

Integration of Soft Rock and Sand into Soil and Its Application Effect Evaluation

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Abstract. Mu us sandy land is a typical ecologically fragile area in our country, which will bring remarkable comprehensive benefits to its rational development and utilization. This research systematically explored the comprehensive improvement technology of Mu Us sandy land through indoor experiment, plot test and field demonstration, and refined the soft rock and sand combined sand-fixing ability improvement technology, efficient irrigation water-saving technology, water and fertilizer management technology, and developed a comprehensive development scale decision support system, which can provide decision support for the development of Mu Us sandy land. Through the integration of technologies, demonstration application has been carried out in Mu Us sandy land of northern Shaanxi and good ecological, social and economic benefits have been achieved.

1. Introduction

Mu Us Desert is the common name of sandy land along the southeast of Erdos Plateau and along the Great Wall of Northern Shaanxi. It is one of the serious desertification areas in China. The area belongs to arid and semi-arid areas, which is superior to the hydrothermal conditions in other desert areas in China. Historically, much of Mu Us Desert has been a richly populated area [1]. As the population continues to grow, human activities continue to exert strong interference with the environment due to the increasing demand for food, feedstuffs, fuel wood, etc., thus making the ecological environment instability in such areas as land desertification, soil erosion and dust storms and other ecological Environmental degradation or deterioration is extremely serious [2-5]. In recent years, the traditional development model of "re-exploitation, light utilization and weak protection" has also strongly affected the ecological environment protection and sustainable utilization of land resources in ecologically fragile areas [6-7]. In order to rehabilitate the regional ecological environment and make use of the vast sand resources, many scholars have tried and practiced various ways.

Throughout the research results of desertification control, the aim of windbreak and sand suppression to curb desertification has been to date. Few people have done so far from the perspective of soil improvement to increase the self-corrosion resistance of sandy land, improve its ability to resist wind erosion and improve the physiological and biochemical properties, Enhance biological



productivity, improve the landscape of the sand. Therefore, it is urgent to dissect the core material which is extremely lacking in sandy land, make use of land engineering means to make up and allocate the material composition of sandy land, and explore a sandy land governance model with good economic, social and ecological benefits. Because of the lack of colloidal substances in the sandy land, its status is unstable and easily migrated and its productivity is lost due to the lack of coordination of the fertility factors such as water, fertilizer and heat. Grasping the key material in sandy land - the key of colloid - is to carry out material selection and compounding technology research and development. By giving the sandy land a colloidal substance, the sandy land is transformed into a life-creating soil, fundamentally improving sand land, a new idea of sand governance. In seeking high-quality colloidal resources for the Mu Us Sandy lands, scientists found that the distribution of loose rock formations commonly known by the locals as "soft rock" in the Jin, Shan and Mongolian regions brought a new hope.

In this study, the unclear problems such as follow-up ecological effect, sustainable utilization of soil and water resources, stability of compound soil and its sustainable utilization after sandy land remediation using sand and sand mixed with soil were emphasized: The technical method of compound soil and sand fixation effect analysis reveals the influencing factors and mechanism of composite sand fixation and quantitatively evaluates the effect of compound soil and sand fixation; studies the water-saving technology system suitable for exploitation and utilization of Mu Us sandy land in northern Shaanxi, Agricultural water-saving technology system, and analyse the potential of regional water resources in the development and utilization of sandy land and its support to population, economy and food production; study on the regulation and control technology of compound soil stability, and explore complex adaptation to the climatic characteristics of Mu Us sandy land Soil and water-rich management techniques of typical crops (potato and spring maize) with soil; establishing an evaluation index system for controlling development scale, economic and environmental impact analysis, building an analysis and decision model for controlling development scale and economic and environmental impact, and finally integrating soft rock and sand complex With soil technology and the combination of various tasks of research technology, integrated control in the Mu Us sandy demonstration projects and promotion, and strive for the technology in the Mu Us Desert large-scale application to lay a solid theoretical foundation.

