Ecological stoichiometry characteristics and influencing factors of carbon, nitrogen and phosphorus in leaves of *Sophora alopecuroides* in the Yili River Valley, Xinjiang

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Background. In order to elucidate the ecological stoichiometry characteristics of carbon, nitrogen and phosphorus in the leaves of *Sophora alopecuroides* in the Yili River Valley and its influencing factors, the leaves of *Sophora alopecuroides* in four habitats of Forest, Roadside, Farmland and Desert in the Yili River Valley were selected as the research objects. **Method.** The variation rules of the ecological stoichiometry characteristics of carbon, nitrogen and phosphorus in the leaves of *Sophora alopecuroides* were analyzed. The correlation between ecological stoichiometry characteristics of leaves and environmental factors was discussed by redundancy analysis (RDA). **Result.** The results showed that: (1) the C, N and P contents of *Sophora alopecuroides* leaves were 391.30~533.10g/kg, 8.90~43.14g/kg, 0.71~2.04g/kg, and the contents of C/N, C/P, N/P were 10.34~44.94, 209.05~698.73, 10.78~31.43 respectively. (2) The C content and C/P of *Sophora alopecuroides* leaves were highest in the desert habitat, the leaf N content and N/P are the highest in the Forest habitat, the leaf P content is the highest in the Farmland habitat, and the leaf C/N is the largest in the Roadside habitat. (3) Redundancy analysis showed that available potassium and pH were the main factors affecting the ecological stoichiometry characteristics of *Sophora alopecuroides* leaves in Yili Valley ($p < 0.05$), and they are positively correlated with C, N, P, N/P, and negatively correlated with C/P, C/N; available potassium is the dominant factor that affects the P content of *Sophora alopecuroides* leaves; soil C, N, P, K content, soil organic matter, nitrate nitrogen, ammonium nitrogen and available phosphorus had no significant effect on the ecological stoichiometry characteristics of leaves (p>0.05).

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Abstract

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Method. The variation rules of the ecological stoichiometry characteristics of carbon, nitrogen and phosphorus in the leaves of *Sophora alopecuroides* were analyzed. The correlation between ecological stoichiometry characteristics of leaves and environmental factors was discussed by redundancy analysis (RDA).

Result. The results showed that: (1) the C, N and P contents of *Sophora alopecuroides* leaves were 391.30~533.10g/kg、8.90~43.14g/kg、0.71~2.04g/kg, and the contents of C/N、C/P、N/P were 10.34~44.94、209.05~698.73、10.78~31.43 respectively.(2) The C content and C/P of *Sophora alopecuroides* leaves were highest in the desert habitat, the leaf N content and N/P are the highest in the Forest habitat, the leaf P content is the highest in the Farmland habitat, and the leaf C/N is the largest in the Roadside habitat. (3) Redundancy analysis showed that available potassium and pH were the main factors affecting the ecological stoichiometry characteristics of *Sophora alopecuroides* leaves in Yili Valley ($p \leq 0.05$), and they are positively correlated with C、N、P、N/P, and negatively correlated with C/P、C/N; available potassium is the dominant factor that affects the P content of *Sophora alopecuroides* leaves; soil C、N、

P、K content, soil organic matter, nitrate nitrogen, ammonium nitrogen and available phosphorus had no significant effect on the ecological stoichiometry characteristics of leaves (p>0.05).

Keywords: *Sophora alopecuroides*; ecological stoichiometry characteristics; soil physical and chemical factors; Redundancy analysis.

Introduction

Ecological stoichiometry is a comprehensive science that studies the changes rule, quantitative relationship and biogeochemical cycle of various chemical elements in the ecological process (Sterner et al., 2002). In the process of plant growth, carbon (C) is the most important element constituting plant dry matter; Nitrogen (N) not only promotes the synthesis of amino acids and proteins, but also enhances the photosynthetic capacity of plants; Phosphorus (P) is not only an important component of nucleic acids and enzymes, but also a basic element of living organisms; C, N and P elements seriously affect plant growth and physiological mechanism regulation (Wang Weiqi et al., 2011). The essence of plant growth process is actually the regulation process of accumulation and relative proportion of C, N, P elements (Koerselman et al., 1996). It is of great significance to explore the ecological stoichiometry characteristics of C, N and P in plant leaves for understanding the effects of nutrients on the growth process and the material cycling process of ecosystem. In recent years, many scholars have carried out extensive research on the C, N, P ecological stoichiometry characteristics of plant leaves at different time scales and spatial scales (Li Zheng et al., 2012). Studies have found that the growth process of plants is affected by the C, N and P elements, and the external environment also affects the growth and development of plants (Cleland et al., 2011). The contents of C, N and P in plant leaves are greatly affected by soil moisture, salinity and nutrients (Chen Qing et al., 2016; Yan Kai et al., 2011), and there is a correlation between the contents of C, N and P in plants and soil pH. Soil pH affects the growth and development of plants by affecting the distribution and variation of soil nutrients (Tang Kun et al., 2013).

