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Feasibility Analysis of Soft Water Cellar in Dryland Area

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Abstract: During the construction of high standard farmland, by introducing new software rainwater harvesting cellar technology, combining big data and intelligence, laying drip irrigation belts and other field facilities in the field, efficient water-saving irrigation was realized according to local conditions, and the problem of supplementary irrigation in key growth periods of agricultural production was solved.

Keywords: Dry tableland area, Cultivated land quality, Water saving irrigation, Soft water cellar.

1. Introduction

The CPC Central Committee and the State Council attach great importance to the construction of high standard farmland. It is emphasized that we should focus on the protection of cultivated land and the improvement of land productivity, unswervingly improve the construction of high standard farmland, improve the construction standards and quality, and truly achieve the goal of ensuring the harvest and high and stable yield in case of drought or waterlogging. Premier Li Keqiang put forward clear requirements for developing grain production and strengthening the construction of high standard farmland. All localities and departments conscientiously implemented the decisions and arrangements of the CPC Central Committee and the State Council, continued to promote the construction of high standard farmland, and strongly supported the improvement of the production capacity of grain and important agricultural products.

At present, China's arable land is still facing problems such as low grade and declining grain production capacity. For this reason, the country proposes to vigorously carry out comprehensive land improvement, build high standard farmland with high yield guaranteed by drought and waterlogging, and improve the quality of arable land. But for a long time, the effect of land consolidation and the change of cultivated land quality grade are often ignored by scholars. From the perspective of cultivated land quality grade change, various projects of land remediation are undoubtedly the most important influencing factors. Therefore, it is necessary to systematically sort out and summarize the changes in cultivated land quality grade for current land remediation, and apply them to guide future land remediation projects. In September 2021, the State Council issued the National Plan for the Construction of High standard Farmland (2021-2030) (GH [2021] No. 86), which proposed to build 1 billion mu of high standard farmland by 2022, so as to ensure the grain production capacity of more than 1 trillion kg. By 2025, 1.075 billion mu of high standard farmland will be built, 105 million mu of high standard farmland will be upgraded, so as to ensure the grain production capacity of more than 1.1 trillion jin. By 2030, 1.2 billion mu of high standard farmland will be built, 280 million mu of high standard farmland will be upgraded, so as to ensure a stable grain production capacity of more than 1.2 trillion jin. From 2021 to 2030, 110 million mu of new efficient water-saving irrigation will be completed. Shaanxi Province requires to build 21.94 million mu accumulatively by 2025, upgrade 1.14 million mu accumulatively, and build 26.17 million mu accumulatively by 2030, upgrade 3.03 million mu accumulatively; Among them, 4.92 million mu (2.68 million mu from 2021-2025 and 2.24 million mu from 2026-2030) will be newly increased for efficient water-saving irrigation from 2021-2030.

Shaanxi Province has a complex landform, including wind and sand areas along the Great Wall, hilly and gully areas on the Loess Plateau, Guanzhong Basin and Daba Mountains. The annual rainfall of Weibei tableland area is about 550mm, and the annual difference of water resources distribution is large, mainly concentrated in July, August and September, and the evaporation is large. Winter, spring and summer droughts are easy to occur, which is the "drought belt" in Guanzhong. The construction of high standard farmland puts forward higher requirements for the improvement of grain production capacity and water-saving irrigation. It is required to locate the land with water, take efficient water-saving measures, and improve the utilization rate of water resources. Shaanxi Provincial Department of Agriculture and Rural Affairs has launched seven main models in the construction of high standard farmland, among which the Weibei dry tableland area is recommended to adopt the construction model of "water diversion and storage - buried underground pipes - supplementary irrigation". The rain fed agricultural area in Weibei dry plateau is an important grain production area in Shaanxi Province, second only to the irrigation area in Guanzhong Plain, with deep soil layer, sufficient sunlight, hot rain in the same season and concentrated cultivated land. However, due to drought and water shortage in most regions, basic irrigation facilities are lacking or incomplete, and the productive potential of solar thermal soil fertilizer resources cannot be fully realized. Therefore, it is urgent to solve the problem of supplementing water sources and improving irrigation facilities to ensure high and stable grain production in this region. The key points of high standard farmland construction are irrigation project and its supporting water diversion and storage project, agricultural power transmission and distribution and field water transmission pipeline construction. Therefore, it is very important to solve the key water demand of crops in Weibei tableland area under limited water resources, which is also the difficulty and blocking point for improving the quality of cultivated land.

