Research Progress of Soil Impoverishment

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Abstract. Soil barrenness is an important type of land degradation, which seriously restricts the food security and sustainable development of agriculture in my country. This paper analyzes the status quo of soil barrenness, its causes and development trends, barrenness treatment measures, and research directions of soil barrenness, in order to serve as a reference for the research and development of soil barrenness.

Key words: Soil depletion; land degradation; overview; progress; direction.

1. Introduction

"Land degradation" was proposed by the United Nations Food and Agriculture Organization in the 1970s. In the 1994 United Nations Convention to Combat Desertification, the definition of land degradation: "'Land degradation' refers to the use of land or due to a force (natural forces) or a combination of forces resulting in a reduction or loss of the biological or economic productivity and complexity of rainfed, irrigated or grasslands, pastures, forests and woodlands in arid, semi-arid and dry sub-humid areas, including Wind erosion and water erosion cause soil material loss; soil physical, chemical and biological characteristics or economic characteristics are degraded; natural vegetation has been lost for a long time." Since then, different scholars have also given different definitions of land degradation from different angles. It refers to the decline of land productivity and use value under the influence of unfavorable natural factors and unreasonable human use of land. Two key aspects need to be emphasized: first, there must be a significant decline in the productivity of the land system, and second, the decline is the result of human activities or adverse natural events. The concept of land degradation not only defines the causes of degradation, but also includes two aspects of the degree of harm of degradation.

People divide land degradation into two types: phenotypic (sexual) degradation and recessive (sexual) degradation. The so-called phenotypic degradation process (some even short-lived) refers to obvious degradation results, and its degradation mechanism, process and results are more intuitive, such as soil erosion, salinization, desertification and other degradation types. Invisible (sexual) degradation refers to some land degradation processes that have already started or have been carried out for a long time, but have not yet led to obvious adverse results. The degeneration process is indeed taking place, but the mechanism, process, location and characteristics of the degeneration are not obvious for the time being. Invisible (sexual) degradation is the main type of modern farmland degradation, and its characteristics (types) and characteristic changes and hazards are relatively concealed and are not easily noticed and valued by people. Such as compaction and compaction inside the soil under the modern rotary tillage technology, conservation tillage system, shallow tillage layer, long-term field water in non-paddy fields Physical degradation such as decreased permeability and internal soil desiccation, acidification of topsoil soil, pollution, nutrient imbalance, decrease in soil base (calcium) saturation, accumulation of reducing substances in paddy soil, decrease in Eh and other chemical degradation, soil organic matter content Nitrogen decline, (micro)biopotential decline, soil-borne diseases increase, crop continuous cropping obstacles or fruit tree exclusion effect accumulation and other biomass degradation, stress resistance determined by poor soil conditions and the ability to coordinate environmental factors diminishes, and fatigue symptoms are prominent. degenerate. Farmland in various places "does not increase production without fertilization, and reduces production without fertilization", the problems of "greed for fat and water", and the high use of fertilizers and pesticides are extremely common and quite serious problems. degradation problem.

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Soil infertility is an important type of land degradation. It is a comprehensive characterization of the soil environment and the deterioration of soil physical, chemical and biological properties. It is the result that various soil properties or ecological environment factors cannot coordinate and promote each other. It is an important manifestation of fragile ecological environment. Decreased soil organic matter content, deficient and unbalanced soil nutrients, soil structure damage, soil erosion, topsoil thinning, soil compaction, soil acidification, alkalization and desertification are all manifestations of soil barrenness. Soil barrenness can be divided into two types: dominant barrenness and recessive barrenness. Dominant barrenness can lead to obvious degradation results, while recessive barrenness means that some degradation processes have already started or have been carried out for a long time, but have not yet led to obvious degradation. result. Soil barrenness means that the capacity and storage of soil's own nutrients are reduced, and the supply capacity to crops is reduced, which may lead to a decrease in the ability to retain water and fertilizer, and crops cannot receive normal supply of nutrients and water, thus causing crop growth and lead to severe yield reductions, which can cause economic losses and threaten food security [1]. At present, a recognized or unified quantitative evaluation system for soil barrenness has not yet been formed. Therefore, it is necessary to keep abreast of the status quo of soil barrenness in my country, analyze the causes and development trends, and carry out research work in this field in combination with the actual situation. development is important.