Yili River Valley is located in the arid and semi-arid area of Xinjiang in China, with sufficient water sources and diverse species in the valley, which is the key ecological diversity reserve in China (Garken jumaken Ette et al., 2014). In recent years, due to the continuous degradation of grassland in the Yili River Valley, a large number of poisonous grasses have spread, especially the rampant spread of *Sophora alopecuroides*. *Sophora alopecuroides*, a perennial herb of the genus sophora of legume, is mainly distributed in Xinjiang, Ningxia and Inner Mongolia, and has the characteristics of salt tolerance and early F resistance (Qi Xiaorong et al., 2008). It is an excellent wild plant for preventing wind and sand fixation or improving saline-alkali land (Chen Mojun et al., 2000). Due to the fast-spreading characteristics of Sophora alopecuroides, it often grows continuously in the Yili River Valley grassland, which can form a single excellent community in a short time, posing a serious threat to the development of local animal husbandry and biodiversity (Cui Dong et al., 2018). At present, scholars at home and abroad mainly focus on seed morphological characteristics, medicinal value, germination conditions and seed dormancy (Liu Ying et al., 2017; Hao Weiliang et al., 2016; Wang Jin et al., 2007), while there are few reports on the ecological stoichiometry characteristics of the leaves of *Sophora alopecuroides* in the Yili River Valley. In this study, the leaf of *Sophora alopecuroides* in the Yili River Valley was taken as the research object, and the variation rule of the ecological stoichiometry characteristics of carbon, nitrogen and phosphorus in the leaves of *Sophora alopecuroides* in different habitats was analyzed systematically. The relationship between the ecological stoichiometric characteristics of *Sophora alopecuroides* in the Yili River Valley and environmental factors was discussed, in order to reveal the ecological mechanism of the rapid spread of *Sophora alopecuroides* in the arid and semi-arid areas, so as to serve as the theoretical basis for the scientific management of arid and semi-arid grasslands.

Materials and Methods

Site description

The study area is located in the Yili River Valley of Xinjiang Uygur Autonomous Region (80°09′E—84°56′，42°14′N—44°50′N). The north, east and south sides of the Yili River Valley are all high mountains. The terrain changes from high narrow to low wide from east to west, in the shape of a trumpet, thus forming the natural landform outline of "three mountains and two valleys", enjoying the reputation of "wet island in the western region". The elevation of the Yili River Valley is 530~1000m high, and it is 360 km long from east to west, 275 km wide from north to south, covers an area of 56400 km^2. The Yili River Valley is the wettest area in the Xinjiang, with warm and humid climate, which belongs to temperate continental climate. The annual average temperature is 10.4℃, the average sunshine hours are 2700~3000 h, and the annual average precipitation is 417.6 mm, mainly in spring and summer, accounting for about 60%~70% of the total annual precipitation. The Yili River Valley has superior geographical location, abundant natural resources, abundant species, diverse mineral resources, and unique wetland landscape. The valley mainly distributes grassland, meadow, forest and other vegetation types.

Study site and sample collection

In this study, four habitats of Forest, Roadside, Farmland and Desert in Qapqal County, Yili River Valley, were selected to collect soil samples and plant samples of *Sophora alopecuroides* leaves in September 2018 (Figure 1).

Three 1 m×1 m quadrats are randomly set in each plot, and each quadrat is a repeat. In the sample, we randomly select the *Sophora alopecuroides* with uniform growth, cut the leaves from the plants, and bring them back to the laboratory for cryopreservation. Afterwards, soil samples of 0~10、10~20、20~30 cm were collected in each quadrat, and a total of 12 soil samples and 12 plant samples was collected in 4 plots. The collected leaves of *Sophora alopecuroides* were dried at 105 ^{O}C for 24 h, and then crushed into foam by a mixed ball mill grinder and sealed for preservation. It was used to determine the content of total carbon, total nitrogen and total phosphorus in *Sophora alopecuroides* leaves. The collected soil samples were put into plastic sealed bags. After full fusion in the laboratory, the soil physical and chemical properties are analyzed after air drying, grinding, and sieving.

Figure 1

Analysis of soil and plant properties

Leaf properties of plants

The total carbon content of *Sophora alopecuroides* leaves were measured by a K_2CrO_7-H_2SO_4 oxidation procedure; The soil and plant samples were boiled with perchloric acid and sulfuric acid, and then the total nitrogen content in the soil and plant samples was determined by colorimetry; For the total phosphorus content, firstly, add perchloric acid and sulfuric acid to the leaves and soil samples of *Sophora alopecuroides*, then, after boiling, measure the total phosphorus content in the soil and plant samples by colorimetry and CARY60 Ultraviolet-visible Spectrophotometer (Bao Shidan, 2000). C, N, and P contents were expressed in units of g/kg.

Soil physical and chemical properties

The content of total potassium in soil was determined by atomic absorption spectrophotometry method; To determine the content of ammonium nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) in soil, first weigh 10.00g of soil sample into a plastic bottle, add $CaCl_2$ extractant, shake for 30min under the condition of 20~25°C, then filtered to the content of ammonium nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) in soil samples by colorimetry; The content of soil organic matter (OM) was determined by a K_2CrO_7-H_2SO_4 oxidation procedure; the soil pH measured by pH meter; For the determination of soil available phosphorus (AP), first weigh 2.50g of soil sample into a plastic bottle, add $NaHCO_3$ extract and 1g of phosphorus-free activated carbon, shake for 30min under the condition of 20~25°C, then filter and measure the content of AP in the soil sample by colorimetry; the content of available potassium (AK) was determined by flame photometric method (Bao Shidan, 2000).

