Asian Agricultural Research 2014, 6(8): 89 -92

# Analysis on the Water-saving Irrigation Technique Based on the Perspective of Food Safety

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**Abstract** The paper analyzed the important role of water saving in protecting the food safety, introduced the present development of agricultural water-saving technique, pointed out the potential risks of water resources, and proposed the future development of water-saving irrigation.

**Key words** Food safety, Agricultural water-saving, Water resources, Development

Food safety and agricultural water-saving irrigation are the two focuses of present international research. As the developing country with the largest population, China supports about 22% of global population with only 7% lands and 8% fresh water. However, with the constant increase of population, a series of problems, such as drought, ecological damage, pollution, shortage of water and farmland resources, are expanding and aggravating. The food resources and food safety in China are facing great pressure and challenge, and have drawn attention from both the Chinese Government and the UN. The food safety in China concerns directly that of whole world, and water plays a very important role in food safety. The agriculture in China consumes over 70% of total water use in the whole nation. The traditional flood irrigation results in a serious waste of water, and the water use rate in China is only 30% -40%, while this figure has reached 60% -70% in some developing countries. The food production was only 0.85 kg for per cubic meter water, far below the 2 kg in the developing countries. The present way to use water resources has greatly affected the development of agricultural production[1]. Therefore, it is necessary to promote the high-efficient water-saving irrigation technique, for it is of great practical significance to improving the grain production and stablizing the grain production capacity.

## 1 The urgent demand for water saving

With the increasing global population, to guarantee the food safety has become a top priority. It is estimated that the global population will reach over eight billion in 2030, and the grain demand will reach three billion ton. Moreover, the water use for agricultural irrigation will also reach 3 800 $km^3$. The shortage of water resources has become the main factor influencing the grain production and safety[2]. The present water use for agriculture in China is 400 billion$m^3$, 70% of which is used for grain production. It is estimated that the about 70% of grain production in China is supported by the irrigation water. However, since the water resources are very limited, the key to solve the conflict between the increase of agricultural water use and the food safety lies in the development of water-saving technique.

In some countries where the agriculture is developed at a high level and the water resources are in extreme shortage, the water-saving technique has become a major research focus. For example, in Israel where the per capita water resources is only 370$m^3$ (about 1/6 that in China), it is its advanced drip and spray irrigation system and other water-saving techniques that increases its water use efficiency from the 1.6 kg/$m^3$ in 1949 to 2.32 kg/$m^3$ in early 1990s, and raises the foreign currency created by per unit water use from 0.04 \$/$m^3$ to 0.42 \$/$m^3$[3]. Another example is that some farms in America adopt the GPS to guide the farming[4]. In Germany, the related agricultural departments also started the high-efficient water use plan to improve the water use rate of agricultural products. FAO has also initiated relevant programs. From the above examples, it can be easily seen that the study on the high-efficient water use is of great scientific significance to both the global food safety and water use.

## 2 Present development of the agricultural water-saving technique

The agricultural water-saving technique is more than a water-saving technique. It means to adopt various water-saving measures during the whole growing process of crops so as to save as much water as possible, improve the water use efficiency and create a good growing conditions for the crops. In addition to the studies on traditional farmland water-saving technique, the present studies focus more on the water saving of a single plant, as well as the distribution of water resources at a macro scale. The water-saving cultivation techniques mainly include the following aspects:

**2.1 Biological water-saving technique** Biological water saving means to realize the largest agricultural output with the least water use by exploiting the biological and genetic potentials of organism[5]. For example, rice is one of the major crops in China which is in high demand for water. Professor Luo Lijun from Shanghai Agrobiological Gene Center carried out a series of studies on the genetic selection and variety breeding of rice, and introduced some high-efficient and water-saving rice varieties. With the advantages of low input and high water-saving efficiency, the

Received: April 28, 2014 Accepted: July 21, 2014
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water-saving and drought-resistant rice is a good news for the drought areas[6]. The varieties selected by the biological technique can improve the transformation of biological growth to economic yield. The genetic regulation can improve the water use efficiency of the crops during the whole growing process and achieve the most yield with the least water[20].

**2.2 Agronomic water-saving technique**

**2.2.1** Dryland mulching (plastics or straw) technique. Dryland mulching technique was firstly studied and promoted in Japan in the 1960s[7], and gets rapid development in both North and South China. It currently includes three types, including plastic mulching, straw mulching and recycled paper mulching. The dryland mulching technique is based on the fact that the mulch can hold the water, retain the heat, and fertilize the soil, thus promoting the growth of rice, narrowing tis growth period to three to five days, and also saving 46% to 68% irrigation water. Moreover, the mulching can also reduce the concentration of cell fluid of crop leaves, decrease its cell membrane permeability, increase its absorption of $CO_2$, and activate various enzymes involved in the whole carbon cycle. The mulching can also help increase the photosynthesis rate, accelerate the accumulation of dry matter, and promote the growth and yield of the whole plant[8-10].