2. The status of soil barrenness in my country

Intensive land use, technology-intensive investment, and soil fertility depletion are extremely serious. Decreased soil organic matter content, deficient and unbalanced soil nutrients, soil structure damage, soil erosion, thinning of topsoil, soil compaction, soil acidification, alkalization and desertification are all manifestations of soil barrenness. The problem of soil barrenness caused by unreasonable human activities has seriously restricted the sustainable development of agriculture. The average fertility level of cultivated land in my country is low, and the cultivated land with organic matter content less than 0.7% accounts for about 10% of the total cultivated land area in China [2]. The soil organic matter content of paddy fields is mostly 1% to 3%, and 30% of dryland soil organic matter content is less than 1% [3]. The total nitrogen content of the vast majority of cultivated land is less than 0.2%. The provinces with severe nitrogen deficiency include Shandong, Hebei, Henan, Shanxi, Xinjiang, etc. There are more than 20 provinces with phosphorus deficiency or severe phosphorus deficiency; the proportion of potassium-deficient soil area is relatively small. Among them, potassium deficiency is more common in southern regions such as Hainan, Guangdong, Guangxi, and Jiangxi, but in recent years, potassium deficiency in the nutrient balance of farmland has generally appeared in all parts of the country, and the content of available potassium in farmland soil has shown a downward trend [4].

Based on 11 indicators such as soil organic matter, total nitrogen, total phosphorus, available phosphorus, total potassium, available potassium, pH value, CEC, physical clay content, powder/stick ratio, and surface soil thickness, comprehensive evaluation of soil fertility was carried out. , the results show that most of the soil in the eastern red soil hilly area is affected by fertility degradation to varying degrees, at the middle and lower levels, and the soil areas with high, medium and low fertility grades account for 25.9%, 40.8% and 33.3%, the fertility degradation has been very serious in the hilly and mountainous areas of Guangdong, Baise area of Guangxi, Jitai Basin of Jiangxi, and southern Fujian.

Although various places put a large amount of inorganic fertilizers into the soil every year, which maintains food safety production, since the 1960s, the amount of fertilizer input in my country has increased by 20 times, and the amount of fertilizer applied per unit area is at the highest level in the world. With the application of a large amount of chemical fertilizers year by year, the general shortage of trace elements in the soil has caused more than 60% of the arable land in the country to lack medium elements; the phenomenon of lack of trace elements is also common, and more than 80% of the soil in the arid regions of Northwest China is deficient in zinc and manganese. , 90% of the soils in the south and southwest regions are deficient in boron and molybdenum, and 80% of the soils in the North China Plain and the Loess Plateau are deficient in zinc and molybdenum [5]. Soil acidification occurs widely throughout the country, especially in the southern region. The tropical and subtropical regions of southern my country are rich in water and heat resources. Acidic soils are mainly distributed in this region. The regional soil acidification rate is significantly accelerated, and the problems of soil acidification and fertility degradation are prominent, which seriously restricts the development of soil production potential [6]. The large-scale use of chemical fertilizers will lead to extremely serious ecological disasters such as soil compaction, soil acidification, biomass degradation, non-point source pollution of water bodies, and aggravation of the environmental greenhouse effect, and the poor trace elements in the soil lead to more and more serious human sub-health problems. situation.

3. Causes and Development Trend of Soil Barrenness

The second national soil census data shows that most of the cultivated land in my country is seriously lacking in organic matter, total nitrogen, and available phosphorus. In the farming process, there are long-term low input, high output, unbalanced fertilization, and poor management. On the one hand, soil barrenness is caused by the local climate and topographical environment, and on the other hand, it is caused by the unreasonable use of cultivated land by humans. The main reason for poor soil is that the soil fertility is not high. The natural reason is the lack of water in the soil, the lack of nutrients, and the lack of air.

For example, the desert soil lacks water, and the acidic soil in the south is heavy and lacks air. This may be caused by climate and terrain.The man-made causes are mainly due to the unreasonable utilization of man-made, or the loss of soil fertility caused by excessive farming. For example, the black soil that was first cultivated in Northeast my country has an organic matter content of 7-10%, but after less than a hundred years of cultivation, the soil organic matter has dropped to 3-4%, and some are even only about 2%. Among the cultivated land in the Huang-Huai-Hai region, there are still large areas of drought, flood and saline-alkali land that have not been improved. In the past, in order to increase production, irrigation was carried out without considering drainage conditions, resulting in severe secondary salinization. After the deforestation in the southern region, the content of soil organic matter dropped from 5-8% to 1-2%, and soil fertility decreased significantly [7]. The phenomenon of soil barrenness occurs all over the country, and a large part of the soil nutrients in cultivated land is still in deficit and imbalance, which restricts the development of agricultural production in my country, thus affecting the food security of our country.

