Analysis for Soil Characteristics of Degraded Grassland on Alpine Meadow

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Abstract

The aim of this study is to explore the effects of grassland degradation on soil physical and chemical properties. The ratio of plant root to soil texture on Alpine Meadow were investigated in this study and soil available N, P, K, Cu, Zn, organic matter and pH value were also analyzed by routine analysis of soil nutrients in different degraded grasslands. With the intensification of degraded gradient and soil depth, the ratio of plant root to soil was decreased gradually. The content of Cu and Zn was relatively lack in degraded grassland. There is no significant correlation between nutrition content or pH value and the succession degree of degraded grassland.

Keywords Alpine meadow; Degraded grassland; Ratio of plant root to soil; Soil texture; Chemical characteristics

Alpine Kobresia meadow is an important grassland type in Qinghai Tibet Plateau which is also the top succession community by grazing1. Recently human activities have seriously influenced grassland, so the eco-environment of alpine meadow has been deteriorating and the area of mouse or pest harm in grassland has reached 4 667 7 thousand hm², accounting for 25% of the total area of grassland. "Black soil type" degraded alpine meadow mainly trends to be worse1-3. The ecosystem of alpine meadow has been damaged and grassland has been deteriorated severely. Especially Kobresia humilis meadow and Kobresia pygmaea meadow community are typically damaged. The grassland type in Sanjiangyuan region is alpine meadow mainly dominated by Kobresia and grassland resource is mainly utilized by husbandry4. Good pasture in "black soil land" has decreased dramatically and poisonous weeds distribute everywhere or even no grass grows here. Currently with the gradual implementation of western development strategy, problems such as ecological deterioration or vegetation destruction in Qinghai Tibet Plateau "black soil land" and ecological restoration have attracted the great attention of government and scholars at home and abroad which have become also the hot issue in the research field of eco-environment engineering construction in western.

The underground biomass of grassland plants is one of the characterization parameters for growth status of aerial part which means the grassland plant with strong growth has rich underground biomass (root). The decline of good perennial forage in grasslands and plant coverage leads to severe soil erosion in Sanjiangyuan region which has changed soil texture and granular constitution5-6. Soil texture is one of the indicators for reflecting soil structure and type, and the chemical property of various mineral nutrients in soil are limited factors for plant growth. Ratio of plant root to soil texture and soil chemical property in Sanjiangyuan region were analyzed in this study which aimed to investigating the content change of various nutrients in soil from deserted grassland and the relationship between soil physical and chemical properties and degradation degree of soil to find the scientific and theoretical basis for preventing from grassland degradation and vegetation restoration.

Materials and Methods

Status of survey area

Sanjiangyuan region is located at altitude of 3900-4300 m with average annual temperature of -4.9 °C-0.6°C, annual gale day of 69.1-108.8 days, annual precipitation of 297.4-542.9 mm, annual accumulated temperature of 579.3-1210.3°C and mainly alpine meadow. It belongs to typical plateau-continental climate with cold weather. Forage grows in a short time and plants are dwarf. Root of grassland plants if undevloped with simple community so it has poor soil fixation and ecosystem, which is easy to be affected by the outside for degradation. Seven sampling sites were located in three areas in Sanjiangyuan region including warm season pasture of Dari and Maqin in Guoluo and Qumalai in Yushu (Tab 1)[1], which was grassland with different degraded degrees respectively. According to the dominance and vegetation coverage of Kobresia pygmaea and good forage, the different degraded degree grasslands were divided into four degraded degrees types including slight degradation, moderate degradation, heavy degradation and extreme degradation.

