within the tropics vegetation, because of the little variation in temperature and precipitation (Townsend et al., 2007). At regional scale, geographic and between-species variations, rather than climatic variation, were the major determinants of grassland foliar N, P stoichiometry at the biome level (He et al., 2006, 2008). Most of these studies focus on scales across latitudes and regional flora, however, only a few were conducted along altitudinal elevation (Sundqvist et al., 2011; Zhao et al., 2014).

Montane environments afford a perfect arena for study on patterns of plant nutrient stoichiometry because of the dramatic changes in environmental factors (Körner, 2007; Sundqvist et al., 2013). Nevertheless, great inconsistency has been obtained for plant N, P stoichiometry along altitudinal gradients. In tropical, subtropical and subarctic tundra zones, studies had found that leaf N and P declined with altitude (Van de Weg et al., 2009; Sundqvist et al., 2011; Zhao et al., 2014), while the leaf N and P increased with elevation in tropical montane forest (Soethe et al., 2008). However, under the extreme environmental conditions in northwest Himalaya, plant nutrient content did not increase simply with elevation (Macek et al., 2012). The inconsistent results suggest that the plant leaf stoichiometry patterns along altitudinal gradients may vary with the vegetation types and climatic characteristics, and be related with root N, P contents. In this study, we examined the plant foliar and root N, P stoichiometry across five representative vegetation communities along elevation gradients in Qilian Mountains in the northwest of China. Our aims addressed the following questions. (1) What is the relationship of N:P stoichiometry between foliar and root in alpine plant? (2) How dose plant N:P stoichiometry shift based on different hierarchical levels, and (3) What are the patterns of root and foliar N:P stoichiometry along altitudinal gradients at typical temperate continental arid climate zone?

2. Materials and methods

2.1. Site description

The Qilian Mountains, situated at the transition zone of the Tibetan Plateau and Mongolia Plateau, northwest of China, present obvious vertical vegetation zonation because of the typical temperate continental arid climate and mountain glacier. Laohugou Valley (39.7451°–39.4993° N, 96.1899°–96.5196° E, 2200 m–4250 m Alt), where the samples were collected, is located at the northwest of Qilian Mountains with the distinctive mean growth rainfall from 41.6 mm (at 2517 m) to 209.5 mm (at 4200 m), and the mean growth temperature from 18.2 °C (at 2517 m) to 1.3 °C (at 4200 m) (offered by Qilian Mountains Station, State Key Laboratory of Cryospheric Sciences).

2.2. Sampling and analysis methods

According to visual inspection and the obvious habitat characteristics, five clearly distinguishable communities with flat topography and subject to minimal grazing and other anthropogenic disturbances at different altitudes were selected for sampling sites. They are desert and desertification grassland, mountain grassland, alpine bushwood, alpine meadow and alpine cold-desert (see Supplemental Table S1 for detailed information). Based on surveys of three 1 m $\times$ 1 m plots at each site, foliar (leaves or leafy shoot) and root samples of dominant species were collected in July 2011 when the aboveground standing biomass reached its annual peak (Cornelissen et al., 2003). Briefly, after the foliar was collected from five to ten individuals for each species at each site, the homologous roots were dug out and the soil was rinsed out from root under running water over a 1 mm screen, then the fine roots under 2 mm in diameter were obtained. After cleaned, dried and ground, samples which were too little for further determination were eliminated. Finally, 86 species for foliar samples and 60 species for root samples, of which, 50 foliar-root paired species were collected (see Supplemental Table S2). Specifically, at desert and desertification grassland, mountain grassland, alpine bushwood, alpine meadow and alpine cold-desert, there were distributions of 16, 12, 18, 28, 12 species for foliar samples, and of 10, 9, 10, 20, 11 species for root samples, respectively (see Supplemental Table S2). The samples were further classified into the following functional groups on the basis of life forms (herbs and shrubs), phylogenetic group (dicots and monocots) according to descriptions in Flora of China (Wu, 1980).

Upon returning to the laboratory, the foliar and root samples were measured according to our previous methods (Wang et al., 2015). Briefly, after oven-dried at 80 °C to a constant weight, the samples were ground with a plant sample mill (MM200, Retsch, Haan, Germany) and sieved through a 0.25 mm mesh screen for chemical analysis. Total N content was assayed by dry combustion using an elemental analyzer (FLASHEA 1112 Series CNS Analyzer, Thermo, USA), and total P content was conducted by the molybdate/ascorbic acid method (John, 1970). All samples were measured in the State Key Laboratory of Grassland Agro-Ecosystem, Lanzhou University.

2.3. Ethics statement

The location is not privately owned, and our studies did not involve endangered or protected species. Thus, no specific relevant permission was required for the field studies.