4. Soil Barrenness Treatment Measures

The departments responsible for soil barrenness management mainly include the Ministry of Agriculture and Rural Affairs and the Ministry of Ecology and Environmental Protection. The "Land Administration Law of the People's Republic of China" clearly puts forward the goal of arable land protection to ensure that the quality of arable land is not reduced. The "Measures for the Management of the Soil Environment of Agricultural Land (Trial)" issued by the Ministry of Environmental Protection and the Ministry of Agriculture in September 2017 provides an important institutional guarantee and basis for ensuring the safety of agricultural production environment.

Yang Qiyong et al. [8] evaluated and analyzed soil nutrient depletion and its obstacle factors based on GIS, and proposed soil depletion control measures: (1) improve soil fertility to enhance soil stress resistance; (2) take small watershed as the basic unit Plant trees and afforestation and green barren hills; (3) implement a reasonable intercropping farming system; (4) strengthen the basic construction of farmland water conservancy. [6] analyzed the current situation of farmland soil acidification in my country and the main hazards of soil acidification, and proposed soil acidification control measures: (1) Control the emission of pollutants such as sulfur dioxide and nitrous oxide; (2) Use physiological alkaline fertilizers instead of Chemical fertilizers; (3) Increase organic fertilizers to reduce soil pH, stabilize or improve soil acid-base buffer capacity, reduce exchangeable acid and aluminum content, and relieve soil acidification; (4) Apply calcium carbonate fertilizers or chemical modifiers. Based on a large number of researches by experts and scholars, the main measures to control the problem of soil barrenness are to increase the application of organic fertilizers, reduce the application of chemical fertilizers reasonably, fallow crops at appropriate times, promote the return of straws to the field, and adopt organic and inorganic composite improvement technologies to prevent and control soil acidification and improve farmland soil. To curb the continuous impoverishment of the soil, maintain the stability of the soil acidity, and improve the soil fertility. Each improvement technology has advantages and disadvantages. Based on the goal of improving the utilization rate of chemical fertilizers and improving the soil environment, combined with soil fertility and existing technical standards, soil testing formula fertilization, chemical soil conditioners, fertilizer-retaining materials, and disinfectants are used, Bio-organic fertilizer and other materials and technologies are integrated to form an efficient and green comprehensive fertility improvement technology system and promote its application.

5. Research direction of soil barrenness

Soil barrenness is a comprehensive nonlinear soil variation process with temporal dynamics and spatial differences [9]. Soil depletion involves soil science, agronomy, ecology, environmental science, and social science. So far, the research work of experts and scholars has mostly focused on the change of specific soil barrenness indicators in specific regions or specific soil types, and the research work on the comprehensive change trend of different soil barrenness types is mostly in the exploratory stage. Although great progress has been made in soil depletion research, fruitful scientific research is still needed. In the future, the research work on soil barrenness in my country should systematically and comprehensively carry out comprehensive evaluation of soil barrenness and the reconstruction and restoration of ecosystems from a broader and deeper level, and gradually expand to the direction of land degradation in the whole area. Research work in the following areas can be strengthened:

(1) Prove the status quo of soil barrenness in my country, and strengthen monitoring, forecasting and early warning. At this stage, soil depletion research and supervision are separate, and the details are unclear. The institutional, policy and governance responses to solve the problem of soil depletion are often passive and fragmented. Soil barrenness is usually the result of multiple factors, and there are many types of barrenness and complex causes. Therefore, it is necessary to coordinate and cooperate with multiple departments to conduct in-depth investigations on the status of soil barrenness in my country, and establish a comprehensive monitoring and research network for soil barrenness. To monitor the type, extent and degree of soil barrenness at different scales and levels to provide a realistic basis for the prevention and control of degraded land.

(2) Pay attention to the hidden problem of soil impoverishment, and curb the transition from recessive to dominant. At present, there is still insufficient attention to the recessive degradation of soil barrenness, lack of knowledge of its occurrence mechanism, insufficient understanding of its harmfulness, and insufficient

understanding of its occurrence mechanism. Paying attention to the problem of recessive soil barrenness and adopting the strategy of prevention first and combination of prevention and control should be the main focus of soil barrenness in the future.

(3) Construct a comprehensive technical system for soil barrenness evaluation, improvement and utilization. At present, there is no unified international or domestic standard related to soil infertility. Strengthening the research on the evaluation index system of soil infertility and establishing a comprehensive evaluation index system is conducive to land degradation prevention and land remediation and utilization.