Statistical analysis

Excel 2010 and SPSS 19.0 software was used to analyze the data after integration. One way ANOVA was used to compare the differences of carbon, nitrogen, phosphorus and their stoichiometric ratios in the leaves of *Sophora alopecuroides* in four different habitats, and the significant analysis was performed using the Duncun tables. The redundancy analysis (RDA) of CANOCO software was used to analyze the relationship between carbon, nitrogen, phosphorus and soil chemical factors in the leaves of *Sophora alopecuroides*. It should be noted that before using the RDA, Monte Carlo test was needed to select the factors significantly related to soil enzyme activities. According to the DCA analysis of the C, N and P contents in the leaves of *Sophora alopecuroides*, the gradient length LGA of sorting axis is less than 3, that is to say, there is a linear relationship between leaves and soil environmental factors, which is suitable for linear sorting method, so the RDA sorting method can be used.

Results

Content and stoichiometric ratios of C, N and P in the *Sophora alopecuroides* leaves

As can be seen from Table 1, the average values of C, N and P contents in the leaves of *Sophora alopecuroides* in the Yili River Valley wetland are 470.09, 32.71, 1.43g/kg, respectively, and the coefficients of variation are 10.96, 30.41, 30.86; the average values of C/N, C/P and N/P are 16.88, 364.67 and 23.20 respectively, and the variation coefficients are 57.04, 38.42 and 24.00 respectively. The coefficients of variation of C, N, P and stoichiometric ratio of leaves are generally large, among which the coefficient of variation of C/N ratio is the largest, which indicates that the C content and N content of leaves had the highest degree of variation and the strongest variability. It can be seen from Figure 2 that there is no significant correlation between C and the content of N, P in leaves ($p>0.05$), but there is a very significant positive correlation between N content and P content in leaves ($p<0.01$). The regression equation ($y=0.0009x^2-0.0095x+0.7532$) clearly reflects the increasing trend of P content in leaves with the increase of N content (Figure 2).

Table 1

Figure 2

Contents and stoichiometric ratios of C, N, and P in *Sophora alopecuroides* leaves in different habitats

There were some differences in the C, N, and P contents of *Sophora alopecuroides* leaf in different habitats (Table 2). For the C content of leaves in different habitats, the C content of leaves in different habitats showed an increasing trend. The C content of leaves in Desert is much higher than that in Forest, Roadside and Farmland. The coefficient of variation of C content in the leaves was 11.58%, 13.28%, 14.93% and 5.73%, respectively. There was no significant difference in N content among four habitats. The variation coefficients of N content in the Forest, Roadside, Farmland and Desert habitats were 7.52%, 63.30%, 3.37% and 31.24%, respectively. In terms of P content in the leaves, the P content in the leaves of the four habitats in order from largest to smallest was Farmland > Forest > Roadside > Desert, and the P content in the leaves of the Desert was significantly lower than that in the Forest, Roadside and Farmland. The variation coefficients of P content in the leaves of the Forest, Roadside, Farmland and Desert were 13.62%, 40.12%, 6.96% and 44.23%, respectively.

There was significant difference in the stoichiometric ratio of C/P in the leaves in different habitats, but there was no significant difference in C/N and N/P in the leaves in different habitats (Table 3). The leaf C/N in the Forest was slightly lower than that in the Desert, Roadside and Farmland. The coefficient of variation of C/N in the Forest, Roadside, Farmland, Desert was

7.59%, 75.31%, 12.19% and 22.65%, respectively. The N/P of leaves in the Farmland habitat was less than that in the Forest land, Roadside and Desert. The coefficients of variation of N/P in the Forest, Roadside, Farmland, Desert habitats were 13.31%, 41.23%, 5.09% and 19.31% respectively. As for the C/P of leaves, the leaf C/P of the four habitats from largest to smallest was Desert > Roadside > Forest > Farmland, and the leaf C/P of the Farmland habitat was significantly lower than that of the Forest, Roadside and Desert. The coefficients of variation of C/P in the leaves were 8.69%, 32.98%, 14.29% and 38.67%, respectively.

Table 2

Table 3

Correlation between ecological stoichiometry characteristics of *Sophora alopecuroides* leaves and factors of soil physical and chemical

Redundancy analysis (RDA) was used to study the correlation between the ecological stoichiometry characteristics of *Sophora alopecuroides* leaves and factors of soil physical and chemical (available potassium, pH, nitrate nitrogen, ammonium nitrogen, available phosphorus, soil organic matter, soil C content, soil N content, soil P content, soil K content). It can be seen from table 4 that the interpretation amount of the first and second sorting axes are 54.8% and 26.9% respectively. The first two sorting axes jointly explain the change of 81.7% of the leaf ecological stoichiometry characteristics of *Sophora alopecuroides*. At the same time, the cumulative interpretation amount of the leaf ecological stoichiometry characteristics and soil physical and chemical factors of *Sophora alopecuroides* reaches 86.8%, indicating that the first two axes can reflect the large difference between the factors of soil physical and chemical and the leaf stoichiometric characteristics, and are mainly determined by the first sorting axis.