**2.2.2** Dryland direct sowing technique. The dryland direct sowing technique of rice generally includes two different patterns: the first is dry tube cultivation, and the second is water tube cultivation. The former one is to sow the rice in dryland, and then start to irrigate water when the rice grows to four to six leaves. The water tube irrigation should select those varieties with large ears, seed setting rate, and grain filling rate due to a lack of water during the initial period, as well as less and late tillering[11]. At present, the yield of water tube cultivation has exceeded or been close to that of the transplanted rice, and with the constant increasing of breeding and cultivation technique, as well as the development of high-quality cultivars and weeding technology, the water tube cultivation has become a major pattern of rice planting[12]. Since the rice cultivated by dry tube is only irrigated when it is extremely dry, it only consumes about 3 000 – 4 500 $m^3/hm^2$ during the whole growth period. The dry tube cultivation is only applicable to those areas which are vulnerable to waterlogging and has certain irrigation conditions or whose rainfall is above 600 mm. There are now about 1.77 million $hm^2$ area of dryland rice, mainly distributing in the mountainous areas in Yunnan and Guizhou Province as well as the less-rain areas in Henan and Hebei; It is estimated that to produce every 1 kg rice in the paddy field would consume 1 – 2t water, five times that in the dryland. To promote the dryland rice would greatly alleviate the shortage of water resources[13].

**2.2.3** Conservation tillage technique. Conservation tillage technique, which is developed in the 20th century, mainly include crop rotation, intercropping, mulch tillage, and minimal tillage which aims to change the physical traits of soil, no tillage. It has been proven by years of experiments that the conservation tillage can significantly retain the water and soil and is of great importance to the sustainable development of the dryland farming. The conservation tillage is to increase the surface roughness, improve the soil structure, soil fertility and water-holding capacity, enlarge the surface vegetation coverage, reduce water evaporation, and prevent runoff. According to the research findings of Tebrugge[14], the water content in the 0 – 15cm soil layer during the whole growth season of the crops is 29.5% for no tillage, and 24.4% for conventional tillage. Their difference results from the fact that the mulching could greatly decrease the water evaporation in the soil.

**2.3 Engineering water-saving** Engineering water-saving means to reduce the loss of water during the whole process of water absorption and utilization by crops to the minimum by adopting various technical measures and methods. It will reduce the water evaporation and loss during the water transport by pumps[15]. The engineering water-saving irrigation should be the results of multiple measures, including the following aspects:

**2.3.1** The seepage control of canal. Owing to its advantages of easy operations and low costs, the seepage control of canal is widely applied in China. However, it still have some disadvantages, such as the great loss and evaporation of water along the canal, the low water use efficiency, the vulnerability to cold weather, and the costly and labor-consuming maintenance of canal. Therefore, it is necessary to promote a new-type water-proof material and canal.

**2.3.2** Spray and drip irrigation. Spray and drip irrigation has the advantages of strong adaptation to terrain, even irrigation, less occupation of farmlands, and labor saving. While it calls for high spending, therefore, to promote it in rural areas needs to reduce the costs and search for the political support. It mostly include the following patterns: fixed pump spray irrigation, half-moving pump spray irrigation, clock-hand spray irrigation, *etc.*[16].

**2.3.3** Seep irrigation. It aims to change the flood irrigation into fine irrigation[17]. It mainly includes low-pressure and gravitational seep irrigation.

**2.3.4** Low-pressure pumping irrigation. Replacing the traditional canal irrigation with the plastic or concrete pump, the low-pressure pumping irrigation has the advantages of high water-transport efficiency, less occupation of lands, reduced loss of water evaporation during transport, and improved use rate of water[18]. The pumping irrigation has been widely adopted in both America and Japan. The low-pressure pumping irrigation saves about 40% water than the cannal irrigation.

**2.3.5** Micro-irrigation. Through the piping system and the emitter installed at the end of thepipe, the micro-irrigation would fill the water directly to the root of crops according to their practical water demand[19]. Compared with the flood irrigation, the micro-irrigation could save 50% – 60% water , increase 20% – 30% yield.

**2.4 Water-saving irrigation management** The management of water-saving irrigation, include organizational management, engineering management and water-use management, *etc.* It enhance the supervision of water rights, water policy, water price, and so on. The management of agricultural water irrigation should follow the principles of total amount control and quota management. In order to achieve this purpose, the water use quota in each district should be made clear and monitored[20]. Moreover, to establish and improve a completed water right system, and construct a total amount control system. The market mechanism could also be introduced, to charge more with the overuse of water and practice the compensated transfer of water right. Ningxia has made exploration on the transfer of water right, which has achieved good results in reducing the input of water-saving, and promoting the agricultural yield.

