Effect of warming on diversity of soil microbial community

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Abstract: Climate warming causes the change of environmental factors such as temperature and moisture, and then changes the material and nutrient cycle of the landing ecosystem, especially the effect on the material and nutrient cycle of the ecosystem at high altitude and high latitude. Soil microorganisms and soil enzymes play an important role in the process of material circulation and energy flow in ecosystem. Warming experiment plays an irreplaceable role in studying the response and adaptation mechanism of terrestrial ecosystem to global warming, and soil microorganism is the key component of soil ecosystem. This paper studies the relationship between different environmental factors and soil prokaryote community structure through the correlation analysis of soil prokaryote community composition, diversity and environmental factors in the alpine grassland of the Qinghai Tibet Plateau, in order to reveal the relationship between soil prokaryote community and global warming, and pave the way for predicting how global warming will change ecosystem functions. The results showed that, combined with the results of environmental factors, the typical correlation analysis of microbial community showed that ammonium nitrogen, plant height, and species number had a higher impact on the prokaryotic community structure, while electrical conductivity had a higher impact on the fungal community structure.

1. Introduction

With the increase of greenhouse gas concentration, the global climate has undergone a very obvious change, mainly manifested in the rise of temperature, the change of precipitation and the high frequency of extreme weather, etc., which is crucial to human life and the stability of the ecosystem. Many biological processes in the ecosystem will be affected by different degrees of temperature [1]. Since 1970, the average surface temperature in China has increased by L.0 C, and the temperature increase rate is obviously higher than the global average level in the same period. In addition, there are obvious differences between the rise of day and night temperature and the change of temperature in different seasons [2]. There is a great asymmetry in the temperature rise, which is embodied in that the temperature rise rate at night is faster than that during the day, and that in winter is higher than that in summer. Climate warming has become an important problem faced by all countries in the world, and the impact of global climate change on the human environment has received extensive international attention. Climate change will change the community structure of soil microorganisms involved in nitrogen cycle, thus affecting the emission of greenhouse gases such as N2O [3]. N2O is one of the important greenhouse gases that cause global warming. Its globalwarmingpotential (GWP) is 298 times that of CO2 in a 100-year time scale, and its contribution rate to greenhouse gases is about 5%. At the same time, N2O also destroys the stratospheric ozone layer. If the concentration of N2O in the atmosphere doubles, the stratospheric ozone will decrease by 10%. The intensity of ultraviolet radiation on the ground will increase by 20%, which will lead to the incidence of various diseases. In addition, NOx produced by N2O decomposition will be converted into nitric acid, forming acid rain or photochemical smog, which will affect the safety of human living environment. Therefore, the normal function of grassland ecosystem plays an extremely important role in maintaining global and regional ecological balance [4].

With the development of social economy, population explosion, increase of grazing, and expansion of reclamation area, the large-scale degradation of grassland ecosystem in the temperate

zone of northern China has directly induced ecological disasters such as sandstorms, posing a serious threat to China's ecological security [5]. The increase of soil temperature changes soil enzyme activity and soil decomposition rate, and further changes the structure and diversity of soil microbial community. The microbial community will be affected to a large extent by changes in soil environmental factors such as pH, temperature, water, electrical conductivity, soil carbon and nitrogen content [6]. As an important biological community in soil microorganisms, soil prokaryotes play an important role in the process of decomposition and geochemical cycle. But now, climate change is mostly studied from the single direction of soil microorganism or soil enzyme, and less from the comprehensive direction of both soil microorganism and soil enzyme [7]. Therefore, by simulating the climate warming caused by altitude difference, this study studied the soil microbial community structure, enzyme activity and its stoichiometric ratio of the soil organic layer and mineral soil layer in the ecotone of the high mountain forest line in western Sichuan. It is expected to provide basic data for further understanding the impact of global warming on soil microorganisms and enzyme activities in alpine ecosystems.

