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Analysis for Soil Characteristics of Degraded Grassland on Alpine Meadow

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Abstract **[Objective]** The aim of this study is to explore the effects of grassland degradation on soil physical and chemical properties. **[Method]** The ratio of plant root to soil and 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. **[Result]** With the intensification of degraded gradient and the soil depth, the ratio of plant root to soil was decreased gradually. The highest ratio of plant root to soil was in 0-10 cm depth of soil in grassland with different degraded gradients, while its ratio of plant root to soil changed from 0.001 to 0.040 with soil type of loam. Soil chemical characteristic changed in different degraded gradients. The content of available N, P, K reduced significantly with the soil depth and the intensification of degraded gradients. The content of Cu and Zn was relatively lack in degraded grassland. **[Conclusion]** There is no significant correlation between nutrition content or pH value and the succession degree of degraded grassland.
Key words 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 grazing[1]. 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 been reached 4 666.7 thousand hm^2, accounting for 25% of the total area of grassland. "Black soil type" degraded alpine meadow mainly trends to be worse[1-3]. 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 husbandry[4]. Good pasture in "black soil land" has decreased dramatically, and poisonous weeds distrbute 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 constitution[5-6]. Soil texture is one of the indicators for reflecting soil structure and type, and the chemical property of various mineral nutrients in soil are limit factors for plant growth. Ratio of plant root to soil, 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 physicochemical 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 in altitude of 3900-4300 m with average annual temperature of -4.9 ℃ - -0.6 ℃, annual gale day of 69.1-108.8 d, annual precipitation of 297.4-542.9 mm, annual accumulated temperature of 579.3-1 210.3 ℃ 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 undeveloped with simple communnity, 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 (Table 1)[7], 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 grassland degradation 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. Three smapling soil in the same soil layer were mixed into one repeat together, and put into the numbered bags with four repeats 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 (g)

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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[8]. Soil texture of different degraded grassland could be determined b soil granular classification, which was physical clay particle smaller than 0.01 mm, and then soil texture type was determined by Kachinsky classification system of soil texture[9]. 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 spectrophotometer[10]. 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.

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

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

Table 1 Status of sampling sites

Degraded sampling site	Altitude m	Longitude E	Latitude N	Average annual temperature ℃	Annual accumulated temperature ℃	Annual precipitation mm	Grass growing season d
S_{1-1} (Moderately degraded in Dari)	4 028 – 4 035	99°49′35.7″	33°36′15.6″	–1.3	1 070.7	542.9	151
S_{1-2} (Extremely degraded in Dari)	4 030 – 4 045	99°49′59.0″	33°36′33.4″	–1.3	1 070.7	542.9	152
S_{2-1} (Moderately degraded in Maqin)	3 954 – 3 979	100°0′46.0″	34°32′02.6″	–0.6	1 210.3	513.2	160
S_{2-2} (Extremely degraded in Maqin)	4 283 – 4 296	99°35′70.0″	34°32′55.8″	–0.6	1 210.3	513.2	160
S_{3-1} (Slightly degraded in Qumalai)	4 267 – 4 288	95°48′36.4″	34°06′14.6″	–2.5	904.3	397.7	133
S_{3-2} (Heavily degraded in Qumalai)	4 205 – 4 233	95°48′48.4″	34°06′15.7″	–2.5	904.3	397.7	133
S_{3-3} (Extremely degraded in Qumalai)	4 182 – 4 236	95°48′49.2″	34°06′18.1″	–2.5	904.3	397.7	133

Result and Analysis

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

Ratio of grass root to soil means the weight ratio of non-composed organic matter in soil such as litter and soil inorganic 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 becomes into 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

Depth of soil/cm	S_{1-1}	S_{1-2}	S_{2-1}	S_{2-2}	S_{3-1}	S_{3-2}	S_{3-3}
0 – 10	0.040 00	0.003 00	0.033 00	0.019 00	0.037 00	0.002 50	0.002 00
10 – 20	0.001 00	0.010 00	0.001 50	0.001 40	0.001 60	0.001 00	0.000 14
20 – 30	0.000 60	0.000 20	0.000 50	0.000 50	0.000 70	0.000 39	0.000 11

Ratio of grass root to soil in different degraded grasslands from S_1 area From Table 2, ratio of grass root to soil in S_1 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 that 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, 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[11]. 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 S_2 area From Table 2, ratio of grass root to soil in S_2 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 S_1 area, so grassland in this area trended to be degraded.

Ratio of grass root to soil in different degraded grasslands from S_3 area From Table 2, ratio of grass root to soil in S_3 area decreased with the intensification of degradation degree in grassland and the soil depth. Compared with S_1 and S_2 area, the ratio of grass root to soil in S_3 area was small, while other aerial biomass was little, and even trended to be more 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 ration of grass root to soil in various soil layers. The relative value of DS means the succession direction of plant community, and its value direction from large to small was the succession direction of community degradation. From Table 3, S_{3-1} and S_{1-1} was 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 S_{3-1} and S_{1-1} 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 loam soil, which was not bad soil texture type (Table 4).