## 3 The hidden risks of water resources

**3.1 The existing irrigation pattern is still inefficient** At present, the irrigation water is mostly distributed according to the permanent irrigation system. Consequently, the different water demands of crops, as well as the spatial distribution of water resources in different regions has seriously constrained the improvement of irrigation efficiency[21]. Therefore, to discuss the high-efficient distribution of irrigation water, and realize the in-time distribution will be a major task facing the present and future agricultural irrigation.

**3.2 The irrigation water is severely polluted** According to the statistics, the Type V water of seven large rivers in China, including Yangtze River, Yellow River, Huai River, accounts for 28.4%. The water pollution has already shown a tendency to expand from the main stream to the branch river, from urban to rural areas, from the surface water to the underground water, from inland water to coastal water[22]. What's even worse, the polluted water is one of the sources of farmland pollution in China, which will produce serious negative impact on the soil environment and threaten the food safety in China.

**3.3 Global warming leads to hydrological variation** The global warming has accelerated the hydrological cycle, increased the average rainfall, thereby resulting in the frequent occurrence of flood, drought and other disasters. The increase of rainfall would directly affect the snow accumulation and river flow, while the temperature increase advances the period of ice melting. If we can't get fully prepared for hydrological variation, the climatic change would be more likely to cause disastrous effects to the agricultural production. For example, in some African areas where the average rainfall is very limited, a 10% reduction of the rainfall would result in a half decrease of river runoff, while on the contrary, the increase of rainfall may cause flood[23]. Global warming increases the temperature while decreases the rainfall in the semiarid areas, which would directly decrease the crop yield in local areas[24].

## 4 Conclusion and suggestion

All in all, the development of water-saving irrigation technique in China should be based on the practical conditions of each area. To improve the ground irrigation technique, promote the spray and micro-irrigation technique, and develop automatic and modern water-saving irrigation system, so as to promote the transformation of traditional agriculture to modern high-efficient agriculture[25]. Meanwhile, the wastewater from factory should be treated before it is used for irrigation. In addition, Since the increasing demand for irrigation water is mainly from some non-food crops, it is necessary to pay more attention to the water-saving irrigation of those crop[26]. Therefore, water saving, water preservation and wastewater treatment should be combined together to promote the related scientific research and cope with the shortage of water resources. The practical ways to save water can be referred to the following aspects.

**4.1 To develop and utilize various sources of water** Since the water resources available in China are very limited, it is necessary to exploit a new source of irrigation water, such as the rainwater which can be collected for use. Thus, we need to design a rainwater collection facility to increase the runoff efficiency and recharge the groundwater with rainwater in both urban and suburban areas[27].

**4.2 To deepen the study of key water-saving technique** Based on the different characteristics of water resources in different regions, the problems, including the diversified standards of water-saving technique, single water-saving mode and lack of technical support, should be studied and solved[28]. With the support of modern agricultural system, we should encourage the international cooperation and learn from the successful water-saving irrigation experiences from US, Japan and Israel[29]. The improvement of the water-saving technique should aim to improve the comprehensive production ability of grains, improve the farmers' income and rural ecological environment. The construction of water-saving facilities should take into account the agriculture in mountainous areas, facility agriculture and special planting.

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Thus, rural teachers should strive to make teaching and learning activities close to the life, so that these activities can fully reflect the daily life of rural students. Only when what they have learned is applied to their familiar life can their interest in learning English be cultivated.

For example, when illustrating something or performing situational teaching, the teachers can make it related to the rural life and the students are always more interested in what they are familiar with, thus the classroom atmosphere can be enlivened. In addition, the selection and compilation of the rural English textbooks should be distinguished from that of the urban English textbooks, and when conditions permit, it is necessary to appropriately supplement it with local materials.

**4.3 Converting the philosophy of education** Education authorities have to effectively change the philosophy of education, and provide opportunities for teachers to implement teaching reform. Education authorities should also urge school to increase more individual ability factors involved in the teaching assessment mechanism so that the teaching is no longer simply assessed by the scores.

In addition, the evaluation system for current rural English teaching is often limited to the teachers' evaluation of students, and it is mostly written exam.

Under the new situation, it is necessary to advocate diversified assessment system, and focus on the combination of formative assessment and summative assessment. For the rural English teaching, there is a need to establish the assessment system in line with reality, including the assessment object, assessment methods, assessment mode, etc.

When conditions permit, the schools can create a file for each student's development, to record the students' usual performance in the schools.

**4.4 Increasing teacher training** Government should increase support for rural teacher training, and offer effective training based on the rural teachers' weaknesses in voice and intonation, not just theoretical learning. Education authorities should formulate strict training system to systematically and purposefully instill new teaching concept into rural English teachers, in order to improve the professional level of rural English teachers.

**4.5 Establishing the new linkage system** Currently as the rural labor forces choose to work outside the home, a large number of students become left-behind children in rural areas, and it lacks stable environment and security for the English learning. This requires schools to establish a new linkage system, and adopt the ways of scenario simulation and fun teaching to enliven the atmosphere for English learning from the inside to the outside of the school.

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