THE RESEARCHES AND APPLICATION OF BRACKISH WATER FOR IRRIGATION IN CHINA

RECHERCHES ET APPLICATION DE L'EAU SAUMATRE EN IRRIGATION EN CHINE

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ABSTRACT

The agricultural production in China is heavily dependent on irrigation. However, the shortage of water resources is gradually proving to be more inadequate due to rapidly increasing demand and uneven distribution of rainfall in both time and space. The utilization of brackish water for irrigation is one measure to cope with the problem of water shortage in China. Accordingly many research and pilot projects have been carried out to utilize brackish water for irrigation. This paper summarized the experiences and lessons drawn from the researches and practices with brackish water irrigation. The paper also discusses the need for using brackish water in sustainable manners and the works to be focused in future.

Key words: *Brackish water, agricultural irrigation, irrigation methods, key technologies.*

RESUME

La production agricole en Chine dépend surtout de l'eau d'irrigation. Cependant, la disponibilité limitée des ressources en eau s'avère insuffisante en raison d'une demande forte et la répartition inégale des précipitations dans le temps et dans l'espace. L'utilisation des eaux saumâtres en irrigation est une mesure nécessaire pour faire face au problème de la pénurie d'eau en Chine. En conséquence, nombreux projets de recherche et projets pilotes sont en cours pour utiliser les eaux saumâtres en irrigation. Ce document donne en bref les expériences et les leçons acquises des recherches et des pratiques d'irrigation en utilisant les eaux saumâtres. Le document examine également la nécessité d'utiliser l'eau saumâtre dans la manière durable et de mettre l'accent sur les travaux y relatif.

Mots clés : *Eau saumâtre, 'irrigation agricole, méthodes d'irrigation, technologies clés.*

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1. INTRODUCTION

China is a big country with irrigated agricultural. Irrigation water accounts for about 62% of the total water supply. However, with the rapid social and economic development, water demand has been increasing continuously. The increasing water demand and shortage of fresh water resources make the use of brackish water for irrigation as one measure to solve the problem. In China many research projects have been carried out to utilize brackish water for irrigation, such as the pilot projects in Ningxia, Gansu, Inner Mongolia, Shaanxi, Henan, Hebei, Shandong, Xinjiang, and Liaoning Province (Zhang Qihai and Zhou Yuxiang. 1998, Ministry of Agriculture, 2000 and Wang Quanjiu et al. 2002). The results of these experiments and pilots showed that brackish water can be used for agricultural irrigation with reasonable technical and management measures (Yu Baolong et al. 1999, Zhao Qing et al. 1998 and Wang Mingzhi, 2000).

Generally, brackish water refers to water with mineralization between 2 and 5g/L. Brackish water resources are widely distributed in China, especially in drought-prone north, northwest and coastal areas (Ministry of Agriculture. 2000). According to survey, the annual brackish groundwater resources is about 20 billion m^3 in China, out of which 13.0 billion m^3 is exploitable water resources. Most of the brackish water resources are located between 10 to 100m below surface and are easy for exploitation (Liu Youzhao, Fu Guanghui. 2004). The distribution area of brackish groundwater in North China Plain covers 43% to 48% of the whole area. Brackish water in the entire North China Plain is about 7.5 billion m^3. Underground brackish water resources were 8.86 billion m^3 in Northwest Region of China, including Xinjiang, Gansu, Ningxia, Shaanxi, Qinghai, and part of Inner Mongolia (Wang Weiguang, et al. 2003).

Brackish water can be used for irrigation under proper technical and management conditions. However, it also runs the risk of soil salinization and crop yield reduction. To utilize brackish water safely and effectively has become an effective way to solve water shortage problem in the areas with rich brackish water resources.

1. Methods in using brackish water for irrigation

There are three methods in using brackish water for irrigation, i.e. direct irrigation with brackish water, rotated interval irrigation with fresh water and brackish water, and irrigation with mixed brackish water and fresh water.

1.1 Direct irrigation with brackish water

Brackish water can be directly used for irrigation if there is no fresh water or fresh water resources are very scarce (Cao Caiyun, et al. 2007). However, it is important to ensure that the soil salinity and solution concentration should not exceed the limit of crops salt tolerance after irrigation. Brackish water should not be used to irrigate crops at seedling stage in order to avoid the hazards to crop growth. Generally speaking, the good results can be achieved by using brackish water to irrigate wheat, cotton, corn and other crops timely and properly in the growing seasons (Wang Hongbin. 1998).

The attention should be paid to the following aspects (Ren Rong. 1999). with direct brackish water irrigation:

- Drainage systems should be properly constructed in farmland in order to regulate groundwater tables below critical dynamics and prevent salinization;
- Irrigation with brackish water only applied one or two times at the crop critical water demand period;
- The accumulated salt should be leached out by making full use of the rainfall in flood season and the irrigation water in fall and winter irrigation;
- The application of organic fertilizers should be increased so as to promote the improvement of soil properties; and
- The leakage should be reduced by adopting proper management measures such as land leveling, border check irrigation or other advanced irrigation methods.

