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Investigation on Soil Fertility of Newly Increased Cultivated Land after Wasteland Improvement in Loess Hilly Region-a Case Study in Ganquan County, Shaanxi Province

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Abstract. Through sampling analysis, field method and weighted sum evaluation method were used to study and analyze the fertility index of newly-increased cultivated land after wasteland land consolidation in loess hilly region. The fertility level, the biggest limiting factors and the comprehensive fertility index of newly-increased cultivated land were discussed, and reasonable fertilization strategies were put forward. The results show that: (1) the soil fertility content of newly-increased cultivated land in the loess hilly region is at a relatively low level after wasteland improvement. The average content of organic matter is 5.95 g / kg, the average content of total nitrogen is 0.52 g / kg, the average content of available phosphorus is 8.80 mg / kg, and the average content of available potassium is 183 mg / kg. (2) The soil fertility index of the newly-increased cultivated land in the study area ranged from 61.5 to 73.0 points, with an average score of 66.3 points. The project area with a score of 65 to 71 accounted for the majority, accounting for about 60 % of the total. (3) Soil organic matter and total nitrogen are the biggest control factors of the newly increased cultivated land fertility index after wasteland improvement in the loess hilly region. Increasing soil organic matter and total nitrogen is the most direct way to improve the comprehensive index of new cultivated land fertility.

1. Introduction

It has a small population and a shortage of arable land reserve resources in China. In order to solve the problem of food and ensure food security, our country implements the most stringent farmland protection system and the most stringent land conservation system. To realize the dynamic balance of the total amount of cultivated land. Practice has proved that land consolidation can increase the effective cultivated land area and improve the quality of cultivated land, and has made positive contributions to the realization of the dynamic balance of the total cultivated land in our country. However, in contrast to the current high efficiency of land consolidation, the quality of newly increased cultivated land after land consolidation, especially the status of soil fertility, is not optimistic. Therefore, it is of great significance to study the basic status of soil fertility of newly-increased cultivated land after land

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consolidation, understand the soil nutrient content level of newly-increased cultivated land after land consolidation in this region, and find out the short board of soil nutrient of newly-increased cultivated land after land consolidation in this region, so as to improve the soil nutrient level of newly-increased cultivated land in this region and even the soil fertility level of the entire region.

At present, most of the studies on land consolidation projects at home and abroad are based on the land consolidation project mode l [1]. There are many studies on [2-4] such as post-treatment effect evaluation of land, and studies on soil nutrient evaluation are also concentrated on mature high-quality farmland [5, 6]. However, the research and evaluation of soil fertility of newly-increased cultivated land in wasteland remediation featuring low soil nutrient content are relatively few. This research can provide data support for the basic level of soil fertility of newly-increased cultivated land after land remediation, the classification of nutrient index grades, and the evaluation of soil fertility of newly-increased cultivated land. It can also provide technical support for improving the soil fertility of newly-increased cultivated land and provide basis for optimizing land use types after land consolidation.

Soil fertility is a comprehensive reflection of many basic characteristics of soil. Scientific and reasonable evaluation of soil fertility will provide a theoretical basis for understanding agricultural production, land use planning and management. This study takes the desert land remediation project in Ganquan county of Shaanxi province as the research object, studies the soil fertility content and distribution characteristics of the newly-increased cultivated land, and explores the biggest limiting factors of the soil nutrients of the newly-increased cultivated land, so as to provide technical guidance for improving the soil nutrient content of the newly-increased cultivated land in the region.

