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Influencing factors and determination of water use in field irrigation technology

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Abstract. Farmland irrigation is the most basic guarantee measure to ensure food security production, and also the basic technology to ensure food increase and income. There are many irrigation techniques in the field, and they are classified according to their irrigation forms or irrigation methods. While facing the challenges and opportunities in the new century, the food problem is the most basic and serious one, which is related to the survival of the whole country and nation. In order not to be supplied by other countries to grasp the lifeblood of our country, vigorously developing field irrigation technology is the inevitable way. On the basis of reading a large number of literatures, this paper briefly introduces the field irrigation technology mainly adopted in China at this stage, and analyses the problems faced by China's irrigation industry at this stage. To provide reference for better adjustment and development of China's field irrigation and the designation of a better management mechanism.

1. Introduction

China is a large agricultural country, and agricultural water consumption currently accounts for 56% of the total social water consumption. By the end of 2013, China's effective irrigation area reached 952 million mu (63.47 million hectares), and the effective utilization coefficient of agricultural irrigation water increased from 0.47 to 0.52 [1]. Although it has made great progress compared with previous decades, it is still far behind countries like Israel and the United States. Field irrigation and water saving technology is the only way to realize sustainable development of agriculture in China. The wue of field irrigation technology has great influence on agricultural production, which is related to the direction of agricultural development and future development policy in China. Water is the lifeblood of agriculture and the basic element for the development of agricultural production. Without water, there can be no agriculture [2]. In order to better and more clearly develop China's agricultural production, it is urgent to solve these influencing factors, reduce their influence degree as far as possible, and increase the utilization efficiency of water. To ensure the high quality, stable and rapid development of agriculture in China, so as to solve the problem of grain supply in China. However, at the present stage, there are still a series of problems in the development of agricultural irrigation technology and the promotion of water-saving technology in China [3].

2. Field irrigation technology

2.1. Border irrigation

Border irrigation is a widely used irrigation method, suitable for the ground with adequate water and good soil permeability. Because of the wide application of this method, the research on it is also very deep. Hang shaohui et al. [4] established an inversion model for the optimization of border irrigation soil infiltration parameters and field roughness coefficient based on the basic genetic algorithm SGA and the one-dimensional surface irrigation model SRFR, and realized the inversion process of the optimization of border irrigation soil infiltration parameters and field roughness coefficient. Bai meijian et al. [5] carried out field irrigation experiments on different types of beds and border irrigation flow patterns, and obtained a numerical model for the process and performance of border irrigation based on random simulation of micro-topography and two-dimensional irrigation model. Based on the formula for calculating the shape coefficient of bottom seepage proposed by FOK and Bishop, nie weibo et al. [6] established the simplified formula and empirical formula for calculating the shape coefficient of bottom seepage, introduced the shape coefficient of surface water storage, and constructed a simplified analytical model for border irrigation water advance based on the principle of water balance. Based on Kostiakov's infiltration model, xi yun et al. [7] constructed an estimation model of nitrogen infiltration with border irrigation under surface fertilizer application, and the model was used to estimate the nitrogen infiltration with water during border irrigation with high accuracy. Based on the principle of water balance and manning's formula, wang yaofei et al. [8] established a method to deduce the parameters of Kostiakov's infiltration formula and the roughness of the field surface by analysing the advance process of irrigation flow in the border field. Li bao et al. [9] established a simple and reliable WinSRFR4.1 optimization model for calculating average soil infiltration parameters and manning roughness values by analysing field measured data.

The influencing factors for border irrigation technology are: border field specifications, the width of border single entry and irrigation time. The main factors affecting these technical factors are soil permeability, border surface slope, roughness and flatness of border fields, and crop cultivation.