Survey methods

Three sampling soil were selected by soil drill with diameter of 3.5 cm from certain grassland with different degradation degrees and three layers of soil was from 0-10, 10-20, 20-30 cm. These sampling soil in the same soil layer were mixed into one repeat together and put into the numbered bags with bar repeat in the same sampling site. After natural drying grass roots were separated from soil with soil sieve and then weighed the grass root by electronic balance.
and the soil after removing grass root (g), so the ratio of both weight mentioned above was the ratio of grass root to soil. Specific gravity of soil suspension was measured by one kind of soil hydrometer methods to verify soil texture. Soil texture of different degraded grassland could be determined by soil granular classification, which was physical clay particle smaller than 0.01 mm, and then soil texture type was determined by Kachinsk's classification system of soil texture. Ammonium nitrogen content in all sampling soil was measured by sodium reagent colorimetric method while available P content was measured by nitric acid testing-powder colorimetric method. Available P content was measured by EDTA, while available K, Cu and Zn were measured by AAS-1 atomic absorption spectrophotometry. All data were processed by ASA 9.0 statistic software and degree of succession (DS) for plant communities in sampling sites was calculated by vegetation characteristic data.

\[ DS = \frac{\sum (I \times d) \times V}{M} \]

In the formula, I means the lifetime of constituted species; \( d \) means the dominance of plant species; \( V \) means the number of plant species; \( M \) means vegetation rate (coverage).

### Table 1: Status of sampling sites

<table>
<thead>
<tr>
<th>Degraded sampling site</th>
<th>Altitude (m)</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Average annual temperature (°C)</th>
<th>Annual accumulated temperature (°C)</th>
<th>Annual precipitation (mm)</th>
<th>Grass growing season (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1-1 (Moderately degraded in Dari)</td>
<td>4 028-4 035</td>
<td>99°49'35&quot;</td>
<td>33°36'15&quot;</td>
<td>1.3</td>
<td>1 070.7</td>
<td>542.9</td>
<td>151</td>
</tr>
<tr>
<td>S1-2 (Extremely degraded in Dari)</td>
<td>4 030-4 045</td>
<td>99°49'59&quot;</td>
<td>33°36'33&quot;</td>
<td>1.3</td>
<td>1 070.7</td>
<td>542.9</td>
<td>152</td>
</tr>
<tr>
<td>S1-3 (Moderately degraded in Maqin)</td>
<td>3 954-3 979</td>
<td>100°0'46&quot;</td>
<td>34°32'02&quot;</td>
<td>0.6</td>
<td>1 210.3</td>
<td>513.2</td>
<td>160</td>
</tr>
<tr>
<td>S1-4 (Extremely degraded in Maqin)</td>
<td>4 283-4 296</td>
<td>99°35'70&quot;</td>
<td>34°32'55&quot;</td>
<td>0.6</td>
<td>1 210.3</td>
<td>513.2</td>
<td>160</td>
</tr>
<tr>
<td>S1-5 (Slightly degraded in Qumalai)</td>
<td>4 267-4 288</td>
<td>95°48'36&quot;</td>
<td>34°06'14&quot;</td>
<td>2.5</td>
<td>904.3</td>
<td>397.7</td>
<td>133</td>
</tr>
<tr>
<td>S1-6 (Heavily degraded in Qumalai)</td>
<td>4 205-4 233</td>
<td>95°48'48&quot;</td>
<td>34°06'17&quot;</td>
<td>2.5</td>
<td>904.3</td>
<td>397.7</td>
<td>133</td>
</tr>
<tr>
<td>S1-7 (Extremely degraded in Qumalai)</td>
<td>4 182-4 236</td>
<td>95°48'49&quot;</td>
<td>34°06'18&quot;</td>
<td>2.5</td>
<td>904.3</td>
<td>397.7</td>
<td>133</td>
</tr>
</tbody>
</table>

### Result and Analysis

**Ratio of grass root to soil in different degraded grasslands from various areas**

The ratio of grass root to soil means the weight ratio of non-composed organic matter in soil such as litter and soil organic matter and its value reflects potential organic matter content in soil. However, organic matter must be composed by microorganisms under the suitable conditions to become available inorganic nutrients, which can be absorbed by plants and further become effective nutrients. According to analysis of ratio of grass root to soil in different degraded grasslands from various areas, its results varied significantly with the change of degradation degree (Table 2).