6. Measures and Suggestions for Preventing Soil Depletion

(1) Strengthen ecological protection and restoration efforts. Focus on the management of prominent ecological and environmental problems. Strengthen the comprehensive management of sand control and desertification, carry out the protection and restoration of natural grasslands, implement the "three modernizations" management of grasslands, promote the comprehensive management of desertified land in the source areas of rivers, and increase the construction of shelter forest systems. Strengthen the comprehensive management of soil erosion and rocky desertification, implement the orderly implementation of returning farmland to forests and grasslands, carry out comprehensive management of mountain, water, fields, forests and roads with small watersheds as units in areas with severe soil erosion, and strengthen comprehensive management of sloping farmland, eroded ditches and collapsed hills. Implement rocky desertification comprehensive control project. Carry out water ecological restoration, promote returning farmland to rivers and lakes and wetlands according to local conditions, prevent water pollution, and strengthen the protection and restoration of natural wetlands.

(2) Steadily promote the ecological restoration of agricultural space. Combined with farmland consolidation and ecological protection and restoration projects, targeted removal of farmland soil obstacles, protection and restoration of farmland semi-natural habitats and biodiversity, and enhancement of farmland ecological infrastructure construction; In areas with weak resource and environmental carrying capacity and high-intensity utilization of cultivated land, establish a fallow rotation system of cultivated land to reduce the intensity of land use.

(3) Under the basic situation that the demand for construction land continues to increase, while the quantity of cultivated land is small, the quality of cultivated land is not high, and the reserve resources are insufficient, the balance of cultivated land occupation and compensation is the most prominent overall and systematic problem in land consolidation. Since 2014, the state has stipulated double red lines of quantity and quality for the balance of arable land occupation and compensation. Government departments should attach equal importance to quantity and quality, establish and improve the supervision and management mechanism of cultivated land quality, a long-term investment mechanism for cultivated land quality construction, and clarify the division of responsibilities of relevant departments at all levels. It is necessary to implement specific projects and specific plots in a timely manner, and promote the implementation of the project. The Bureau of Land and Resources should continue to do a good job of stripping and reusing topsoil, strengthen the inspection and guidance of development and land reclamation, and promptly urge rectification in place if the quality does not meet the requirements to ensure the quality of supplementary cultivated land.

(4) Relevant departments should strengthen the leading role of planning, guide the orderly progress of land consolidation work, and avoid policy contradictions, overlaps and gaps. First, it is necessary to further find out the current situation and potential of land improvement in my country, and to formulate land improvement plans and work plans scientifically and reasonably; second, to maintain a good order of land use. Strengthen the awareness of supervision, strengthen the supervision of land law enforcement, actively exert the supervision role of the grassroots, and seriously investigate and deal with the illegal occupation and abuse of cultivated land. Increase the disposal of idle land and revitalize the stock land; thirdly, we must do a good job of development and land construction. The balance of cultivated land occupation and compensation is a hard lever and a strict requirement for the protection of cultivated land. Land must be used and supplemented in accordance with the law, and the principles of overall use of cultivated land and whoever occupies it should be compensated. To balance the occupation and compensation of cultivated land.

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References

1. Zhao Qian. A brief discussion on the construction of the ecological restoration area of barren soil green space in the western region [J]. Modern Horticulture, 2017, 4(14): 170-171.
2. Zhang Xuelei, Gong Zitong. Human-induced soil degradation in China [J]. Ecological Environment, 2003(03):317-321.
3. Ning Tangyuan, Li Zengjia, Han Huifang. Modern circular agriculture is a strategic choice for sustainable development of my country's main grain producing areas [J]. Agricultural Modernization Research, 2010, 31(05): 519-524.
4. Yang Qing, Lang Nanjun, Su Zhihao, Cai Shuo. A review of soil degradation research [J]. Forestry Survey and Planning, 2009, 34(01): 20-24.

5. Xie Ji. Impact of regional climate conditions and evolution on soil degradation in rocky desertification areas [D]. Tongji University, 2008.
6. Xu Renkou, Li Jiuyu, Zhou Shiwei, et al. Scientific issues and technical measures for the regulation of farmland soil acidification in my country [J]. Proceedings of the Chinese Academy of Sciences, 2018, 33(02): 160-167.
7. Zhang Yan. Current situation and countermeasures for the transformation of low- and medium-yield fields in my country [D]. Southwestern University of Finance and Economics, 2010.
8. Yang Qiyong, Yang Jinsong, Yao Rongjiang, Huang Biao, Sun Weixia. GIS-based evaluation of soil nutrient infertility in cultivated land and analysis of its obstacle factors [J]. Journal of Natural Resources, 2010, 25(08): 1375-1384.
9. Zhang Cuilian, Ma Xi. Progress and Trend of Soil Degradation Research [J]. Northern Environment, 2010, 22(03): 42-45.