Bibliometric analysis and research progress of Mu Us Sandy Land soil biological crust based on CNKI

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Abstract. Based on CNKI data, this paper analyzes the number of papers, keywords and research content of biological soil crusts in the Mu Us Sandy Land. It was reviewed that the effects of biological soil crust on water infiltration, photosynthesis, respiration and succession characteristics and the influence of the technology of the compound soil of feldspathic sandstone and sand to create land on the development of biological crusts is considered in the Mu Us Sandy Land. The increase in clay content will significantly promote the expansion of sand biological crusts. At the same time, it is recommended to further carry out research on the development and succession characteristics of sand biological crusts after compounding of feldspathic sandstone and sand.

Keywords: The Mu Us Sandy Land; Biological Crust; Biological Crust Development; Research Progress.

1. Introduction

Biological crust is the most characteristic micro natural landscape in desert area Biological crust is the most characteristic micro natural landscape in desert area, which is distributed in desert and desert area. It is mainly composed of bacteria, fungi, algae, lichens, mosses and other lower organisms interacting with soil particles, forming a thin and dense organic composite shell on the surface of soil [1]. The physical, chemical and biological characteristics of the soil forming biological crust are not obvious Similar to loose sandy soil, it has strong wind erosion resistance and important ecological and environmental benefits, which is an important basis for vegetation succession in arid desert area [2].

The Mu Us Sandy Land is one of the four largest sandy land in China, with a total area of about 40,000 km². The bioclimatic zone belongs to the transitional position from arid desert steppe to semi-arid steppe subzone, and is also an important ecological barrier in the north of China. Most of the sand control measures in the area are based on physical methods, however, it is extremely vulnerable to wind erosion. Biological crusts are highly ecologically adaptable for the unique physiological ecology structure and the function, are closely related to the structure and functions of desert ecosystems, and have an important position in desert ecosystems [3, 4]. In addition to improving the nutrient content of
sandy soil and enriching nutrients, biological crusts also play a positive role in preventing wind erosion and improving the ecological environment [5]. In desertified areas, biological crusts, as a biological protection layer on the surface, have obvious effects on blocking water infiltration and water conservation, and play an important role in the succession of local vegetation [6]. So far, a large number of studies have shown that the formation and development of biological crusts are affected by factors including soil texture, plant coverage, and moisture conditions [7]. With the succession of the pioneer species in the group to the semi-fixed and fixed stages, the biological crusts in the community begin to gradually develop and increasingly become one of the important signs of sandy land fixation. The development of biological crusts can effectively prevent wind erosion on the surface. At present, the study of biological crusts is a frontier area where geosciences and biology intersect, and has become one of the core scientific issues in the study of surface processes in arid regions in the world [8].

2. Literature analysis and statistics

2.1. Paper selection and statistical methods
The papers are selected from the CNKI database. The journal articles containing "the Mu Us Sandy Land" are searched under the condition of "Crusting", and statistics on the number of annual publications, keywords, and research content of 65 papers are collected, analyzing data with Excel 2016.

2.2. Statistics on the number of annual papers published
More and more papers have been published in the field of biological soil crusts in the Mu Us Sandy Land. The publication year reflects the development process, speed and heat of scientific research on biological soil crusts in the Mu Us Sandy Land. Fig. 1 shows the number of papers annually on biological soil crusts in the Mu Us Sandy Land in China from 1993 to 2020. It can be seen that the number of papers was relatively small in the 15 years from 1993 to 2008, two papers in 2007 and one paper in the rest of the year. A total of 6 papers in 10 years. The number of papers is the highest in 2014, have 9 papers, and showed a rapid decline in the following three years. The number of papers in 2013 and 2017 was 2 papers, and the number of papers rose again to 5 papers in 2018. In 27 years, there are 65 papers an average of about 2.4 per year.

![Fig. 1 The number of papers on soil crusts in the Mu Us Sandy Land](image)

2.3. Keyword analysis
The keywords are the terms and core concepts that express the central ideas of the paper. Through keyword search, you can quickly find the required literature. The analysis of the keywords can quickly and accurately grasp the key research direction of research field. At the same time, the relevant papers can also reflect the different branches of the research direction, which helps researchers quickly understand the breadth of research, and also has certain reference significance for opening up new research fields. Through the analysis of keywords in the study of biological soil crusts in the Mu Us Sandy Land (Fig. 2), among the keywords that frequently appear 4 times or more, the most widely
studied are "The Mu Us Sandy Land", "Biological Soil Crusts", "Biological Crust" and "Developmental Characteristics", the paper using this keyword accounted for more than 77% of the top ten keywords. In terms of the research content, the keywords are mainly manifested in the development characteristics of crusts, soil moisture, biological communities, and organisms.