### Table 2: Analysis of ratio of grass root to soil in different degraded grasslands

<table>
<thead>
<tr>
<th>Depth of soil (cm)</th>
<th>S1-1</th>
<th>S1-2</th>
<th>S1-3</th>
<th>S1-4</th>
<th>S1-5</th>
<th>S1-6</th>
<th>S1-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>0 040 00</td>
<td>0 003 00</td>
<td>0 033 00</td>
<td>0 019 00</td>
<td>0 037 00</td>
<td>0 00 2 50</td>
<td>0 02 2 00</td>
</tr>
<tr>
<td>10-20</td>
<td>0 001 00</td>
<td>0 010 00</td>
<td>0 011 50</td>
<td>0 00 1 40</td>
<td>0 00 1 60</td>
<td>0 00 0 00</td>
<td>0 00 0 14</td>
</tr>
<tr>
<td>20-30</td>
<td>0 000 60</td>
<td>0 000 20</td>
<td>0 000 50</td>
<td>0 000 50</td>
<td>0 000 70</td>
<td>0 000 39</td>
<td>0 000 11</td>
</tr>
</tbody>
</table>

**Ratio of grass root to soil in different degraded grasslands from S1 area**

From Table 2, ratio of grass root to soil in S1 area decreased with the intensification of degradation degree in grassland. The ratio of grass root to soil in deep soil from 0 to 10 cm greatly decreased with the intensification of degradation degree in grassland, while in deep soil from 10 to 20 cm and 20 to 30 cm slightly decreased with the intensification of degradation degree in grassland. With the soil depth, the ratio of grass root to soil in the same degradation degree decreased. Thus, plant roots in alpine meadow mostly distributed in soil with depth from 0 to 10 cm. Root variation was in accordance with aerial part variation and other aerial biomass also decreased with the intensification of degradation degree.

**Ratio of grass root to soil in different degraded grasslands from S2 area**

From Table 2, ratio of grass root to soil in S2 area decreased with the intensification of degradation degree in grassland and the soil depth, and it greatly decreased with the intensification of degradation degree in grassland. Other aerial biomass also decreased with the intensification of degradation degree, which was smaller than aerial biomass in S1 area, so grassland in this area tended to be degraded.

**Relationship between DS and ratio of grass root to soil in different areas**

To verify the relationship between DS and ratio of grass root to soil, plant community DS of seven sampling sites in this study was compared with the ratio of grass root to soil.
various soil layers. The relative value of DS means the success direction of plant community and its value direction from large to small was the success direction of community degradation. From Table 3, S₁₁ and S₁₂ were slight degradation and moderate degradation respectively, which reached the largest DS value and ratio of grass root to soil. Sampling sites with DS value smaller than S₁₁ and S₁₂ had more serious grassland degradation and its ratio of grass root to soil correspondingly decreased.

**Soil texture in different degraded grasslands**

There were different degradations in the survey area from grassland landscape and plant community, and analysis of soil texture with different degradation degree in various areas showed that its soil was silt loam soil which was not bad soil texture type (Table 4).

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>DS</th>
<th>Ratio of grass root to soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁₁</td>
<td>0.494</td>
<td>0.037</td>
</tr>
<tr>
<td>S₁₂</td>
<td>0.446</td>
<td>0.04</td>
</tr>
<tr>
<td>S₁₃</td>
<td>0.396</td>
<td>0.002 5</td>
</tr>
<tr>
<td>S₁₄</td>
<td>0.372</td>
<td>0.003</td>
</tr>
<tr>
<td>S₁₅</td>
<td>0.189</td>
<td>0.002</td>
</tr>
<tr>
<td>S₁₆</td>
<td>0.132</td>
<td>0.001 5</td>
</tr>
<tr>
<td>S₁₇</td>
<td>0.103</td>
<td>0.019</td>
</tr>
</tbody>
</table>