2. Effect of Temperature Increase on Plant Community Structure in Alpine Grassland

2.1. Effects of warming on plant communities

Different gradient warming and water increasing test platforms are located in the typical alpine Kobresia meadow in the modern grassland animal husbandry science and technology demonstration park in Naqu, Qinghai-Tibet Plateau. Naqu is located in the north of Tibet Autonomous Region (29 55 ′— 36 30 ′ n, 83 55 ′— 95 05 ′ e) [8]. The average altitude is about 4500m, with many snow peaks and mountains, alpine valleys in the east, and plateau lakes and basins in the central and western regions. This area belongs to the Qinghai-Tibet alpine climate zone, which is dry and cold, with an average annual temperature of-2.9-3.4℃, the highest in Leng Yue in January, and a monthly average temperature of-14.9-7.4℃. The hottest month is July, with an average monthly temperature of 8.7-12.2℃ and an average annual precipitation of 298.6—708.4mm More than 80% of the annual rainfall is concentrated in May-September [9]. There are significant differences in soil temperature among different grassland types ($P<0.001$,. The soil temperature of desert (16.31c) is higher than that of typical grassland (ST:15.41ºC) and meadow grassland (ST:15.90ºC). On average, the temperature of soil in three types of grasslands increased by 0.47 C at night ($P < 0.05$). According to the "2℃ threshold" put forward by scholars, under the conditions of increasing temperature by 0 and 2℃, the experiment of reducing water by 50% was set. The water-reducing plot occupied the whole circle with a diameter of 3m, and each treatment had 4 repetitions, with 8 water-reducing plots [10]. The whole experimental area is 40m×40m square, with 10 treatments, 4 repetitions for each treatment, 40 samples, and 24 experimental plots randomly distributed in it. At the same time, global warming has an asymmetry between day and night in most areas, which is mainly manifested in that the increase of night temperature is significantly higher than that of daytime temperature. Therefore, it is of profound significance to distinguish the nighttime and daytime warming and study its impact on farmland ecosystem, especially the underground part.

The temperature rise caused by global warming directly affects the content of soil nutrients, while the content of soil available nutrients reflects the level of soil fertility and indirectly reflects the nutrient transformation capacity of farmland ecosystem. As the connecting part between the above ground and underground parts of crops, root system is an important organ for crops to absorb and metabolize, and is very vulnerable to the impact of soil nutrient status. At the same time, the growth and development of roots also affect the growth and development of crops. The research shows that the temperature change of 1 ° C can affect the root growth, thus significantly affecting the growth and development of the aboveground part of crops. Therefore, this experiment simulates the response of wheat field ecosystem to different nitrogen rates under global warming by setting an open nighttime warming platform before flowering, and studies the impact of nighttime warming before flowering on wheat field ecosystem environment, which is not only conducive to comprehensively understanding the response of wheat production to global warming, but also

provides an important theoretical basis for evaluating the impact of global warming on food security.

2.2. Effect of warming on alpine grassland community α Impact of diversity

During the test period, the aluminum alloy edge at the bottom of the heating chamber shall be plunged into the soil to ensure the airtightness of the heating chamber and the ground, and avoid the strong wind in winter. The site of the sample plot is flat and the composition of plant communities is relatively uniform; In order to ensure that the test sample land will not be disturbed and damaged, it is enclosed with a fence and grazing activities are prohibited. Two treatments were set in the experimental area, namely, temperature enhancement (T) and control (CK). Each treatment was repeated three times, randomly arranged, and the repeated sample plot spacing was 3 m. In this paper, F represents temperature enhancement and M represents control. HOBO U30 small automatic weather station and CR1000 based soil three parameter layered measurement system are installed in the test sample plot, which can continuously observe the air temperature and humidity, wind speed and direction, rainfall, soil moisture, photosynthetically active radiation, total radiation sensor, soil moisture, soil temperature, soil conductivity and other meteorological and soil indicators, and in each treatment plot, 30 cm, 15 cm above the ground, 7.5 cm, 15 cm below the ground An automatic temperature and humidity recorder probe (a temperature and humidity tester produced by onset company) is installed at 22.5cm, which can realize the collection, synchronous storage, display and historical data query of multiple soil temperature, soil humidity, soil moisture and other parameters. Take some samples in the oven, bake them at 105 ° C to constant weight, and measure the moisture content. The activities of five enzymes involved in C, N and P decomposition in soil, namely P-glucosidase (BG), cellobiohydrolase (CBH) and laccase (LAC) related to C decomposition, N _ acetylglucosamine glucosidase (NAG) related to N decomposition and acid phosphatase (AP) related to P decomposition, as well as the stoichiometric ratio of enzymes (LNBG/LNNAG,. The community structure adopts the methods of principal component analysis (PCA) and canonical correlation analysis (CCA) in T-RFLP and Canoco5 software. PCA is used to analyze the distribution law of community structure affected by a single factor of short-term warming or precipitation change, and CCA is used to analyze the significance and contribution rate of short-term warming and precipitation change on community structure.

