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Improving agricultural water use efficiency in arid and semiarid areas of China

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Abstract

Water shortage in China, particularly in the north and northwest of China, is very serious. The region accounts for half of the total area of China, but has less than 20% of total national available water resources. While the water shortage in this region is severe, irrigation water use efficiency is only about 40%, with a typical agricultural water use efficiency of about 0.46 kg m^{-3}. Excessive irrigation in Ningxia and Inner Mongolia has had a significant influence on downstream water users along the Yellow River. It is widely believed that an increase in the agricultural water use efficiency is the key to mitigating water shortage and reducing environmental problems. This paper reviews water-saving agricultural systems and approaches to improve agricultural water use efficiency in the arid and semiarid areas of China. The paper will cover biological mechanisms of water-saving agriculture and water-saving irrigation technologies, including low pressure irrigation, furrow irrigation, plastic mulches, drip irrigation under plastic, rainfall harvesting and terracing. In addition, the paper addresses the compensatory effect of limited irrigation and fertilizer supplementation on water use efficiency and highlights the need to breed new varieties for high water use efficiency. Considerable

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potential for further improvement in agricultural water use efficiency in the region depends on effective conservation of moisture and efficient use of the limited water.

Keywords: Water-saving; Plastic mulch; Terracing; Limited irrigation; North and northwest China

1. Introduction

China is a country of both water scarcity and abundance because of the imbalance in the distribution and timing of precipitation. The total annual water resources available in China are 2800 billion m^3. With a population of 1.3 billion, the available water per capita is less than 2200 m^3, one quarter the world average (Shan et al., 2000). Over 80% of the water resources are concentrated in the southeastern part of China where the arable area is only 35% of the country's total arable area of 95 million ha. In contrast, the water resources in the northern parts of the country account for less than 20% of the total, whereas arable land accounts for 65% of the total.

Of the total arable area, 50 million ha, or about 50% of the total, is irrigated, mainly in the southeast where the water resources are more abundant (Wu, 2001). As 80% of the food is produced on irrigated farmland, irrigation water plays an important role in feeding the large population (Zhang et al., 1999; Yang et al., 2003). Dryland agriculture (crops and pastures) accounts for more than 70% of total farmland in northern and north-western China, including the vast rain-fed areas to the north of the Qinling Mountains and Huaihe River. Twenty-five million hectares are located in the Loess Plateau, while the North China Plain has 16 million hectares of arable land and produces about 20% of the nation's food.

With its large population, China cannot maintain food security without irrigation. In northern and northwestern China where natural rainfall cannot match crop water requirements, supplementary irrigation is used to increase yields and provide the food needs of the nation. However, excessive-use of diverted river flows and groundwater has caused severe environmental problems. For example, since 1972 the Yellow River in northern China (low reaches of the Yellow River) has dried up in the winter months for several years to the extent that water did not reach the sea and in an extreme drought year failed to reach the sea for 7.5 months (MWR, 2000). In the North China Plain where groundwater is the primary source of water for irrigation, the groundwater level has declined rapidly from about 10 m below the ground in the 1970s to about 30 m in 2001 (Zhang et al., 2003). Moreover, inefficient use of water is a notorious phenomenon in irrigation systems. It is estimated that in the North China Plain about half of the water is lost to leakage during transfer to farmers' fields (Liu and He, 1996). Of the water reaching the field, losses of water are also substantial. Flood irrigation is predominant and more efficient irrigation systems such as sprinklers and drip irrigation is rarely used.

China's population will increase by 12 million people annually over next half century. To support this growing population, food production has to be based on improving water use efficiency and further expansion of irrigation. Given the severe shortage of water resources in North China, the expansion of irrigated land is expected to be limited. Therefore, increasing water use efficiency in both irrigated agriculture and promoting