2. Materials and methods

2.1. Overview of the study area

Ganquan county is located in the central part of Yan' a city. Located between 108 45' 34 " and 109 33' 46" east longitude, 36 6' 57 " to 36 37' 33" north latitude. It belongs to the loess hilly and gully region of northern Shaanxi. The altitude is generally between 950 and 1600 m, and the relative altitude difference is within 200 m. Luohe river stretches from northwest to southeast. The northeast side of Luohe River belongs to Laoshan mountain range and the southwest side belongs to Ziwuling mountain range. The annual average temperature is 8.6℃ and the annual average precipitation is 561.3 mm, which belongs to the semi-humid region of warm temperate zone. The county has a total land area of 228,700 ha and agricultural land of 62,900 ha. Ganquan County is representative of the whole loess plateau in its geographical location and vegetation status. In this paper, Ganquan county wasteland improvement project is selected as the research area to study the soil fertility and evaluation of newly increased cultivated land, so as to provide reference for improving and increasing the soil fertility of newly increased cultivated land after wasteland improvement in loess hilly region.

2.2. Sample collection and determination

Through on-the-spot investigation, the desert reclamation project of Ganquan County in loess hilly region was selected as the research object, and 45 reclamation project areas were selected for sample collection within the whole county. Three sample points were collected in each project area. Mixed soil samples were collected from 0 - 30cm surface soil by diagonal sampling method. A total of 15 project areas were collected and 45 sample points (about 2 kg each) were obtained. The soil was brought back to the laboratory for air drying.

The experimental method used to analyse soil samples is mainly referred to *soil agrochemical analysis*. Soil organic matter is oxidized by potassium dichromate - external heating method, total nitrogen (TN) is semi-micro method (clever chem 200), available phosphorus (AP) is extracted by sodium bicarbonate - molybdenum antimony colorimetry (752 n), and available potassium (AK) is extracted by neutral ammonium acetate - flame photometry (FP 640).The data analysis was completed by SPSS 20.0 and excel 2007 software.

2.3. Evaluation index selection

Based on the comparability of the research results, this paper selects conventional soil fertility indexes, namely soil organic carbon (SOC), soil total nitrogen (TN), soil available phosphorus (AP), and soil available potassium (AK).

2.4. Evaluation method

In this paper, the weighted sum evaluation method is used. The soil fertility comprehensive index (IFI) is used to express the level of soil fertility. Its value is between 0 and 6. The higher the soil fertility comprehensive index is, the better the soil fertility status is, and the better it is for the growth and development of crops. The comprehensive index of fertility is calculated by weighted sum model;

$$IFI = \sum_{i=1}^{n} W_i \bullet F_i$$

Where n is the number of words in the participating reason; WI is the weight of factor i Fi is the classification level of factor i.