Table 3 Analysis of relationship between DS and ratio of grass root to soil

Sampling site	DS	Ratio of grass root to soil			
		0–10 cm	10–20 cm	20–30 cm	Mean
S_{3-1}	0.494 5	0.037	0.001 6	0.000 7	0.013 1
S_{1-2}	0.448 7	0.04	0.01	0.000 6	0.016 9
S_{3-2}	0.396 6	0.002 5	0.001	0.000 39	0.001 3
S_{1-1}	0.372 2	0.003	0.001	0.000 2	0.001 4
S_{3-3}	0.189 1	0.002	0.000 14	0.000 11	0.000 75
S_{2-2}	0.132 2	0.033	0.001 5	0.000 5	0.011 67
S_{2-1}	0.103 4	0.019	0.001 4	0.000 5	0.006 97

Table 4 Content of < 0.01 mm physical clay in different degraded grasslands %

Depth of soil/cm	S_{1-1} Extremely degraded	S_{1-2} Moderately degraded	S_{2-1} Moderately degraded	S_{2-2} Heavily degraded	S_{3-1} Slightly degraded	S_{3-2} Heavily degraded	S_{3-3} Extremely degraded
0–10	18.14	23.77	22.16	12.67	22.101	30.99	46.86
10–20	18.32	23.23	28.33	16.96	35.23	43.91	48.45
20–30	16.14	27.46	/	18.14	44.27	45.10	48.99

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 S_{1-1} grassland in S_1 area was light-loam soil, and soil from S_{1-2} 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 S_2 area was consistent with that in S_1 area. Soil from S_{3-1} and S_{3-2} grassland in S_3 area was medium-loam soil, and soil from S_{3-3} grassland was heavy-loam soil. There was no significant difference in the content of physical particle smaller than 0.01 mm between S_{3-1} and S_{3-2}, while the content of physical particle smaller than 0.01 mm in S_{3-1} was smaller than that in S_{3-3}, which was related to the specificity of soil texture (red-loam soil) in S_3 area.

Chemical property of different degraded grasslands in alpine meadow

The content of various mineral nutrients is the limit factor for plant growth in grassland, and grassland degradation is always accompanied by the deterioration of nutrients in soil.

According to hypothesis test of means (*t*-test) for Table 5, there was no significant difference in available N content of degraded grassland in S_1 area, and its total content ranged from 35.68 to 44.76 mg/kg. There was no significant difference in available P content, and its content maintained 0.98–1.01 mg/kg. However, available P content of the degraded grassland was in low level based on the P classification, and available K content in this degraded grassland was smaller than the average of available K content in Qinghai[10], which could not satisfy plant growth requirement. There was no significant difference in trace element Cu content in this area, and its content ranged from 1.10 to 1.65 mg/kg, which could satisfy the basic requirement of plant growth[10]. There was a significant difference in Zn content ($t = 4.70$, $t_{0.05} = 3.46$), and its content ranged from 3.37 to 6.47 mg/kg, which could not satisfy plant growth requirement (10–100 mg/kg). pH value in soil varied from 7.4 to 7.6, belonging to alkaline soil, and organic matter content showed the declining trend with the intensification of degradation.

Table 5 Soil nutrition status of different degraded grassland in Alpine Meadow

Sampling site	Depth of soil cm	Available N mg/kg	Available P mg/kg	Available K mg/kg	Available Cu mg/kg	Available Zn mg/kg	Organic matter/ %	pH
S_{1-1}	0–10	44.15	1.79	239.08	1.78	3.67	15.27	7.1
	10–20	49.71	0.79	191.34	1.67	3.29	15.95	7.3
	20–30	37.42	0.45	150.65	1.52	3.16	15.87	7.6
	Mean	44.76	0.98	193.68	1.65	3.37	16	7.4
S_{1-2}	0–10	35.97	1.67	272.49	1.21	7.26	15.9	7.8
	10–20	37.17	1.34	210.79	1.13	6.95	16.07	7.8
	20–30	33.91	0.54	170.39	0.98	5.21	15.86	7.2
	Mean	35.68	1.01	217.89	1.10	6.47	15.94	7.6
S_{2-1}	0–10	48.42	0.80	219.31	1.51	4.21	15.41	8.3
	10–20	41.70	0.56	191.01	1.19	2.30	15.01	7.9
	Mean	45.05	0.68	205.15	1.35	3.25	15.23	8.0
S_{2-2}	0–10	39.64	0.45	211.41	0.41	2.56	15.65	8.3
	10–20	31.20	0.37	168.60	0.33	2.36	15.63	8.4
	20–30	27.15	0.36	156.30	/	/	15.61	8.5
	Mean	35.42	0.41	160.04	0.37	2.46	15.69	8.4
S_{3-1}	0–10	50.26	2.18	280.78	0.72	3.35	15.26	7.8
	10–20	40.62	0.85	243.96	0.53	2.76	15.95	8.1

Contined (Table 5)