![Fig. 2 Top ten keywords and the proportion of papers](image)

**3. Research progress on biological soil crusts in the Mu Us Sandy Land**

**3.1. Development characteristics of biological soil crusts in the Mu Us Sandy Land**

Some scholars have explored the key factors that determine the spatial distribution of biological soil crusts on different scales. On the micro-scale, the micro-topography is a key factor in the formation and maintenance of the diversity of the biological soil crust community [9], on the medium scale, the coverage and diversity of the biological soil crust community are affected by the accumulation of atmospheric dust, light, soil moisture and soil nutrients [10]. Li [11] believe that precipitation at the landscape scale (sand areas in different climatic zones) determines the spatial distribution of the dominant populations of biological soil crusts, and on the regional scale (a certain sand Area) soil properties determine the distribution of dominant populations of biological soil crusts, and disturbance and vegetation coverage at the local scale (specific research plots) play an important role in the distribution of biological soil crusts. Zhou [12] analyzed the bacterial community composition and diversity of biological soil crusts (microbial crusts, algal crusts, lichen crusts and moss crusts) and naked sand at different development stages of the Sabina vulgaris community in the Mu Us Sandy Land, and their influence of the main environmental factor of bacterial community structure, it is found that Sabina vulgaris is the main sand-fixing plant in the Mu Us Sandy Land. The widespread biological soil crusts in the Sabina vulgaris community is a great significance for maintaining the stability of the sandy ecosystem. Sun [13] took the bare land, lichen crust and moss crust among the Artemisia ordosica shrubs in the Mu Us Sandy Land of Yanchi, Ningxia as the research objects, and studied the effect of biological soil crusts on the soil enzyme activities of the Artemisia ordosica community in the Mu Us Sandy Land. It was found that moss crusts can accelerate the soil carbon turnover of Artemisia ordosica shrubs, and lichen crusts can accelerate the soil carbon and nitrogen turnovers of Artemisia ordosica shrubs. It is proposed that biological soil crusts can accelerate the turnover of soil nutrients in Artemisia ordosica communities, and improve soil quality and promote the restoration of vegetation and desert ecosystems in the region.

Regarding the succession of biological soil crusts in deserts, Li [9] believe that the continuous deposition of atmospheric dust on sandy surfaces is an important material basis for the colonization and development of biological soil crusts. The succession of biological soil crusts in temperate deserts follows from the succession law of "algae crust, algae-lichen mixed crust, lichen crust, lichen-moss mixed crust and moss crust"[14]. Li [15] tested the soil carbon flux of the biological crust covered in
the Mu Us Sandy Land, and showed that the daily variation trend of the photosynthetic rate of the biological crust is approximately a double peak curve, with the peaks mainly at 9:00 and 16:00. The daily change trend of the house type rate of biological crust soil showed a single-peak curve, reaching a peak at about 12:00. The soil temperature and water content at 2cm of the biological crust have significant effects on the photosynthetic rate and respiration rate. Wu [16] found that after the implementation of sand control and ecological restoration projects in the Mu Us Sandy Land, biological crusts developed preferentially on the surface of dunes with plant-specific values. Biological crusts develop well in the areas of Populus simonii, mainly moss crusts. The establishment of Populus simonii is conducive to the expansion of biological crusts, while the planting of Yang Chai between rows of Salix is not conducive to the development of biological crusts. Through research on different types of ground surface, it is found that algae and moss crusts have a significant impact on water infiltration, and different types of surface biological crusts have different effects on water infiltration, about 3~8 minutes, and overall water infiltration. The rate is positively correlated with soil bulk density, and negatively correlated with clay content, crust thickness, crust shear strength, crust layer bulk density, and soil organic carbon. The biggest influence on water infiltration rate is clay content, crust shear strength and soil bulk density [17].

3.2. The influence of soil texture on biological crust research
Soil microorganisms play an important role in maintaining the structure, function and process of ecosystems. Yin [18] researched that the total number of soil microorganisms, bacteria, actinomycetes and fungi in the crust layer of the Mu Us Sandy Land dune showed an increasing trend with the development of the biological crust, and the fine particles in the crust layer were higher than the soil under the crust. There is a significant or very significant negative correlation between the number of soil microorganisms and the content of soil clay particles, and a significant positive relationship with soil powder, clay and other fine particles, indicating that changes in these indicators can sensitively indicate changes in the number of microorganisms. Conversely, with the continuous expansion of biological crusts at different development stages, soil clay and powder particles and other fine-grained substances are also continuously increased, and the particle size composition is continuously optimized, so as to gradually improve the soil structure and effectively promote soil development [19]. Han [20] found that the soil stability was significantly enhanced after compounding of feldspathic sandstone and sand, and the clay content of sandy land was significantly increased after the mixture. The addition of feldspathic sandstone was conducive to the expansion of biological soil crust in sand land soil of the Mu Us Sandy Land, but the influence of the compound soil of feldspathic sandstone and sand on the development and succession characteristics of biological soil crust still needs further research.

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