From Table 4, the content of physical particle smaller than 0.01 mm in alpine meadow decreased with the intensification of degradation degree. Soil from S₁₁, grassland in S₁ area was light-loam soil and soil from S₁₂ and S₁₃ grassland was sandy-loam soil. With the intensification of degradation degree, the content of physical particle smaller than 0.01 mm decreased. The variation of two sampling sites in S₁ area was consistent with that in S₁₁ area. Soil from S₁₂ and S₁₃ grassland in S₁ area was medium-barn soil and soil from S₁₃ grassland was heavy-barn soil. There was no significant difference in the content of physical particle smaller than 0.01 mm between S₁₁ and S₁₂, while the content of physical particle smaller than 0.01 mm in S₁₁ was smaller than that in S₁₃, which was related to the specificity of soil texture (red-barn soil) in S₁ area.

**Chemical property of different degraded grasslands in alpine meadow**

The content of various mineral nutrients is the limiting factor for plant growth in grassland and grassland degradation is always accompanied by the deterioration of nutrients in soil.
There was a significant difference in available N content of degraded grassland in S1 area \((t = 5.34, \ p < 0.05)\), and its content decreased with the intensification of degradation degree. When heavy degradation declined to \(35.42\) mg/kg, available N content of the heavily degraded grassland was deficient. There was no significant difference in available P content of grassland, and its content ranged from \(40.01\) to \(68.08\) mg/kg. According to the classification of P content in soil, P content in this degraded grassland was in the water level. There was no significant difference in available K content with degradation degree. There was a significant difference in available Cu content with the intensification of degradation degree \((t = 3.15, \ p < 0.05)\), and its content decreased with the intensification of degradation degree. There was a significant difference in available Zn content with the intensification of degradation degree \((t = 2.13, \ p < 0.05)\), and its content decreased to extremely deficient \(25.36\) mg/kg. There was no significant difference in available Cu content with the intensification of degradation degree \((t = 2.94, \ p < 0.05)\), and its content decreased with the intensification of degradation degree. There was no significant difference in available Zn content \(20-30\) cm depth of soil, so it could not satisfy the basic requirement for plant growth. Available Cu content accounting for \(0.56\) to \(0.81\) mg/kg, and its content decreased with the intensification of degradation degree. Available Zn content was \(0.28\) to \(0.26\) mg/kg. There was no significant difference in available Zn content \(0-10\) cm depth of soil. Soil nutrition in different degraded alpine meadow in Dawu region is related to vegetation succession degree, which was in accordance with other studies \([3, 4]\).

**Conclusions**

Soil physiochemical property of different degraded grasslands from seven sampling sites in three areas of alpine meadow is analyzed, and the results are as follows:

1. With the intensification of degradation degree, underground biomass and ratio of grass root to soil gradually decrease. With soil depth in the same area, underground biomass and ratio of grass root to soil also gradually decrease. The highest ratio of plant root to soil is in 0-10 cm depth of soil, and its underground biomass mainly distributes in 0-10 cm depth of soil. With the increase of DS and the reduce of degradation degree in grassland, the ratio of plant root to soil increases. Conversely, with the decline of DS, degradation degree of grassland intensifies.

2. The soil type of degraded alpine meadow belongs to sandy soil and physical particle in this area does not change with DS, so soil texture in different areas is property related to soil parent material and its development process.

3. Available N, P, K, Cu, Zn, organic matter, and pH value in different degraded alpine meadow have all changed and available N, K, and P content all show the declining trend with soil depth; or even dramatically decrease with the intensification of degradation degree. Trace element Cu content accounting for 0.56 to 0.81 mg/kg, and its content decreased with the intensification of degradation degree. Organic matter content showed declining trend, but the difference was not significant. All in all, available N, P, K, and organic matter content of this degraded grassland all showed the declining trend, and decreased with soil depth or dramatically decreased with the intensification of degradation degree in grassland. There is no obvious rule for the change of available Zn content in three areas, which was possibly related to soil parent material in different areas.

**References**


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