Sampling site	Depth of soil cm	Available N mg/kg	Available P mg/kg	Available K mg/kg	Available Cu mg/kg	Available Zn mg/kg	Organic matter/ %	pH
	20–30	35.84	0.49	247.11	0.43	2.28	15.87	8.3
	Mean	42.41	1.11	257.28	0.56	2.79	16.02	8.1
S_{3-2}	0–10	48.39	1.21	258.72	0.28	4.26	15.91	7.8
	10–20	39.21	0.43	184.22	0.21	2.52	15.06	8.1
	20–30	23.74	0.55	181.88	0.14	2.46	15.67	8.2
	Mean	37.11	0.73	208.27	0.21	3.08	15.72	8.0
S_{3-3}	0–10	31.93	0.25	170.12	0.98	1.69	15.71	8.0
	10–20	23.55	0.28	186.92	0.76	1.25	15.64	7.8
	20–30	20.61	0.31	187.54	0.67	1.13	15.79	8.2
	Mean	25.36	0.37	190.52	0.81	1.35	15.71	8.0

There was a significant difference in available N content of degraded grassland in S_2 area ($t = 5.34$, $t_{0.05} = 4.31$), and its content decreased with the intensification of degradation degree. When heavy degradation declined to 35.42 mg/kg, available N content of heavily degraded grassland was deficient. There was no significant difference in available P content of grassland, and its content ranged from 0.41 to 0.68 mg/kg. According to the classification of P content in soil, P content in this degraded grassland was in low 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 ($t = 3.15$, $t_{0.05} = 2.13$), and its content decreased by 0.98 mg/kg, so Cu content of this degraded grassland could satisfy the basic requirement for plant growth[10]. There was no significant difference in available Zn content, but its content was low, so it could not satisfy the basic requirement for plant growth. Soil in this degraded grassland showed alkaline property (pH 8.0–8.4), and there was no significant difference in pH with the intensification of degradation degree, which was in accordance with other studies[12].

There was a significant difference in available N content of degraded grassland in S_3 area ($t = 3.11$, $t_{0.05} = 2.41$), and its content decreased to extreme degradation of 25.36 mg/kg from slight degradation of 42.41 mg/kg. There was also a significant difference in available K content ($t = 3.08$, $t_{0.05} = 2.94$), and its content decreased with the intensification of degradation degree. There was a significant difference in available Zn content ($t = 4.41$, $t_{0.05} = 3.15$), and its content increased firstly and then decreased with the intensification of degradation degree. There was no significant difference in trace element Cu content accounting for 0.56 to 0.81 mg/kg, but it could not satisfy the basic requirement for plant growth (1 mg/kg)[10]. There was no significant difference in pH, and soil in this degraded grassland showed alkaline property. 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.

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 bam soil, and physical particle in this area does not change with DS, so soil texture in different areas is properly 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. Trace element of degraded grassland in alpine meadow is deficient, while there is no significant difference in pH, and soil in this degraded grassland shows alkaline property. There is no significant difference in organic matter content, but showing the declining trend. Chemical property in soil is little related to succession degree of grassland community.

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高寒草甸退化草地土壤特性分析(摘要)

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[目的] 探讨草地退化对土壤理化性状的影响。
[方法] 研究退化高寒草甸土壤草土比、土壤质地等物理性状, 用土壤养分常规分析法分析不同退化草地土壤速效氮、速效磷、速效钾、有效铜、有效锌、有机质及 pH 等。
[结果] 随着退化梯度的加剧和土层的加深, 草土比逐渐减小; 不同退化梯度的草地草土比在土层 0~10 cm 中最大, 该层的草土比在 0.001 00~0.040 00 变化, 土壤类型为壤土类。不同退化梯度上土壤化学性质均发生变化, 其中速效氮、磷、钾含量随土层的加深和退化程度的加剧明显减少。退化草地的微量元素铜、锌含量比较缺乏。
[结论] 各种养分含量和 pH 与退化草地演替度的大小无显著相关。
关键词 高寒草甸; 退化草地; 草土比; 土壤质地; 化学性质

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芦苇地下生物量垂直分布规律性研究(摘要)

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[目的] 探讨干旱区盐渍化严重地区芦苇与盐分关系, 揭示芦苇地下生物量垂直分布规律。
[方法] 通过野外调查、野外实地采样得到了较准确的芦苇种群地下生物量数据, 利用统计学和生态学相结合的方法分析了芦苇地下生物量的垂直分布。通过试验测定了芦苇湿地有机碳和全氮的含量, 求取了 C/N 比值, 并分析了三者之间的相关性模型。
[结果] 芦苇种群地下总的生物量集中在 10~40 cm 土层, 粗根在总的生物量中起明显的决定性作用。有机碳和全氮总体变化呈下降趋势, 50 cm 以下土壤有机碳和全氮变化趋势稳定。土壤有机碳与全氮含量呈显著正相关。
[结论] 为干旱区盐渍化地区芦苇地下生物量的获取提供了理论依据。
关键词 芦苇; 地下生物量; 碳氮含量; 垂直分布

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