According to the redundancy analysis (Figure 3), the arrow line between available potassium and pH is the longest, which is consistent with the importance ranking results in Table 5, which together shows that available potassium and pH has a greater impact on the ecological stoichiometry characteristics of *Sophora alopecuroides* leaves. Available potassium and pH were positively correlated with leaf C, N, P, N/P, and negatively correlated with leaf C/P and C/N. The direction of the arrow line of available potassium and leaf P content is the same, and the angle is small, which indicates that the available potassium is significantly positively related to the leaf P content, and the available potassium may be an important factor affecting the leaf P content in the Yili River Valley.

In the sorting diagram, the quadrant in which the arrow is located represents the positive and negative correlation between the factors and the sorting axis, the hollow arrow represents the ecological stoichiometry characteristics of the leaves. The solid arrow represents the physical and chemical factors of the soil. The length of the line represents the relationship between the ecological stoichiometry characteristics of the leaves of *Sophora alopecuroides* and the soil chemical factors. The angle between the two arrows represents the correlation between the ecological stoichiometry characteristics of the leaves and the soil chemical factors. The smaller the angle is, the greater the correlation is. The solid line represents the factors significantly related to the stoichiometric characteristics of leaves ($p<0.05$).

It can be seen that different soil physical and chemical factors have significant differences on the ecological stoichiometry characteristics of *Sophora alopecuroides* leaves (Table 5). The effects of soil physical and chemical factors on the stoichiometric characteristics of *Sophora alopecuroides* leaves were as follows: AK > pH > NO_3^--N > soil P content > NH_4^+-N > soil N content > soil K content > soil OM > soil C content > AP. Among them, the available potassium and pH had significant effect on the stoichiometric characteristics of leaves ($p \leq 0.05$). Available potassium had the most significant effect on the stoichiometric characteristics of leaves, accounting for 19.9% of the total interpretation (4.487, p=0.05). Nitrate nitrogen, soil P content, ammonium nitrogen, soil N content, soil K content, organic matter, soil C content and available phosphorus had no significant effect on the stoichiometric characteristics of leaves ($p>0.05$).

Table 4

Table 5

Figure 3

Discussion

Ecological stoichiometry characteristic of C, N and P in the leaves of *Sophora alopecuroides* in different habitats

The contents of C, N, P and their stoichiometric ratios in the leaves of *Sophora alopecuroides* are closely related to the growing environment. However, the restricted factors of C, N and P ecological stoichiometry characteristics of the same plant in the same area under different environmental conditions are different (Wang Zhennan et al., 2013). Leaves are the most sensitive organs of plants to the changes of the surrounding environment (Vendramini et al., 2002). The stoichiometric ratios of C, N and P in leaves of plants are relatively stable, which can be reflected in the dynamics of C accumulation and the pattern of N, P nutrient restriction in the ecosystem to a certain extent (He et al., 2008). Among them, the C element is the most important element of dry matter in plants, C/N and C/P represents the ability of assimilating C when plants absorb nutrient elements. To some extent, it can reflect the utilization efficiency of nutrient elements in plants, and its ratio is closely related to the growth rate of organisms (Davis et al., 2006). It can be seen from table 2 that there are some differences in the C content of *Sophora alopecuroides* at four habitats, indicating that the carbon accumulation of *Sophora alopecuroides* at four habitats is different. Among them, the C content of *Sophora alopecuroides* grown in desert is higher than that in other habitats, which may be due to the fact that the C element usually exists in plants in the form of organic matter. Under the condition of low soil moisture and high salt content of soil, it is easy to form a high stress and low interference habitat, and *Sophora alopecuroides* is easy to store carbon element, reduce its reproductive and competitive ability, so as to maintain the normal growth of plants and achieve a balanced resource allocation (Zhang Dayong, 2000). The C content of *Sophora alopecuroides* growing in forest land is lower than that in other habitats, probably because in a well-resourced environment, it is easy to reach environmental accommodation saturation, which intensifies interspecific competition and leads to a decrease in the availability of natural resources. The study found that in nutrient-rich environments, plants grow at a fast rate, organic matter synthesis is large, and their C/N and C/P ratios are low; in nutrient-poor environments, plants grow more slowly, plants use nutrient elements more efficiently, and their C/N and C/P ratios are higher (Ng et al., 2014). Therefore, the ratio of C/N and C/P of *Sophora alopecuroides* growing in Desert and Roadside is higher than that of *Sophora alopecuroides* growing in Farmland and Forest.

It can be seen from Table 2 that the N content of *Sophora alopecuroides* leaves are basically stable, indicating that the N element of *Sophora alopecuroides* leaves in arid and semi-arid areas has high internal stability. And it may also be that the N content in the soil is relatively high, providing sufficient nitrogen source for *Sophora alopecuroides* leaves. Previous studies have shown that fertilization and other activities, such as farming, fertilization and irrigation, will improve the local soil nutrients and soil quality, increase the content of available phosphorus, and provide a good environment for the growth of *Sophora alopecuroides*, which is consistent with the results in Table 2 that the P content of *Sophora alopecuroides* leaves grown in Farmland is higher than that in other habitats. The ratio of N, P and N/P in plant leaves reflects the dynamic balance between soil nutrient supply and plant nutrient demand. The N/P ratio can be used to judge the limiting growth factors of plant nutrients (Duan Xiaonan et al., 2004). Aerts and Chapin (2000) studies showed that when leaf $N/P<14$, plant growth was mainly restricted by N; when leaf $N/P>16$, plant growth was mainly restricted by P; when leaf $14<N/P<16$, plant growth was mainly restricted by N and P together. Although the nutrient conditions of the four different habitats in Table 3 are different, the N/P of the leaves of *Sophora alopecuroides* is greater than 16, which indicates that the growth of *Sophora alopecuroides* in each habitat of the study area is mainly limited by P. The study area belongs to the arid and semi-arid area of Xinjiang, its water and soil nutrient conditions are poor, the P element in the soil cannot be fully absorbed, resulting in the loss of P element. At the same time, with the growth of *Sophora alopecuroides*, the P element will produce a release effect, resulting in the decrease of P content available for the growth of *Sophora alopecuroides*, and the growth of *Sophora alopecuroides* is limited by P element.