Specifically, when there was no night warming treatment, increasing precipitation increased the total nitrogen content of meadow grassland by 0.27 g kg-1; However, in the case of nighttime warming treatment, the precipitation decreased by 0.17 g kg-1. In the quadrat without precipitation treatment, the total nitrogen content of meadow grassland increased 0.14 g kg-1 by night warming; However, in the sample with increased precipitation, the increase of temperature at night reduced it by 0.31 g kg-1. PCR amplification, detailed information purification of the amplicon, library preparation, IlluminaMiseq sequencing sequence integration with the necessary bioinformatics tools in the (http;//mem.rcees. ac.cn: 8080) processing internal channel, using UPARSE to delete the chimera and classify the sequence into the operation classification similarity unit (OTU) of 97%, without discarding any single case; The random resampling OTU table is obtained.

3. Results and analysis

3.1. Prokaryotic biodiversity analysis

Through the long-term monitoring of the temperature at two altitudes and two soil layers in the study area. The temperature fluctuation trend is the same, and the R average temperature of soil organic layer is higher than that of mineral soil layer in growing season. In non-growing season, the average temperature of mineral soil layer R is higher than that of soil organic layer. By using high-throughput sequencing technique, the diversity of microbial community structure in different soils of alpine grassland was analyzed, and the unqualified sequences were removed by sequencing. The number of effective prokaryotic sequences was between 124,000 and 173,000. The dilution curve is constructed by the number of individuals and species, which reflects whether the sequencing data is reasonable and whether the species in the sample are abundant. The analysis of soil moisture

content at two altitudes shows that the change of altitude does not cause the change of soil moisture content at the same soil level. The average moisture content of organic soil layer is 58%-64%, and that of mineral soil layer is 35%-40%. From the time point of view, the soil moisture content does not change with the change of sampling time. The change of altitude causes the temperature to rise, but it does not cause the change of soil moisture content. From the altitude, there is no significant difference in the total microbial content in most sampling periods ($P < 0.05$), but there are significant differences in the soil organic layer in SFS2, SMS2 and GS2 ($P > 0.05$), and there are significant differences in the soil mineral layer in SCSI and SMS1 ($P > 0.05$). At night, the average temperature increase range is 1-2 C, and the temperature increase effect is most obvious on the surface, and the trend is that the surface soil temperature > canopy temperature > canopy middle temperature > 5 cm underground soil temperature increases. This may be because the canopy temperature and the middle canopy temperature of wheat are close to the warming device, so the warming effect of the aboveground part is more obvious than that of the surface and underground soil. As shown in Figure 1 and Figure 2.