1.2 Rotated interval irrigation with brackish and fresh water

The method of rotated interval irrigation with brackish and fresh water is using brackish water to irrigate salt-tolerant crops or crops at the salt-tolerant growth stages, and using fresh water to irrigate salt sensitive crops or crops at salt sensitive growth stages. The application time and volume of the brackish and fresh water changed with mineralization of water, crop patterns and water supply conditions (Guo Yongchen, et al. 1992). For example, using brackish water to irrigate crops in dry season and using fresh water to irrigate crops when surface water is plenty after rainfall; to irrigate salt-tolerant crops (such as cotton and sunflower) with brackish water and to irrigate salt sensitive crops (such as wheat, corn, soybean) with fresh water under rotation or intercropping condition; to irrigate with fresh water before sowing and in seedling stage and to irrigate with brackish water in middle and late growth stages of crops (Cao Caiyun, et al. 2007). Chen Xiuling et.al. (1990) used fresh water (less than 1g/L) to irrigate wheat in seedling stage and saline water (5~6g/L) in stem elongation stage at Nanpi Pilot Area in CangZhou, Hebei Province. The wheat yield could reach up to 4545kg/ha, which was only 2.2% lower than the yield of wheat irrigated with fresh water during the whole growth period (Chen Xiuling, et al. 1990).

For the rotational irrigation regions, the irrigation times with brackish water should be reduced with the increase of the salt concentration in brackish water. For the areas always irrigated with brackish water, irrigation quota should be increased in order to reduce the salt concentration in soil solution and leach salt, especially the irrigation duty should be increased (Zhang Yongbo and Wang Xiulan. 1997).

1.3 Irrigation with mixed saline and fresh water

The method of irrigation with mixed saline and fresh water is that saline water and fresh water are mixed for irrigation to mitigate the hazards induced by direct irrigation with saline water. The mechanism of irrigation with mixed saline and fresh water is that salinity and alkalinity can be diluted and decreased, and the reaction of ions after mixing can reduce the RSC in mixed irrigation water (Sun Binghua and Liu Lanfang, 2010). Irrigation with mixed water can not only improve the irrigation water quality, but also increase the amount of irrigation water.

Irrigation with mixed water could generate significant economic and social benefits (Xu Jingqiao and Qiu Qianrui, 2007). It can not only reduce the exploitation of deep fresh water and make full use of shallow brackish and saline water, but also reduce the production costs, solve water shortage problem and promote the sustainable utilization of water resources. Guo Yongchen et. al. (1992) mixed deep alkaline fresh water with shallow saline water for irrigation in Nanpi Pilot Area in Hebei Province. The average yield of winter wheat and summer maize was 8355kg/ha, which was 162.7% higher than non-irrigated farmland and 20% higher than the yield of the farmland irrigated with saline water (4~6g/L) during the whole growing period (Guo Yongchen, et al, 1992).

2. THE KEY POINTS FOR IRRIGATION WITH BRACKISH WATER

Irrigation with brackish water not only increases the soil moisture but also increase the soil salinity. Therefore, the relationship between meeting crop water demand and controlling salinity must be balanced (Zhao Qing, et al. 1998) in order to keep the salinity in root zone of soil below the threshold level of crops tolerance. Otherwise the normal crop growth could be affected, and consequently result in yield reduction and soil degradation with increased salinity in soil (G.J. Hoffman et al, 1990). The key factors for irrigation with brackish water include: the soil salinity should not exceed the threshold of crop salt tolerance, and the salt accumulated in soil due to irrigation with brackish water should be leached out by rainfall or irrigation with fresh water in order to maintain annual or perennial salt balance in soil (Chen Xiuling. 1995). Therefore, the following key points should be highlighted with brackish water irrigation (Chen Xiuling, et al. 1990) :

- The mineralization degree of brackish water should not exceed 5g/L with PH value from 7 to 8 (Chen Xiuling. 1995).
- The groundwater tables should be controlled below the critical depth. The salt accumulation in soil caused by irrigation with brackish water should be leached by rainfall or irrigation with fresh water so as to keep dynamic balance of soil salinity.
- Irrigation with brackish water only applied when crops need irrigation and irrigation times should be minimized.
- Comprehensive measures should be adopted, such as land leveling, application of mulching film, rainfall collection and storage, time tillage after irrigation, etc.
- Salt tolerant crops should be selected. Green manure grass plantation or fellow should be properly arranged after crop plantation.
- The application of organic manure should be increased by returning crop residues back to land (Li Zhijie, et al. 2001).

3. DISCUSSION AND RECOMMENDATIONS

Developing and utilizing brackish water for irrigation can alleviate the problem of water shortage in some extent. It can also lead to high concentration of soluble salt in soil. When insufficient irrigation with brackish water applied, both water stress and salt stress could exist[23]. Improper utilization of brackish water for irrigation may not only lead to soil salinity

or alkalinity, waterlogging and soil degradation, but also induce groundwater degradation. [24]. By contrary if the proper technology and measure are taken irrigation with brackish water can improve groundwater quality. For large-scale exploitation of brackish water for irrigation, land subsidence and seawater intrusion in coastal areas might be induced. To maintain the sustainable application of brackish water for irrigation, the following researches should be carried out:

- integrated technology researches on using brackish and saline water for irrigation by considering regional characteristics to achieve sustainability;
- water and salt balance under large-scale brackish water irrigation and management strategies for using brackish and saline water for irrigation in large area; and
- Development and cultivation of salt-tolerant crops.

4. CONCLUSIONS

In China water shortage is getting more and more serious with the increase of water demand due to the rapid social and economic development. North China and Northwest China are rich with brackish water. Therefore, the utilization of brackish water for irrigation is one measure to cope with the water shortage problem. China has successfully piloted and practiced irrigation with brackish water by using three methods, i.e. direct irrigation with brackish water, rotated interval irrigation with brackish and fresh water, and irrigation with mixed brackish and fresh water. Under appropriate conditions, irrigation with brackish water in proper practices can not only increase water supply and crop yield, but also improve groundwater quality. However, the large-scale exploitation and application of brackish water for irrigation might induce soil secondary salinization, crop yield reduction, land subsidence and seawater intrusion in coastal areas. Therefore, it is necessary to carry out further researches on technologies and measures to provide technical support for the sustainable utilization of brackish water for irrigation.

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