Factors affecting the ecological stoichiometry characteristic of C, N and P in *Sophora alopecuroides* Leaves

Plants need to absorb nutrients from the soil to supplement the nutrients needed for the growth and development of leaves, so soil physical and chemical factors have a greater impact on the C, N, P ecological stoichiometry characteristics of *Sophora alopecuroides* leaves.

According to RDA ranking, available potassium and pH were the main factors affecting the C, N and P stoichiometric characteristics of leaves. Zhan X et al. (2013) found that soil pH can change soil nutrient content and distribution area, thus affecting plant growth and development process. In this study, pH was positively correlated with C, N, P and N/P of *Sophora alopecuroides* leaves, and negatively correlated with C/P and C/N, indicating that pH was closely related to the growth of *Sophora alopecuroides* leaves, which was similar to the result that pH affected the growth and development of plants by affecting the physical, chemical and biological characteristics of soil (Xu Kaijie et al., 2015). With the increase of the content of available potassium in this study, the C, N, P and N/P in the leaves increased, but the C/P, C/N decreased, in which the content of P in the leaves was positively correlated with the content of available potassium, indicating that available potassium was the main factor affecting the content of P in the leaves of *Sophora alopecuroides*. This may be because the absorption efficiency of the leaves of *Sophora alopecuroides* to soil nutrients is different, and the absorption efficiency of available potassium is higher in arid and semi-arid areas, which provides a good environment for the growth of *Sophora alopecuroides*.

By analyzing the influence of soil physical and chemical factors on the ecological stoichiometry characteristics of *Sophora alopecuroides* leaves, the internal stability of grassland ecosystem in arid and semi-arid areas of Xinjiang was explored. According to the redundancy analysis, the soil organic matter, nitrate nitrogen, ammonium nitrogen and available phosphorus, the contents of soil C, N, P and K did not significantly affect the stoichiometric characteristics of C, N and P in *Sophora alopecuroides* leaves. However, the current independent analysis of soil physical and chemical factors on the stoichiometry characteristics of *Sophora alopecuroides* leaves has some deficiencies. First of all, effects of soil physical and chemical factors on the C, N and P ecological stoichiometry characteristics of *Sophora alopecuroides* leaves were not independent. Secondly, soil physical and chemical factors have mutual influence and restriction. Therefore, based on the current basis, it is necessary to further analyze the double or even multiple effects of soil physical and chemical factors on the ecological stoichiometry characteristics of C, N and P in *Sophora alopecuroides* leaf, so as to make the results more accurate (Li Xiaofei et al., 2019).

As the dominant species of degraded grassland in the Yili River Valley, the growth, development and distribution of *Sophora alopecuroides* seriously affect the grassland ecosystem in the Yili River Valley. Studying the relationship between the C, N, P ecological stoichiometry characteristics of *Sophora alopecuroides* leaf in the Yili River Valley and environmental factors are of great significance to reveal the ecological mechanism of the successful diffusion of *Sophora alopecuroides* plants in the Yili River Valley.

Conclusions

(a) The C, N and P contents of leaves in the Wetland of the Yili River Valley was 391.30~533.10g/kg, 8.90~43.14g/kg, 0.71~2.04g/kg, respectively. The C/N, C/P and N/P was 10.34~44.94, 209.05~698.73, 10.78~31.43, respectively.

(b) There were significant differences in P content and C/P between leaves in different habitats, but there was no significant difference in the content of C and N, C/N, N/P in leaves at different habitats. The order of leaf P content in four habitats was Farmland > Forest > Roadside > Desert, and the order of leaf C/P was Desert > Roadside > Forest > Farmland.

(c) Available potassium and pH were the main factors affecting the ecological stoichiometry characteristics of *Sophora alopecuroides* leaves in Yili Valley ($p \leq 0.05$), and they are positively correlated with C、N、P、N/P, and negatively correlated with C/P、C/N; available potassium is the dominant factor that affects the P content of *Sophora alopecuroides* leaves.

(d) Soil C、N、P、K content, soil organic matter, nitrate nitrogen, ammonium nitrogen and available phosphorus had no significant effect on the ecological stoichiometry characteristics of leaves (p>0.05).

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Figure legends

Figure.1

Diagram of sampling point in Yili Valley

Figure.2

Correlation of contents of C, N and P in leaves of *Sophora alopecuroides*

Figure.3

Redundancy analysis of the influence of soil physical and chemical properties on the ecological stoichiometry characteristics of leaves

LC: (leaf C) carbon content of *Sophora alopecuroides* leaves; LN: (leaf N) nitrogen content of *Sophora alopecuroides* leaves; LP: (leaf P) phosphorus content of *Sophora alopecuroides* leaves; L(C/N): carbon nitrogen ratio of leaves; L(N/P): nitrogen phosphorus ratio of leaves; L(C/P): carbon phosphorus ratio of leaves; C: soil carbon content; N: soil nitrogen content; P: soil phosphorus content; K: soil potassium content.