3. Results and analysis

3.1. Distribution of nutrient content in newly increased cultivated land

3.1.1. Distribution of soil organic matter and total nitrogen

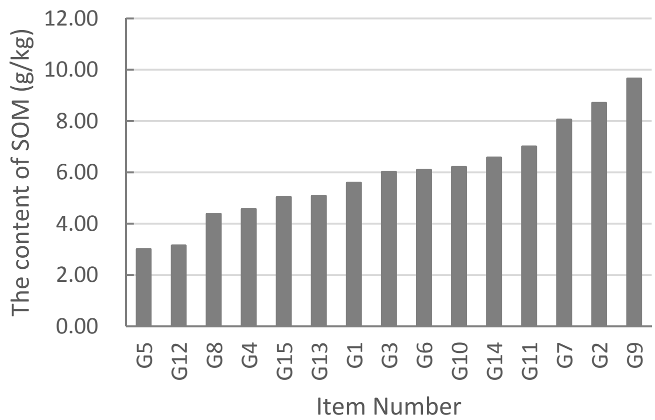

Figure 1. Soil organic matter content in each project area

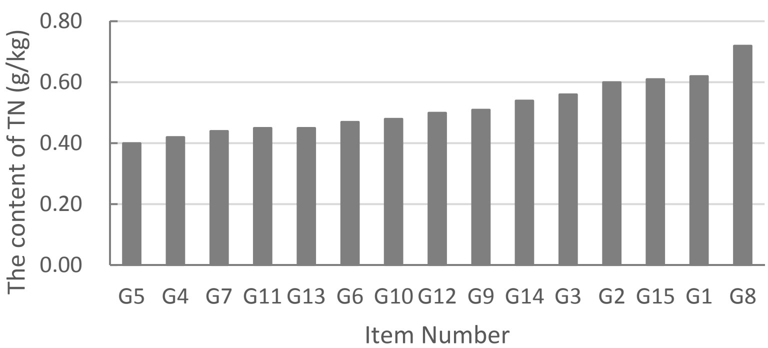

Figure 2. Soil total nitrogen content in each project area

The content of soil organic matter in newly increased cultivated land in Ganquan county of Shaanxi province ranged from 3.01g / kg to 9.66g / kg, among which the samples with organic matter content less than 4.0g / kg accounted for 13.3 % of the total number of samples, and the samples with organic matter content between 4.0g / kg and 7.0g / kg accounted for 60.0 % of the total number of samples. Samples larger than 7g / kg accounted for 26.7 %. The total nitrogen content in soil ranged from 0.40g / kg to 0.72g / kg, among which the sample sites with the total nitrogen content of 0.40 g / kg to 0.50g / kg accounted for 53.3 % of the total sample number, with an average value of 0.45 g / kg; 0.51g / kg ~ 0.70g / kg samples accounted for 40 % of the total number of samples, with an average of 0.57g / kg; Samples larger than 0.7g / kg accounted for only 6.7 %.

3.1.2. Distribution of available phosphorus and available potassium

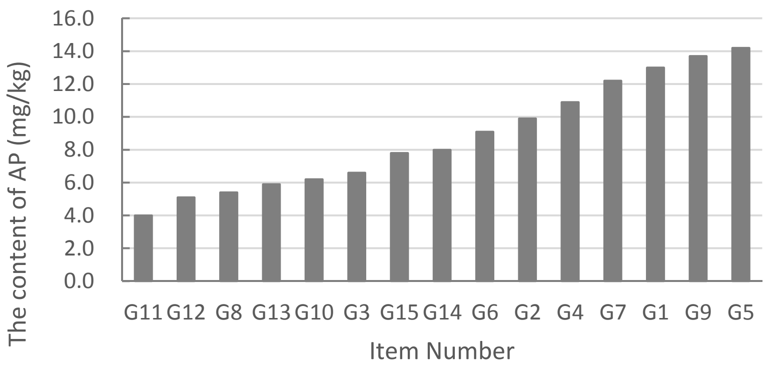

Figure 3. Soil available phosphorus content in each project area

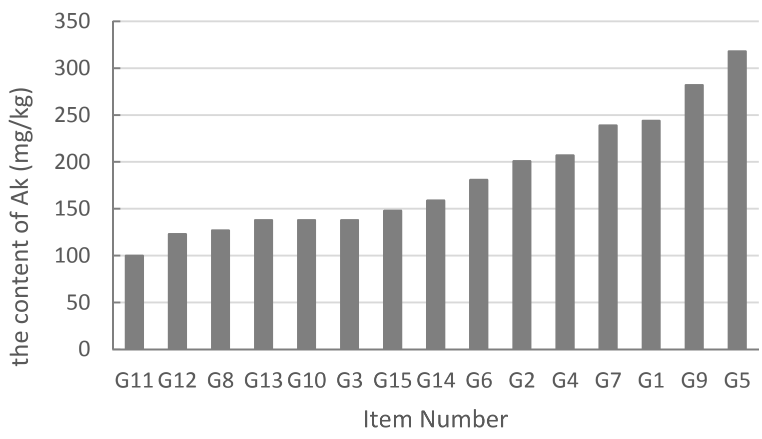

Figure 4. Soil available potassium content in each project area

The content of available phosphorus in newly increased cultivated land in Ganquan county of Shaanxi province ranged from 4.0 mg / kg to 14.2 mg / kg, among which 6.7 % of the total samples were samples with the content of available phosphorus less than 5 mg / kg. Samples ranging from 5.0 mg / kg to 10.0 mg / kg accounted for 60.0 % of the total number of samples, with an average of 7.1 mg / kg. Samples larger than 10.0 mg / kg accounted for only 33.3 %, with an average of 12.8 g / kg. The content of available potassium in soil ranged from 100 mg / kg to 318 mg / kg, among which samples with the content of available potassium below 150 mg / kg accounted for 46.7 % of the total number of samples, with an average value of 130.3 mg / kg; Samples from 150 mg / kg to 200 mg / kg accounted for 13.3 % of the total number of samples, with an average of 170 mg / kg. Samples larger than 200 mg / kg accounted for 40.0 % of the total number of samples, with an average of 248.5 mg / kg.