2. Technical integration on compounded soil of Soft Rock and sand

2.1. Technology to enhance sanding ability

The soft rock and sand particles gradation and mixing proportion combination test were carried out. Through scanning electron microscope, wind tunnel test and field positioning observation we analysed the comprehensive comparative of the test data to obtain the technology of enhancing the sand fixing ability of compound soil. The results show that the composite soil has the potential to resist wind erosion. The wind erosion amount of sandstone and sand alone is relatively large, and the amount of wind erosion after compounding into soil is significantly reduced. According to the clay content of sandstone and sand in the study area, the anti-wind erosion capacity of sandstone and sand mixture ratio of 1:5-1:2 was the strongest. Aiming at the problem of weak sand fixation capacity in the early stage of compounding, in the engineering application, the formation of composite soil crust and the formation of winter cold cover are mainly promoted by determining the reasonable ratio of soft rock and sand. Through agricultural planting, increase the coverage of surface vegetation of compound soil, give full play to the production function and ecological function of the technology, and realize the sustainable utilization of compound soil.

2.2. Efficient irrigation and water saving technology

(1) Water saving irrigation mode

The water-saving irrigation system of the typical crops of soft rock and sand mixed with soil formulated by field experiment was compared with the traditional crop irrigation system (sand flood

irrigation and sand sprinkler irrigation) and so on. It was found that "the combination of soil and sprinkler irrigation system Compared with the "Irrigation System under Flooding Irrigation System", the water saving effect of corn irrigation water with the compounding ratio of 1:1, 1:2 and 1:5 reached 43.1%, 43.9% and 41.6% respectively, and the water-saving effect of potato reached 27.2%, 27.2%, 26.1%. Comparing the irrigation system of compound soil and sprinkler irrigation with the irrigation system of sprinkler irrigation, the water saving effect of corn irrigation water with compounding ratio of 1: 1, 1: 2 and 1: 5 reached 28.9% , 29.8% and 27.0% respectively. The water-saving effect of potato was 9.0%, 9.0% and 7.7% respectively. It proved that the use of sprinkler irrigation had made a good water-saving effect, in achieving the expansion of cultivated land resources at the same time, improve the effective utilization of agricultural water resources.

(2) Water-saving irrigation system

Based on the local climatic conditions and agricultural planting tradition in Mu Us sandy land, corn and potato, which are the typical crops suitable for local growth, were selected and divided into stages according to their growth state. Based on the measured field water holding capacity, moisture content and other moisture constants and water requirements during the growing stage of the crop to determine the different growth stages of the planned depth of wet soil, and then calculate the appropriate range of soil moisture within each growth stage threshold. Through the soil moisture content threshold to determine the different stages of crop water requirements, in order to develop a crop water-saving irrigation system. According to the calculation of crop water demand, develop a comprehensive water-saving measures under the corn and potato irrigation system. The results showed that when the ratio of sandstone to sand was 1: 2 and 1: 5, they were suitable for planting corn and potato respectively. Therefore, the water-saving irrigation system with the corresponding compounding ratio was selected (Table 1 and Table 2).

Table 1. Corn irrigation system

Crop	Irrigation order	Growth Period	Irrigation quotas (m ³ /mu)	Irrigation quota (m ³ / mu / time)	Irrigation times (times)
Corn	1	Seeding period	162.8	7.7	1
	2	Seedling stage		7.7	2
	3	Jointing period		23.1	3
	4	Heading		28.6	2
	5	Filling period		14.3	1

Table 2. Potato irrigation system

Crop	Irrigation order	Growth Period	Irrigation quotas (m ³ /mu)	Irrigation quota (m ³ / mu / time)	Irrigation times (times)
Potato	1	Seeding period	157.3	7.7	2
	2	Seedling stage		7.7	3
	3	Tuber formation period		15.4	3
	4	Tuber enlargement		15.4	3
	5	Starch accumulation period		13.2	2

2.3. *Water and fertilizer management technology*

Simulated studies on water dynamics in compound soil, carbon and nitrogen cycle in soil and crop system, crop growth and agricultural management measures were carried out by using WNMM model. The results show that soft rock plays an important role in improving water and nitrogen content and fertilizer use efficiency. For the spring maize planted on the compound soil, the better water and fertilizer management system is 477 mm, 291 mm and 176 mm irrigated in the dry year, flat water year and heavy water year respectively, and the fertilization amounts are 114 kg N/hm², 90 kg N/hm², 169 kg N/hm². For the potato planted on the compound soil, the better water and fertilizer management system is that the annual irrigations are 245 mm, 219 mm and 104 mm respectively in the dry year, the plain water year and the abundant water year, and the fertilization amounts are respectively 120 kg N/hm², 120 kg N/hm², 121 kg N/hm².