Figure 1

Diagram of sampling point in Yili Valley

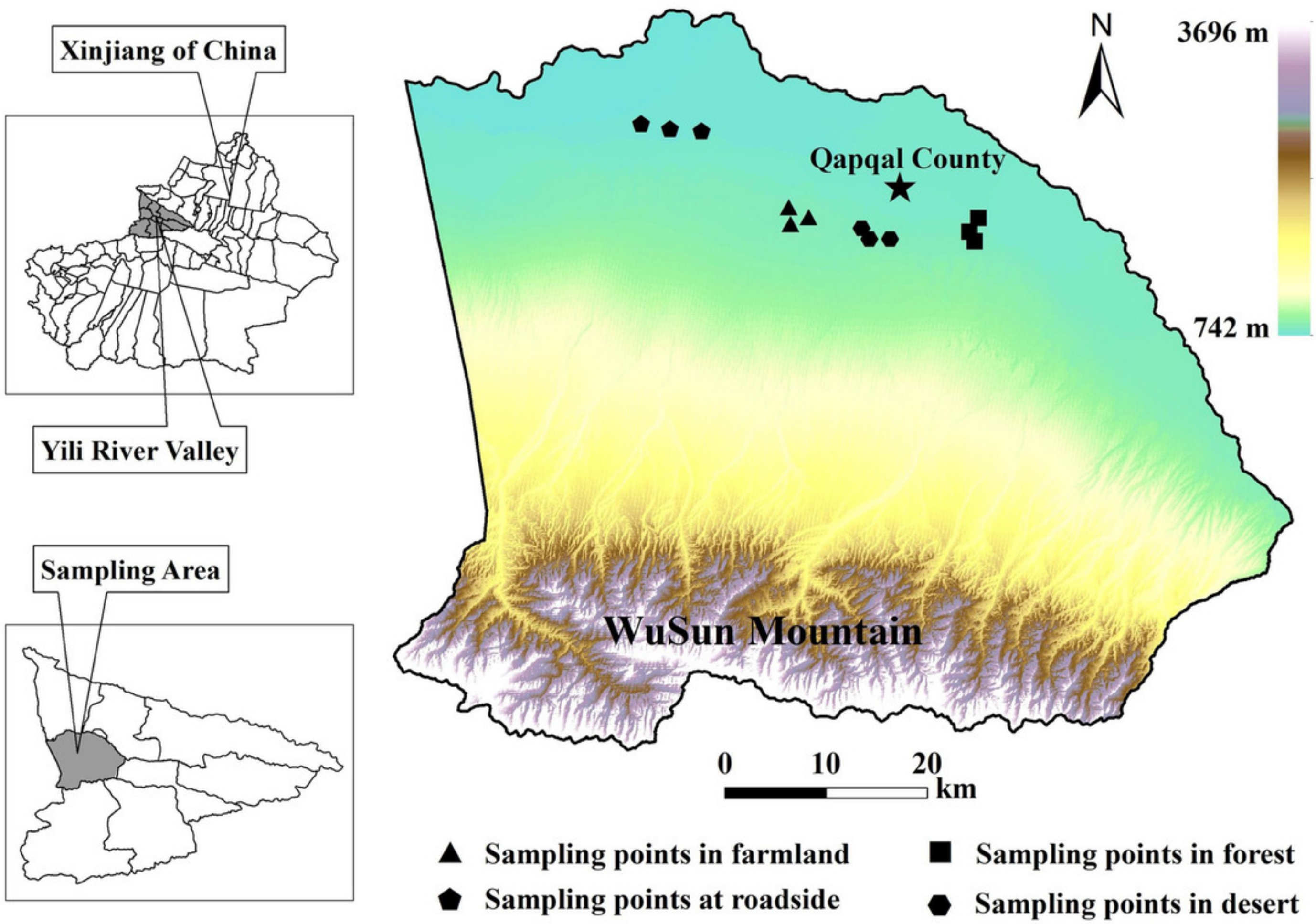

Figure 2

Correlation of contents of C, N and P in leaves of *Sophora alopecuroides*

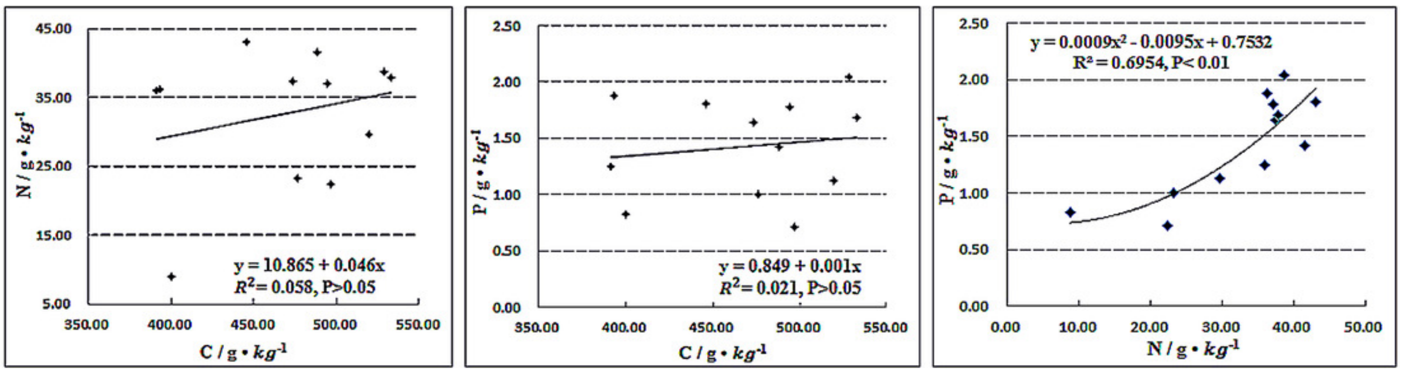

Figure 3

Redundancy analysis of the influence of soil physical and chemical properties on the ecological stoichiometry characteristics of leaves

LC: (leaf C) carbon content of *Sophora alopecuroides* leaves; LN: (leaf N) nitrogen content of *Sophora alopecuroides* leaves; LP: (leaf P) phosphorus content