3.2. Description of nutrient characteristics of soil samples
The results of soil sample analysis showed that the coefficient of variation of soil available phosphorus was the largest, followed by soil available potassium. The coefficient of variation of soil total nitrogen was the smallest. Soil available potassium and total nitrogen had larger deviation and soil available phosphorus had the largest kurtosis. The standard deviation of available potassium is the largest.

Table 1. soil attribute statistics

Indicators	Sample number	Average value	Standard deviation	Minimum value	Skewness	Kurtosis	Coefficient of variation
Organic matter (g / kg)	15	5.95	1.83	3.01	0.35	-0.18	0.31
Total nitrogen (g / kg)	15	0.52	0.09	0.40	0.79	0.15	0.17
Available phosphorus (mg / kg)	15	8.80	3.25	4.0	0.31	-1.28	0.37
Available potassium (mg / kg)	15	183	61.80	100	0.81	-0.24	0.34

3.3. Index magnitude and weight division

3.3.1. Classification of index levels. According to the second national soil census nutrient classification standard (table 3), this paper classifies the newly added cultivated land soil nutrients in the land remediation project of Ganquan county, Shaanxi province, as follows:

Table 2. Criteria for classification of fertility levels in cultivated land quality evaluation

Indicators	SOC	TN	AP	AK	Score
Level 1	>40	>2	>40	>200	100
Level 2	30-40	1.5-2	20-40	150-200	90
Level 3	20-30	1-1.5	10-20	100-150	80
Level 4	10-20	0.75-1	5-10	50-100	70
Level 5	6-10	0.5-0.75	3-5	30-50	60
Level 6	<6	<0.5	<3	<30	50

According to the classification method of soil nutrient index levels for the second national soil survey, the nutrient content of each index of newly-increased cultivated land in the research area was classified. The results are shown in table 4. The contents of soil organic matter and soil total nitrogen in all the project areas are at the level of grade 5 and grade 6. 33.3 % of the total soil available phosphorus was found at level 3, only one sample was found at level 5, accounting for 6.7 % of the total, and the remaining available phosphorus was found at level 4, accounting for 60 % of the total. The soil available potassium content at level 1 accounted for 40 % of the total sample points, while levels 2, 3 and 4 accounted for 13.3 %, 40 % and 6.7 % respectively.

Table 3. Distribution of corresponding levels of various indicators at sample points where various project areas are located

Sample number	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
organic matter	50	60	60	50	50	60	60	50	60	60	60	50	50	60	50
Total nitrogen	60	60	60	50	50	50	50	60	60	50	50	60	50	60	60
Available phosphorus	80	70	70	80	80	70	80	70	80	70	60	70	70	70	70
Available potassium	80	80	100	80	80	80	90	70	100	100	80	100	100	100	90

3.3.2. Determination and method of index weight. Determining the weight of a single soil fertility index is a key issue in the comprehensive evaluation of soil fertility. There are many studies on determining the weight of an evaluation index, including fuzzy comprehensive evaluation method [7], principal component analysis method [8], analytic hierarchy process [2], matter element method [10], rough set theory and other methods for analyzing the weight of a variety of soil fertility evaluation indexes. Based on the comparability of the results, this paper selects the most widely used illegal expert at present, inviting six experts with rich experience in soil quality to score, and based on the results of a large number of literature studies, obtains the weight of the factor (Table 5).