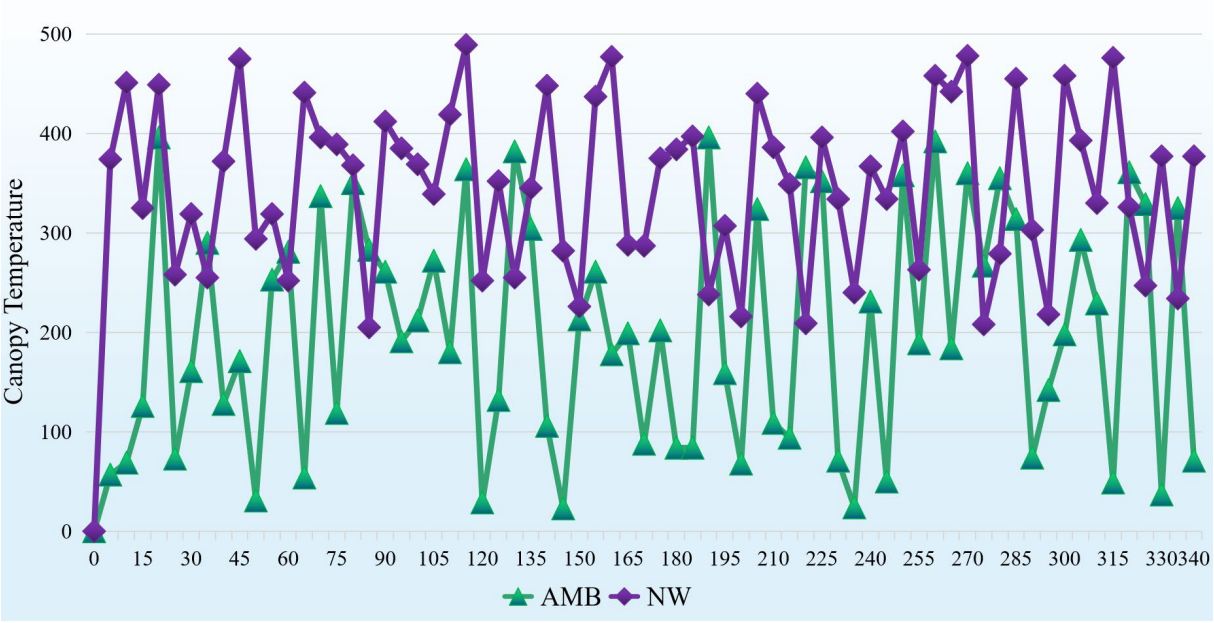

Figure 1 Effect of nighttime temperature on ecosystem temperature in wheat fields.