of *Sophora alopecuroides* leaves; L(C/N): carbon nitrogen ratio of leaves; L(N/P): nitrogen phosphorus ratio of leaves; L(C/P): carbon phosphorus ratio of leaves; C: soil carbon content; N: soil nitrogen content; P: soil phosphorus content; K: soil potassium content.

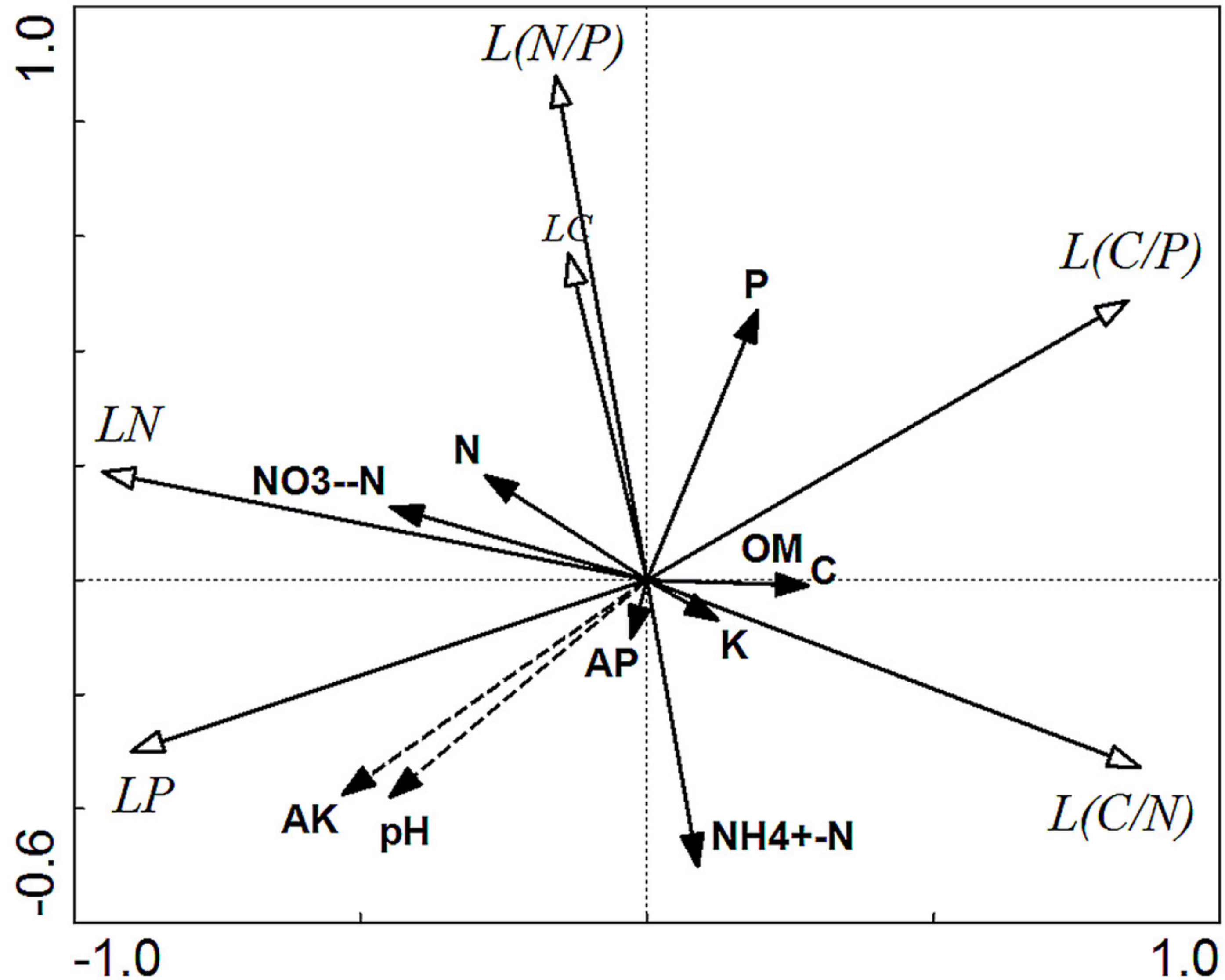
1.0
-0.6
-1.0
1.0
L(N/P)
LC
L(C/P)
P
LN
N
NO3--N
OM
C
K
AP
LP
AK
pH
NH4+-N
L(C/N)

Table 1(on next page)

(on next page)

Ecological stoichiometry characteristics of C, N and P in the *Sophora alopecuroides L.* leaves.