2.2. Furrow irrigation

Furrow irrigation is a good irrigation method which is widely used in surface irrigation in China. To implement ditch irrigation technology, first of all, the irrigation ditch should be dug between the rows of crops. After irrigation water enters into the irrigation ditch from the drainage ditch or the gully, in the flow process, it mainly penetrates into the surrounding moist soil from the ditch bottom and ditch wall by the action of soil capillaries. At the same time, there is gravity at the bottom of the trench infiltrating the soil. Based on the water balance method, Wang chengzhi et al. [10] used the indoor platform experiment to deduce and verify the water infiltration amount and water infiltration function Kostiakov or the modified Kostiakovde parameters in the ditch irrigation movement, and constructed the soil water infiltration parameters expressing the law of soil water infiltration by using the measured values in the water flow propulsion stage and the post-propulsion stage. Guan xiaoyan et al. [11] estimated soil infiltration parameters of ditch irrigation based on IPARM method. Zhu xia et al. carried out an experimental study on the influence of micro-topography and shape variability of groove section on the performance of ditch irrigation, showing that both of them have a significant impact on the uniformity and efficiency of irrigation. Wang shunsheng et al. studied the evaporation between summer maize plants under different furrow irrigation methods and obtained the soil water evaporation under different furrow irrigation methods. Li caixia et al. studied the differences of stomata on maize leaves under different irrigation methods, indicating that stomatal resistance on maize leaves has a great relationship with irrigation methods. Wang wenjuan et al. studied ridge planting and furrow irrigation of spring wheat in arid area, and obtained the influence of different ridge planting parameters on spring wheat.

2.3. Surge flow irrigation

Surge irrigation is the development of surface furrow and furrow irrigation, also known as surge irrigation or intermittent irrigation.

2.3.1. Surge irrigation method of field irrigation. There are two irrigation methods of surge irrigation in the field: variable flow method with time interval and variable period method with fixed flow. At present, timing interval variable flow method is mostly adopted, that is, in the whole process of irrigation, the discharge flow and discharge time of each irrigation cycle (one water supply time and one water cut-off time constitute an irrigation cycle) are fixed, and the length of water flow propulsion is not the same. This method is effective when the length of irrigation ditch (check) is less than 400m. The required automatic control device is relatively simple and easy to operate, and it is also easy to control in the irrigation process. When the length of irrigation ditch (furrow) is more than 400m, the effect of constant flow and variable period method is better. In this irrigation method, the newly added length of water flow in each irrigation cycle is the same as the discharge flow, but the discharge time is not equal. However, this irrigation method is not easy to control, labor intensity, irrigation equipment is relatively complex. For the case that the soil has strong water permeability, the incremental method can be adopted, that is, an inrush flow irrigation method that can achieve higher irrigation quality by adjusting and controlling irrigation flow.

2.3.2. Technical elements of surge irrigation. Flow rate: a better method to determine the appropriate flow rate of surge irrigation is to observe the operation of surge irrigation in the application. When the water flow is too slow and the irrigation efficiency is not high, the flow rate into the ditch (bed) can be increased by reducing the number of each group of furrows (beds) that supply water at the same time. If tail water is found, the method of reducing the flow is adopted. The upper limit of the flow should be so that irrigation ditch (check) head does not occur, not over the top. For furrow irrigation, the length should be no less than 80m, and the flow rate into the furrow should be 0.6-0.8l /s. For furrow irrigation, if the furrow length is less than 80m, the flow rate per unit width should be 2-3 l/s.

Water supply time: the method to determine the water supply time is based on the existing test data to determine, from the continuous ditch (check) irrigation time to estimate.

In the actual operation of surge irrigation, in order to ensure even irrigation and improve irrigation efficiency, the water supply time of each irrigation cycle can be adjusted appropriately according to the situation to achieve the best irrigation effect.

There are also ways of surge irrigation, flood irrigation and flood irrigation.

2.4. Subsurface drip irrigation

Subsurface drip irrigation may be the newest, most complex, and most efficient method of irrigation for crops, enabling optimal water efficiency and crop yield simultaneously. Subsurface drip irrigation is a kind of micro-technology, which means that water or a mixture of water and fertilizer flows slowly out into the surrounding soil through the irrigator on the buried capillary. With the help of capillary force or gravity, water diffuses to the active area of crop root system for the absorption and utilization of crops. In the process of irrigation, the soil structure disturbance is small and can be better Ensure that the soil transportation in the active area of crop roots is transparent, and the evaporation of irrigated water is reduced, which has an obvious effect of saving water and increasing production. Field water pipeline is buried in the ground, which is convenient for cultivation and planting of crops, and enhances the anti-aging performance of pipeline and is not easy to be damaged or lost. The biggest application problem of subsurface drip irrigation is the blockage of irrigator.