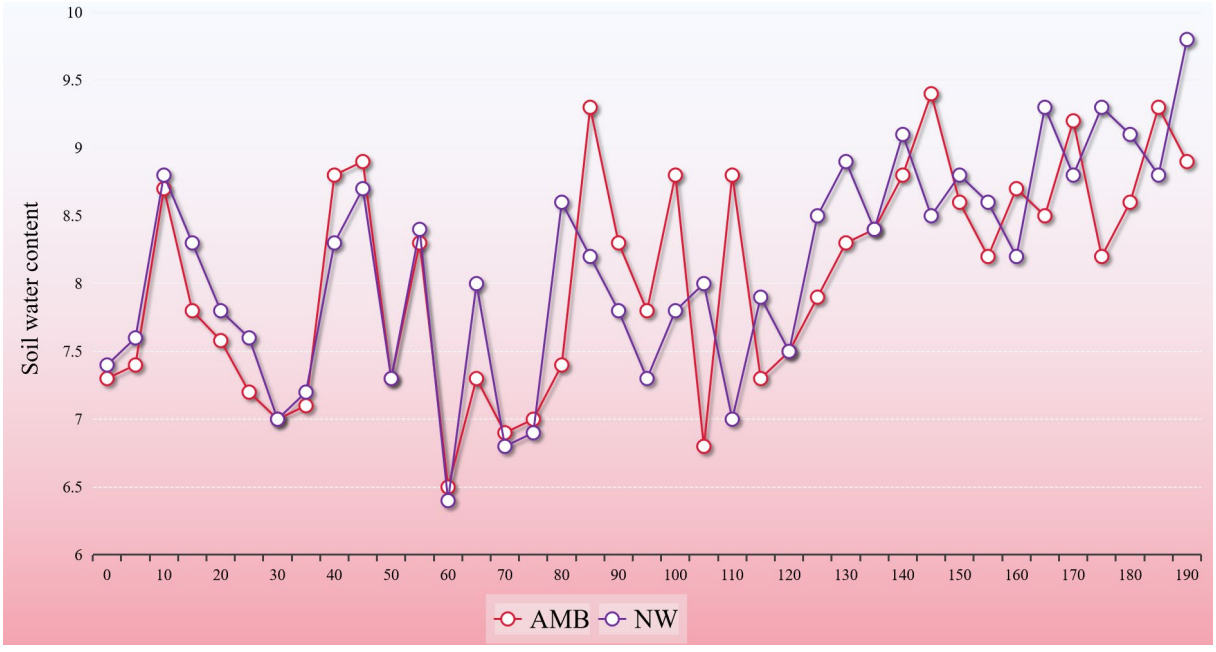

Figure 2 Effects of nighttime warming and different nitrogen application rates on soil water content

The average ammonium nitrogen content of night warming treatment was 8.37% higher than that of non warming treatment; During 2017-2018, the night warming increased the ammonium nitrogen content under the N2 level, and the ammonium nitrogen content under the night warming treatment under the N2 level was 25.56% higher than that under the non warming treatment; From 2019 to 2020, the content of soil ammonium nitrogen will increase with the increase of nitrogen application. The importance analysis shows that from 2019 to 2020, temperature increase plays a major role in the change of organic matter and available potassium content, nitrogen application rate plays a major role in the change of pH and total nitrogen content, and the interaction of temperature increase and nitrogen application rate plays a major role in the change of ammonium nitrogen and nitrate nitrogen content; From 2019 to 2020, warming will play a major role in the change of ammonium nitrogen content, nitrogen application rate will play a major role in the change of pH, nitrate nitrogen, available potassium and total nitrogen content, and the interaction between warming and nitrogen application rate will have a greater impact on organic matter content.

3.2. Discuss

As a sensitive area of global climate, the Qinghai Tibet Plateau has direct or indirect impacts on vegetation, soil, microorganisms, etc. in the context of global warming. Soil microbial diversity is an important index to evaluate soil quality. Studying soil microbial diversity can promote the sustainable use of soil and improve the practical application value of soil. The soil environment has a great impact on the growth and reproduction of microorganisms. Soil pH, temperature and humidity, and soil respiration will all affect the survival of microorganisms to varying degrees. Under similar environment, the structure of microbial community is determined by the type of plant. As the conclusion of this paper, plant height and species number are the main factors affecting the prokaryotic community structure. The difference of soil microbial diversity and the impact of vegetation are closely related to soil carbon, nitrogen content, soil water content, pH, etc.

The phylogenetic diversity of bacteria and protozoa in temperate grassland soil increases with the increase of soil water content, but the increase of soil water content does not improve the phylogenetic diversity of fungi. Adding nighttime warming treatment on the basis of changing precipitation will aggravate the sensitivity of soil bacterial diversity to water. However, the addition of night warming treatment weakened the positive effect of soil water increase on protozoa, and changed the community composition of protozoa in soil. Night warming treatment has little effect on the phylogenetic diversity of fungal communities and soil water content in grassland. The effect of night warming treatment on the relationship between the relative abundance of main microbial species and soil water content is consistent with the trend of the effect on diversity. Proteobacteria, Bacteroides, Acinetobacter and Actinomycetes were found as the main dominant flora in alpine grassland of Qinghai-Tibet Plateau, and Proteobacteria was the most abundant bacteria group in the soil. Non-metric multi-dimensional analysis showed that there was no significant difference in prokaryotic community composition of soil samples under different treatment levels. Generally speaking, microorganisms are extremely sensitive to temperature changes, but in this paper, the prokaryotes have not changed significantly after warming. The reason may be that the average annual temperature in Yuduo County, Yushu Prefecture, the sample plot of this study, is-4.8℃, and the highest temperature in the growing season can reach 16.77℃, while the suitable growth temperature of prokaryotes is 25℃ ~ 30℃. In a similar environment, the structure of microbial community is determined by the types of plants, just as the height of plants and the number of species are the main factors affecting the structure of prokaryotic community. By analyzing the dominant factors affecting prokaryotes, it can be concluded that although simulated warming has no significant effect on the community structure of prokaryotes, it can indirectly affect prokaryotes by influencing environmental factors.

