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The wheat yields and water-use efficiency in the Loess Plateau: straw mulch and irrigation effects

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Abstract

The yield of spring wheat (*Triticum aestivum* L.), one of the major crops planted in the Loess Plateau, China, is mainly affected by available water. Straw mulch and irrigation are efficient ways of influencing wheat yield and water-use efficiency. To develop better semiarid crop and water management practices, a 13-year experiment in spring wheat monoculture was conducted at the Dingxi Soil and Water Conservation Institute of the Loess Plateau. The influence of rainfall during the growing season (March–July) on yields of rain-fed wheat was studied for 13 years (1982–1992 and 1997–1998). The influence of straw mulch and irrigation on wheat yield, and water-use efficiency, was studied for 2 years (1997–1998). We found that growing season rainfall had a significant ($P < 0.05$) influence on biomass and grain yield of spring wheat in rain-fed conditions during the 13 years. Both biomass and grain yield were very low and varied significantly due to the low and significant variability of growing season rainfall. Straw mulch increased wheat yields significantly during both dry (1997) and wet (1998) years. It increased biomass and grain yield by 37 and 52%, respectively, in 1997, and by 20 and 26%, respectively, in 1998. Straw mulch also significantly decreased evapotranspiration ($P < 0.05$), soil water depletion ($P < 0.01$), and increased water-use efficiency ($P < 0.001$). Biomass and grain yield both increased ($P < 0.01$ or$P < 0.001$) with increasing irrigation in 1997 and 1998. The three irrigation levels increased the biomass yield from 34 to 66% in 1997, and from 34 to 77% in 1998. The irrigation levels also increased grain yield from 53 to 102% in 1997, and from 22 to 57% in 1998. Water-use efficiency for biomass and grain yield also increased with increasing irrigation. On the other hand, irrigation water-use efficiency for biomass and grain yield decreased with increasing irrigation. The results suggest that higher crop

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yields in the semiarid Loess Plateau may be achieved by using irrigation, or a proper combination of straw mulch and irrigation.

Keywords: Wheat yields; Soil water; Water-use efficiency; Evapotranspiration; Loess Plateau

1. Introduction

The semiarid Loess Plateau is the major region of rain-fed agriculture of China with a production area of about 6.6 million ha. Spring wheat (*Triticum aestivum* L.) is one of the major crops, accounting for 30–40% of the total agricultural area (Yang et al., 1999). Traditional rain-fed agriculture has a long history in this region; however, spring wheat grain yield is less than 2000 kg ha^{-1}, and as low as 1500 kg ha^{-1} in some areas due to water deficit, which is one-third of the national average. Consequently, there is great potential of increasing crop yield, if the water is available. Development of effective semiarid crop and water management practices plus improvement of crop yield in the Loess Plateau region are important since it would improve the food security and lead to sustainable development in the 21st century.

The main environmental factors responsible for diminished crop yields are lacked timely precipitation plus temperature and salinity stress (Boyer, 1982). In the Loess Plateau region, however, crop yield is mainly affected by the availability of water (Yang et al., 1999; Yan and Wang, 2001). The available water is limited by stored soil water, summer dominant precipitation and its significant variability in the Loess Plateau. In addition, water-use efficiency (WUE) also influences the crop yield given constant water conditions. Thus, crop yields can be improved by increasing available water and WUE in this region.

Several soil and crop management practices can increase the crop yields and WUE (Ludlow and Muchow, 1990). Fertilization can increase the use of stored soil water and increase crop yield in semiarid regions; however, in the long term, increasing fertilization may not be sufficient to maintain higher yields (Huang et al., 2003). Plastic or straw mulch is an efficient practice, which can alter water distribution between soil evaporation and plant transpiration (Raeini-Sarjaz and Barthakur, 1997). Otherwise, mulches modify the microclimate and growing condition of crops (Albright et al., 1989). It is known that water shortage restricts crop productivity and the purpose of irrigation is to minimize crop water stress and to achieve maximum yield (Wang et al., 2001). However, maximizing yield should not be the sole objective; other constraints (e.g. water availability, irrigation cost, etc.) should also be considered, especially in the Loess Plateau. The response of crop yields to irrigation has been studied extensively (Skogerboe et al., 1979). Hagan et al. (1967) asserted that excessive irrigation delays maturity, harvesting, encourages vine growth, and decreases yield. To achieve better control and management of water in crop production and irrigation efficiency, the irrigation should match crop requirements (Maggio et al., 2002; Bauerle et al., 2002).

There has been an ongoing effort to understand the relationships between crop yield, soil water balance, and water-use efficiency in order to develop better semiarid crop and water management practices (Halitligil et al., 2000; Wiedenfeld, 2000). These studies are,