2.4. *Develop decision support system*

We used a variety of methods and hardware tools to obtain the key factors affecting development activities index data. Dealing with and analysing data related to the impact of development activities on the environmental surface and underground to set, analyse and screen economic, social and environmental impact indicators for control development. Based on the integrated data processing method combining AHP and expert investigation, the evaluation index system of development decision was established and the development decision model was constructed by using weighted index method. On this basis, the decision-making system for the comprehensive development of Mu Us sandy land has been established. At the same time, the bearing capacity model of water resources to the scale of agricultural development and utilization obtained by irrigation and water saving technology can realize the function of assistant decision of experts, make an intuitive appraisal for the land development scale and development intensity in the project area, and provide the basic support for the project implementation.

3. **Technical application evaluation**

The total demonstration areas were about 12000 mu in Yulin City, Yuyang District and Shenmue County. It had made significant social, economic and ecological benefits.

3.1. *Social benefits*

(1) Contribution to the national food security. After the implementation of the project, a high standard of basic farmland with complete infrastructures of fields, dams, ditches, roads and forests will be formed. The water retention, fertilizer conservation and disaster resilience of cultivated land will be significantly enhanced, and the quality of cultivated land will be significantly improved, thus steadily improving Cultivated land comprehensive production capacity, enhance food production capacity. After preliminary calculation, the demonstration areas of Yuyang and Shenmu will achieve an annual increase of grain output of 5,359,500 kg and 28,156,300 kg respectively, which will effectively support the sustainable economic and social development in the project area and ensure the national food security positive contribution.

(2) Contribution to realizing the balance of total arable land in the region. Yulin City is in the new stage of urban-rural transformation and development. The demand for land of urban, industrial and infrastructure construction is growing rapidly, which brings great challenges to the balance of total cultivated land in the region. The major construction project soft rock and sand complex into soil has significantly improved the quality of arable land, while achieving a new area of 11,861.35 mu of arable land, the new cultivated land rate was 96.57%. By improving the infrastructure of farmland infrastructure, the quality of farmland replenishment has been significantly improved, thus making a positive contribution to the realization of the total arable land balance in Yulin City and even to Shaanxi Province and the improvement of the comprehensive production capacity of arable land.

(3) The positive effect on rural development. The project is designed to promote the integration of peasants' income, poverty alleviation and development, focusing on the market and the construction of

new rural communities in advanced agricultural production mode. It not only can greatly improve agricultural production conditions, promote the large-scale operation of rural land, raise the level of agricultural output and increase the income of peasants, but also improve rural roads, transport facilities and public service facilities to effectively promote the construction of small towns and central villages. This has a positive role in guiding and promoting the consolidation of rural infrastructure, narrowing the gap between urban and rural areas and promoting the coordinated development of urban and rural areas.

3.2. Economic benefits

The main planting crops in the demonstration area are potatoes. In order to implement crop rotation, the cropping pattern is one year. The rotation system is potato-potato-corn. The new cultivated land of Yuyang and Shenmue demonstration area were 2475.93 mu and 9385.42 mu respectively. When the multiple cropping index was 1.0, the year of stable production was planted. The yield of potato was about 3000 kg/mu and that of corn was about 1000 kg/mu. The estimated economic benefits after the development are shown in Table 3.