4. Conclusions

In the past three decades, the global land and ocean have shown that the average temperature has increased by 0.85 ° C. It is predicted that the global temperature will further increase by 1.4-3.0 ° C

by 2050. There is asymmetry in global warming, which is mainly reflected in the fact that the increase in temperature at night is significantly higher than that during the day, and the increase in temperature in winter is higher than that in summer. The community structure of nirK, nirS, nos Z denitrifying bacteria in alpine meadow soil of Qinghai Tibet Plateau was sensitive to the difference of sampling time. Compared with 2 ℃ and 100% increase in precipitation, the sampling time has a more obvious impact on the community structure of nirK, nirS and nos Z denitrifying bacteria. For nirK and nirS, 100% increase in precipitation is more able to regulate the impact of sampling time than 2 ℃ increase in temperature. The community structure of nos Z denitrifying bacteria is more sensitive to the regulation of increased precipitation and 2 ℃ increase in temperature. The results of correlation analysis between microorganisms and soil environmental factors show that ammonium nitrogen, plant height and species number are the main influencing factors on prokaryotic community structure, while organic matter and nitrate nitrogen have weak correlation. Electrical conductivity is the main influencing factor of fungal community structure, but the correlation between vegetation height and species number is weak.

References

[1] Chen W, Zhou H, Wu Y. Plant-mediated effects of long-term warming on soil microorganisms on the Qinghai-Tibet Plateau[J]. Catena, 2021, 204(12):10-15.

[2] Wang C, Zhao X, Zi H. The effect of simulated warming on root dynamics and soil microbial community in an alpine meadow of the Qinghai-Tibet Plateau[J]. Applied Soil Ecology, 2017, 116:30-41.

[3] Lim P P J, Newsham K K, Convey P. Effects of Field Warming on a High Arctic Soil Bacterial Community:A Metagenomic Analysis[J]. Current science, 2018, 115(9):16-17.

[4] Chengqun, Yu, Fusong. Effects of 7?years experimental warming on soil bacterial and fungal community structure in the Northern Tibet alpine meadow at three elevations.[J]. Science of the Total Environment, 2018,62(2):3-14.

[5] Li G, Kim S, Park M. Short-Term Effects of Experimental Warming and Precipitation Manipulation on Soil Microbial Biomass C and N, Community Substrate Utilization Patterns and Community Composition[J]. Pedosphere, 2017, 27(004):14-24.

[6] Li G, Wang J, Zhang J. Effects of Experimental Warming and Canada Goldenrod Invasion on the Diversity and Function of the Soil Nematode Community[J]. Sustainability, 2021, 13(10):23-26.

[7] Liu Y, He F. Incorporating the disease triangle framework for testing the effect of soil-borne pathogens on tree species diversity[J]. Functional Ecology, 2019, 33(3):14-17.

[8] Šťovíček Adam, Ani A, Soares M. The Impact of Hydration and Temperature on Bacterial Diversity in Arid Soil Mesocosms[J]. Frontiers in Microbiology, 2017, 8:10-17.

[9] Scharn R, Little C J, Bacon C D. Decreased soil moisture due to warming drives phylogenetic diversity and community transitions in the tundra[J]. Environmental Research Letters, 2021, 16(6):23-29.

[10] Zhu J, Zhang Z, Meiying G U. Investigation on Metabolic Characteristics of Soil Microbial Community under High Background Radiation in Yangjiang[J]. Environmental Science & Technology, 2017,55(12):16-22.