The main reasons for the clogging of the drip are as follows: 1. the existing drip runner is very thin with small flow, and solid particles in water are easy to be deposited and adsorbed on the runner [11]; 2. When the first irrigation is over, a certain negative pressure will be generated around the drip head, and the soil particles around the drip head will be pressed into the drip head, causing the flow passage to be blocked ;3. Due to the hydrotropism of the root system, part of the root system may enter the drip

head and block the flow passage .The main measure to solve the problem of solid particle blockage in irrigators is to strengthen filtration measures [11], and to develop special underground drip irrigation heads with strong anti-blockage .The main measure to solve the negative pressure problem of the emitter is to install a vacuum valve in the pipeline and wrap non-woven fabric around the drip head .The main solution to crop root invasion is to add herbicides to irrigation water .Due to the hydrotropism of crop roots, a large number of roots are concentrated around the irrigator, leading to the phenomenon of hypoxia. In order to solve this problem, a study on subsurface aerated drip irrigation has been carried out, and experimental studies have shown that this technology can improve crop quality and yield.

2.5. Notes for subsurface drip irrigation
One is the depth of field cultivation: to avoid damage caused by ploughing and turning over the soil. For no-tillage, it can be determined according to soil and root development depth. Second, the state of the soil: in light soil with strong water permeability, the buried depth of the capillary should not be too large to prevent deep seepage; for loamy soils with strong water absorption capacity, the burial depth can be appropriately increased and ineffective evaporation loss can be reduced. If the surface layer contains clay interlayer with poor water permeability, the capillary should be buried above the interlayer. In addition, because of the growth and development of the crop root system, if the buried depth of the capillary is too large, it is not conducive to the growth of the crop seedlings, but if the buried depth is too small, it will affect the later growth of the crop demand for water. Synthesizing the above factors, the best capillary depth is generally between 20 cm ~ 70 cm, the best capillary depth of fruit trees is generally 40 cm ~ 50 cm, field crops are 30 cm ~ 40 cm. The third is the capillary spacing: mainly depends on the local climatic conditions, soil texture and crop species, usually in the range of 0. 25 meters to 5 meters. Between 0 meters. For crops grown on sandy soils or in arid regions, smaller capillary spacing helps to distribute soil moisture evenly in the field, but too small spacing increases investment. Larger spacing may be used in wet areas where there is a lot of rain, but this depends on the type of crop, soil conditions and acceptable levels of risk. Generally, the smaller spacing is mostly used for planar and dense planting crops, such as turf, wheat, etc., while the larger spacing is often used for vegetable, fruit tree, cotton, corn and other row sowing crops. For large plants equidistant crops, the capillary was embedded in the middle of two rows of crops or trailing arrangement; for crops grown in narrow rows, the capillary should be placed between narrow rows. It is suitable for the fruit trees with irregular arrangement of plants to adopt the accompanying arrangement. Fourth, irrigation time: generally based on the measured or calculated evaporation, soil characteristics and crop characteristics. If the irrigation time is determined according to the water consumption rate of crops, the method of multiple irrigation with small quota should be adopted. If irrigation is to be carried out only when soil moisture has dropped below a certain threshold, it may take several days. For vegetables and other crops with high water content, the former irrigation frequency is often used, while the latter method should be adopted for fruit trees and field crops.

There are also many new irrigation methods, such as micro-sprinkling irrigation, membrane irrigation, seepage irrigation, etc. In recent years, a trace irrigation, negative pressure irrigation, low pressure irrigation and other irrigation methods have been proposed.

3. Conclusion
Although the water-saving irrigation technology in our country has made great progress at the present stage, we still need to strengthen scientific research and cultivate corresponding scientific research talents. At the same time, it needs the correct guidance of the state and the government and the supervision of relevant departments to strengthen the management of water-saving irrigation projects and check the field work status of projects in real time and irregularly. So that China's water-saving irrigation technology can better, healthy and stable development.

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