It is very difficult to develop agricultural irrigation for the dry land in Weibei tableland area due to the restriction of its physical and geographical conditions. There are mainly outstanding problems such as lack of water sources, different sizes, poor flatness, etc. The cultivated land is generally lack of irrigation conditions, totally dependent on the weather, the grain output is low and unstable, and the planting structure is single. The growth of farmers' economic income is very slow, and farmers' self-development ability has been in a state of hesitation, most of them belong to poor or very poor areas. Therefore, vigorously developing rainwater harvesting and water-saving irrigation is a fundamental way to solve the problem of water shortage in poor mountain areas and change their backwardness.

A rainwater harvesting and water-saving irrigation project must have four conditions to bring its due benefits into play. That is to say, there is a certain amount of natural precipitation, a relatively efficient rainwater collection underlay, engineering measures to divert and store rainwater, and supporting field water-saving projects. The natural slopes, grasslands and existing roads in the tableland area can be used as a good rainwater catchment area, which has the basis for constructing a rainwater harvesting system, and the soft water cellar also has application prospects.

2. Main Research Methods

Based on the field survey of the study area, combined with the use of software water cellars in Shaanxi Province, the paper focuses on the field survey of rainwater storage and promotion in Weibei tableland area, and analyzes the advantages and disadvantages of software water cellars through technical summary. At the same time, in combination with the construction of high standard farmland, in the areas where surface water sources are scarce, by investigating the topography of the proposed project area and the surrounding water and soil conditions, we will carry out the demonstration design of rainwater storage and soft water cellar on specific typical plots with the construction unit at the design stage, and analyze the technical means of rainwater storage that can be adopted in the project.

Theoretical analysis and empirical research method: at the same time, in combination with the construction needs of the project, explore and formulate water-saving irrigation technology under limited water resources and limited costs, and improve the water resource utilization efficiency. For example, study the irrigation efficiency of soft water cellar and rainwater collection cellar, whether it can ensure the water storage of crops during the storage period, and explore how to improve the irrigation assurance rate under water resource constraints; Finally, the quality of cultivated land will be improved.

3. Calculation and Construction of Rainwater Storage System

3.1. Calculation of irrigation water volume

Water harvesting irrigation shall adopt water-saving irrigation method. On the premise of water-saving irrigation, agricultural irrigation water consumption shall be determined according to the principle of insufficient irrigation (quota irrigation), according to the local or similar regional crop water demand or irrigation system test data, and the rainfall during the growth period of the local crop. The annual irrigation water volume per mu of land can be estimated according to the following formula:

$$M_d=(0.5\sim0.8)\times(N-0.667P_e-W_e)/\eta$$

Including:

M_d—annual irrigation quota under insufficient irrigation conditions, m^3/mu;

N—annual water demand of crops or fruit trees, m^3/mu;

P_e—effective rainfall during crop growth period, mm, which can be obtained by multiplying the rainfall during crop growth period by the effective coefficient. The coefficient is 0.7~0.8 for summer crops and 0.8~0.9 for autumn crops;

W_e—the effective water storage in the soil before sowing, which can be determined according to the measured data. If there is no measured data, it can be roughly estimated according to (0.15~0.25) N;

η—The water utilization rate of irrigation field is 0.9 under water-saving irrigation conditions such as drip irrigation.

3.2. Annual rainfall

The annual rainfall amount per unit catchment area can be calculated according to the following formula:

$$F_p=E_y\cdot R_p/1000$$

In the formula, F_p -- annual collectible water volume per unit catchment area in the year when the guarantee rate is equal to P, m^3/m^2;

E_y—annual catchment area of a certain material, annual catchment efficiency, expressed in decimal

R_p—Annual rainfall with assurance rate equal to P, mm.

R_p can be taken from the contour map of the average annual rainfall in the region, or calculated according to the following formula:

$R_p=KP_p$

$P_p=KpP_o$

Including:

P_p—annual precipitation with assurance rate of P, mm;

P_o—mean annual precipitation, mm, determined according to meteorological data;

K_p—according to the assurance rate and Cv value, it is obtained from the chart of the corresponding region;

K—the ratio of annual rainfall to precipitation, which can be determined according to meteorological data.