Table 1

Ecological stoichiometry characteristics of C, N and P in the *Sophora alopecuroides L.* leaves.

	C(g/kg)	N(g/kg)	P(g/kg)	C/N	C/P	N/P
Mean	470.09	32.71	1.43	16.88	364.67	23.20
Median	482.26	36.70	1.53	13.48	314.75	23.06
Standard Error	14.87	2.87	0.13	2.78	40.44	1.61
Range	391.30~533.10	8.90~43.14	0.71~2.04	10.34~44.94	209.05~698.73	10.78~31.43
Coefficient of Variation (%)	10.96	30.41	30.86	57.04	38.42	24.00

Table 2(on next page)

Contents of C, N and P in leaves of *Sophora alopecuroides L.* in different habitats and their variation coefficients.

The value is (mean ± SD). Different letters in the upper right corner of the peer data indicate that the data in different habitats are significantly different (*p* <0.05). Table 3 is the same.

Table 2

Contents of C, N and P in leaves of *Sophora alopecuroides L.* in different habitats and their variation coefficients.

	Forest	**Roadside**	**Farmland**	**Desert**
C (g/kg)	$(450.98 \pm 52.21)^{a}$	$(455.22 \pm 60.44)^{a}$	$(472.05 \pm 70.47)^{a}$	$(502.09 \pm 28.76)^{a}$
Coefficient of Variation (%)	11.58	13.28	14.93	5.73
N (g/kg)	$(38.35 \pm 2.88)^{a}$	$(27.25 \pm 17.25)^{a}$	$(37.39 \pm 1.26)^{a}$	$(27.83 \pm 8.69)^{a}$
Coefficient of Variation (%)	7.52	63.30	3.37	31.24
P (g/kg)	$(1.44 \pm 0.20)^{a}$	$(1.25 \pm 0.50)^{ab}$	$(1.90 \pm 0.13)^{ab}$	$(1.13 \pm 0.50)^{b}$
Coefficient of Variation (%)	13.62	40.12	6.96	44.23

The value is (mean ± SD). Different letters in the upper right corner of the peer data indicate that the data in different habitats are significantly different ($p < 0.05$). Table 3 is the same.

Table 3(on next page)

Ratios of carbon-nitrogen, carbon-phosphorus, nitrogen-phosphorus and coefficient of variation in leaves of *Sophora alopecuroides L.* in different habitats.

Table 3

Ratios of carbon-nitrogen, carbon-phosphorus, nitrogen-phosphorus and coefficient of variation in leaves of *Sophora alopecuroides L.* in different habitats.

	Forest	**Roadside**	**Farmland**	**Desert**
C/N	$(11.75 \pm 0.89)^{a}$	$(24.26 \pm 18.27)^{a}$	$(12.60 \pm 1.54)^{a}$	$(18.93 \pm 4.29)^{a}$
Coefficient of Variation (%)	7.59	75.31	12.19	22.65
C/P	$(315.27 \pm 27.39)^{a}$	$(397.90 \pm 131.21)^{ab}$	$(248.56 \pm 35.51)^{ab}$	$(496.97 \pm 192.18)^{b}$
Coefficient of Variation (%)	8.69	32.98	14.29	38.67
N/P	$(26.99 \pm 3.59)^{a}$	$(20.37 \pm 8.40)^{a}$	$(19.71 \pm 1.00)^{a}$	$(25.71 \pm 4.97)^{a}$
Coefficient of Variation (%)	13.31	41.23	5.09	19.31

Table 4(on next page)

Correlation between ecological stoichiometry characteristics of leaves and sorting axis.

Table 4

Correlation between ecological stoichiometry characteristics of leaves and sorting axis.

Sort axis	The axis I	The axis II	The axis III	The axis IV
Characteristic Value	0.548	0.269	0.113	0.008
Correlation Between Leaf Stoichiometric Characteristics And Factors of Soil Physical And Chemical	0.986	0.980	0.893	0.972
Cumulative Interpretation of Stoichiometric Characteristics (%)	54.8	81.7	93.0	93.8
Stoichiometric Characteristics And Cumulative Interpretation of Factors For Soil Physical And Chemical (%)	58.3	86.8	98.8	99.7
Typical Eigenvalues	0.941			
Total Eigenvalue	1			

Table 5(on next page)

Significance rank and significance test of soil physicochemical factors in explanation.

Table 5

Significance rank and significance test of soil physicochemical factors in explanation.

Environmental Factor	Significance Rank	Explanatory Capacity (%)	Importance (*F* Value)	Saliency (*p* Value)
AK	1	19.9	4.487	0.042
pH	2	15.4	2.916	0.050
NO_3^--N	3	14.1	1.646	0.188
Soil P Content	4	8.6	0.939	0.418
NH4+-N	5	8.5	0.924	0.444
Soil N Content	6	5.8	0.620	0.628
Soil K Content	7	4.9	0.512	0.722
OM	8	4.6	0.480	0.72
Soil C Content	9	4.5	0.476	0.698
AP	10	0.7	0.073	0.982