Table 3 Economic Benefits of Crops after Development Calculation

Demonstration Area	crop	Area (mu)	Yield (kg /mu)	Price (yuan / kg)	Gross output value (ten thousand yuan)	Cost of production		Net income (ten thousand yuan)
						(yuan / mu)	(ten thousand yuan)	
Yuyang	Potato	2475.93	3000	2.0	1485.56	2700	668.50	817.06
	Corn	2475.93	1000	2.0	495.19	480	118.84	376.35
Shenmu	Potato	9385.42	3000	2.0	5631.25	2000	1877.08	3754.17
	Corn	9385.42	1000	2.0	1877.08	480	450.50	1426.58

After estimation, the newly-increased cultivated land after the completion of Yuyang project reaches a stable production year, the annual income of planting potatoes can reach 14, 855, 600 yuan, with the total cost of 6.6850 million yuan and the expected annual net income of 8,170,600 yuan. The annual income of planting corn can reach 4951900 yuan, the total cost of 11818400 yuan, the expected annual net income of 3763500 yuan. In Shenmue project area, the annual income of planting potatoes can reach 56.3152 million yuan, with the total cost of 18.7788 million yuan and the expected annual net income of 37.5417 million yuan. Annual income of corn planting up to 18,770,800 yuan, the total cost of 4.55 million yuan, the expected annual net income 14,265,800 yuan.

The investment of Yuyang demonstration zone was 21,489,100 yuan. In accordance with the new 2475.93 acres of arable land area, the investment amount was 8679.20 yuan/mu. Calculated according to the three-year planting season (potato-potato-corn), the average annual net income was 6,701,600 yuan, and the annual net income per mu was 2,706.70 yuan, and the input-output rate per mu was 31.19%.

The total investment of Yuyang demonstration area was 21,489,100 yuan. The payback period of calculation is as follows:

Payback period = total investment/new net income = 2148.91/670.16 = 3.21 years.

The payback period was 4 years and the project had good economic returns.

The total investment of Shenmue was 83451900 yuan. According to the development and finishing net increase of 9385.42 acres of arable land, the amount of investment per mu was 8891.65 yuan. Calculated according to the three-year planting season, the average annual net income was 29,783,100 yuan, and the annual net income per mu was 3,173.34 yuan, with an investment output rate of 35.69% per mu.

The Shenmue payback period of calculation is as follows:

Payback period = total investment/new net income = 8345.19/2978.31 = 2.80 years.

The payback period was 3 years and the project had good economic returns.

3.3. *Ecological Benefits*

Through the integrated application of engineering measures, biological measures and other measures in the land development and consolidation area, the comprehensive management of fields, water, electricity, forests and roads had been implemented, effectively increasing the area of cultivated land and improving the ecological environment. Through implementing the land remediation project with the core technology of soft rock and sand composting soil, it is effective in drastically improving the efficiency of soil and water conservation, consolidating the achievements of returning farmland to forestland, preventing desertification of land and improving regional ecological environment [8].

(1) Significantly enhanced the effectiveness of soil and water conservation. After the implementation of the project of soft rock and sand compounding into soil, the water and soil loss could be effectively controlled and the ecological environment in the area had been remarkably improved. The treatment rate of the disturbed land under the project construction can reach 95.5% and the degree of soil and water erosion control reached 85.7%. After the construction project was completed, with the growth of new plantation belts and the planting of crops, the plant restoration coefficient can reach 95.8%, and the coverage of forest and grass reaches 69.0%. The project played an important role in windbreak, sand fixation, air purification, improvement of regional microclimate and beautification of the environment, forming a patchwork artificial green farmland ecosystem.

(2) Continue to promote the project of returning farmland to afforestation. The farmland built in the project is more fertile, with sufficient water and stronger drought resistance, which is a good basic farmland with high and stable yield. In order to adjust the rural industrial structure, develop a diversified economy and promote the return of cultivated land to forests and pastures, we have created favourable conditions. This major project can not only increase the quality of farmland, but also effectively consolidate the achievements of returning farmlands to forests and ecological construction.

4. Conclusion

The integrated application of soft rock and sand compounding soil technology has made it possible to transform 5.3 million mu of decertified shrub land into cultivated land in northern Shaanxi Province and will open a large area of cultivated land with good quality for Shaanxi Province. The application of technology will help promote economy through demonstration, promote promotion through practice, and promote scientific research and innovation in promotion. It is of great significance to effectively increase the cultivated land area in the Mu Us Sandy Area and even the whole province, ensure food security, and consolidate the achievements of returning farmland to forests, economic development and ecological civilization are all of strategic significance.

Acknowledgments

This work was funded by the public welfare scientific research of Ministry of Land and Resources, No.201411008.

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