See the Technical Specifications for Rainwater Collection and Utilization Engineering (GB/T 50596-2010) for the table of annual collection efficiency of different material collection surfaces under different precipitation and guarantee rate.

4. Site Selection Principles for Construction of Agricultural Soft Water Cellar Technology Project in Dryland Area

1) Places lacking irrigation conditions. There are large tracts of drought prone dry land or "thunder fields", which are far away from water sources and cannot build large water conservancy facilities such as reservoirs and water diversion channels.

2) Rural areas with a certain foundation for industrial construction. In recent years, the structure has been adjusted reasonably, and the development of efficient crops has a certain foundation and basically formed a scale, which is conducive to giving full play to the role of rainwater harvesting and water-saving irrigation projects.

3) The traffic in the project area is convenient. Organic farming road or production access road in the project area is conducive to material, machinery transportation and project construction.

4) The farmers are highly motivated and have a strong sense of science and technology. It is easy to accept rainwater harvesting and water-saving irrigation and advanced agricultural production technology, and can actively participate in the implementation of the project. At the same time, village cadres should have certain coordination and command ability, and can actively cooperate with the implementation of the project.

5) Insist on highlighting regional characteristics, and focus on a relatively continuous area. Relatively concentrated and continuous, it has a strong demonstration and promotion effect, and is also convenient for technical tracking services.

5. Application of Agricultural Rainwater Harvesting and Storage Engineering Technology in Arid Plateau Area

According to the purpose of utilization, rainwater collection and utilization can be divided into three types: water for human and animal life, water for agricultural production and water for ecological construction; According to the underlying surface of rainwater collection, rainwater collection and utilization can be divided into courtyard rainwater collection, road rainwater collection, slope rainwater collection and small watershed rainwater collection. In places where there is slope confluence or surface runoff during rainfall, the rainwater is diverted to the dry soil or the nearby water storage cellar for storage by building ditches to intercept the flow. Through the construction of cascade water storage pits, the annual precipitation of the whole hillside can be stored in multiple water storage pits at different altitudes for use when crops are dry. At the same time, the surface runoff is decomposed, preventing the formation and outbreak of mountain torrents, and greatly reducing the water and soil loss on the hillside. The water storage cellar site shall be constructed in the place with deep soil layer, slight slope and large rainwater collection area. The soil layer is deep, which is convenient for cellar excavation and will not give up halfway. It has a slight slope, which is easy to form surface runoff and facilitate the introduction of water storage pits. The area of rainwater collection is large, so I'm not worried that there will be no water source after the water cellar is built.

6. Benefit Analysis

6.1. Economic benefit analysis

Make full use of the characteristics of facility agriculture. The soft rainwater collection cellar is arranged in the open space between greenhouses. The shape and size can be customized according to the area of the open space and local conditions to meet the actual needs. The rainwater collection surface makes full use of the facility shed, does not occupy additional arable land resources, and improves the land utilization rate. Compared with the traditional brick and cement rainwater harvesting cellar, the new soft rainwater harvesting cellar does not need to harden the land. It is a movable device that can be laid when needed and recycled when not needed. It is less destructive to the cultivated land and can be restored after demolition. The material of the water cellar is a new green environmental protection material, which has no adverse impact on the environment. The traditional brick and cement rainwater collecting cellar has many building materials, long construction period and high cost, while the new soft rainwater collecting cellar is made as a whole, which can be installed in place at one time, reducing the cost by more than 50%. Moreover, the installation is simple and convenient, without frequent dredging and maintenance, and the input cost is reduced.

6.2. Analysis of ecological and social benefits

Instead of pumping groundwater, rainwater harvesting irrigation is used to realize the rain fed production of facility vegetables, which changes the water for facility agricultural production from relying entirely on pumping groundwater to relying basically on natural precipitation, fundamentally solving the water shortage dilemma of facility vegetable industry, maintaining the facility vegetable industry, and ensuring the supply of vegetables in urban areas. At the same time, because the quality of rainwater is more suitable for irrigation, the application of integrated technology of water and fertilizer has improved the utilization efficiency of irrigation water and fertilizer, improved the vegetable yield and quality, increased the average cost and income of the shed by more than 5000 yuan, increased farmers' income, and made farmers live and work in peace and contentment, which shows that the integrated technology of water and fertilizer in the soft water cellar with film rain collection facilities has certain social benefits.

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