Table 4. weight distribution of each influence index of soil quality

Evaluation index weight	SOM	TN	AP	AK
weight	0.30	0.25	0.25	0.20

3.4. Comprehensive evaluation and analysis of nutrients in newly added cultivated land
According to the fuzzy comprehensive evaluation method, the soil fertility comprehensive index (IFI) is calculated by the following weighted sum model:

$$IFI = \sum_{i=1}^{n} W_i \bullet F_i \qquad (i=1, 2, 3, 4\ n=4)$$

3.4.1. Comprehensive index map of soil fertility at various sites

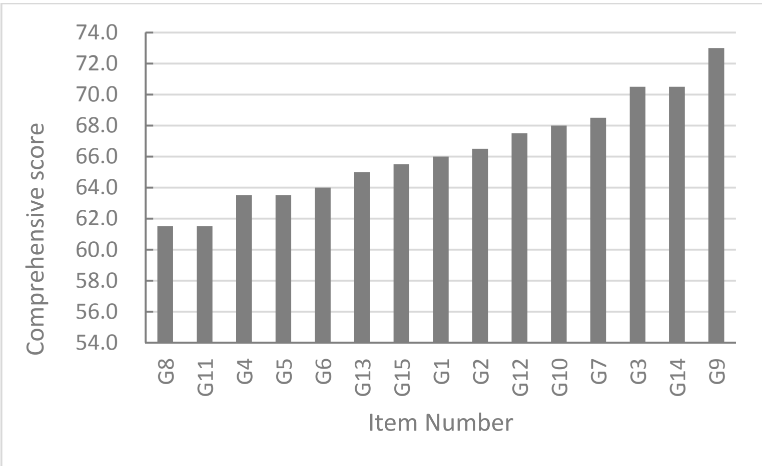

Figure 5. Comprehensive index of soil fertility at various points

3.4.2. Frequency distribution of soil fertility index of newly-increased cultivated land in the project area. The evaluation and analysis showed (Figure 5) that the soil fertility index of the newly-increased cultivated land in each project ranged from 61.5 to 73.0 points, with an average score of 66.3 points, among which the project area with a score of 65 to 71 accounted for about 60 % of the total and those with a score of more than 70 accounted for about 20 %. The nutrients of the newly-increased cultivated land soil samples are generally at the level of grade 5, and the fertility level is relatively low.

Table 5. Weight and contribution ratio of each index of soil nutrients

Index weight	SOC	TN	AP	AK
Theoretical weight/%	30	25	25	20
Actual weight/%	20	20	27	33
Relative weight/%	67	80	108	165

3.5. Suggestion on reasonable fertilization

Under the current weight ratio (Table 4), the contribution of each index of soil fertility to its comprehensive score from big to small is soil available potassium, soil total nitrogen, soil total nitrogen, and soil organic matter. It can be seen that soil organic matter and soil total nitrogen are important factors affecting the low nutrient content of newly increased cultivated land in the loess hilly region. Based on the barrel effect theory, increasing soil organic matter and total nitrogen is the most direct way to increase nutrients in newly-increased cultivated land. Therefore, the combination of organic fertilizer and urea will be the most effective way to improve the soil fertility of the newly-increased cultivated land in this region.

4. Conclusion

The results show that: the fertility level, the biggest limiting factors and the comprehensive fertility index of newly-increased cultivated land were discussed, and reasonable fertilization strategies were put forward.

1) The soil fertility content of newly-increased cultivated land in the loess hilly region is at a relatively low level after wasteland improvement. The average content of organic matter is 5.95 g / kg, the average content of total nitrogen is 0.52 g / kg, the average content of available phosphorus is 8.80 mg / kg, and the average content of available potassium is 183 mg / kg.

2) The soil fertility index of the newly-increased cultivated land in the study area ranged from 61.5 to 73.0 points, with an average score of 66.3 points. The project area with a score of 65 to 71 accounted for the majority, accounting for about 60 % of the total.

3) Soil organic matter and total nitrogen are the biggest control factors of the newly increased cultivated land fertility index after wasteland improvement in the loess hilly region. Increasing soil organic matter and total nitrogen is the most direct way to improve the comprehensive index of new cultivated land fertility.

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