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Effect of Limited Single Irrigation on Yield of Winter Wheat and Spring Maize Relay Intercropping*[1]

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ABSTRACT

A field experiment was conducted during the 2002/2003 cropping season of winter wheat (*Triticum aestivum*) and spring maize (*Zea mays*) to evaluate the effect of limited single drip irrigation on the yield and water use of both crops under relay intercropping in a semi-arid area of northwestern China. A controlled 35 mm single irrigation, either early or late, was applied to each crop at a certain growth stage. Soil water, leaf area, final grain yield and yield components such as the thousand-grain weight, length of spike, fertile spikelet number, number of grains per spike, and grain weight per spike were measured, and water use efficiency and leaf area index were calculated for the irrigated and non-irrigated relay intercropping treatments and sole cropping controls. The results showed that yield, yield components, water use efficiency, and leaf area index in the relay intercropping treatments were affected by limited single drip irrigation during various growth stages of wheat and maize. The total yields in the relay intercropping treatment irrigated during the heading stage of wheat and the heading and anthesis stage of maize were the highest among all the treatments, followed by that irrigated during the anthesis stage of wheat and silking stage of maize; so was the water use efficiency. Significant differences occurred in most yield components between the irrigated and non-irrigated relay-intercropping treatments. The dynamics of the leaf area index in the relay-intercropped or solely cropped wheat and maize showed a type of single-peak pattern, whereas that of the relay intercropping treatments showed a type of double-peak pattern. Appropriately, limited single irrigation and controlled soil water content level could result in higher total yield, water use efficiency, and leaf area index, and improved yield components in relay intercropping. This practice saved the amount of water used for irrigation and also increased the yield. Therefore, heading stage of wheat and heading and anthesis stage of maize were suggested to be the optimum limited single irrigation time for relay-intercropped wheat and maize in the semi-arid area.

Key Words: leaf area index, limited single irrigation, water use efficiency, winter wheat and spring maize relay intercropping, yield and yield components

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Many regions of the world need to implement improved on-farm water management, to meet the goals of water conservation, sustainable food production, farm profitability, and environmental quality (Brian *et al.*, 2002). However, drought is a major constraint to agricultural production (Samson *et al.*, 2002). Fortunately, wide attention has already been paid to the immediate permeation and efficient use of water in the traditional dryland farming system in northwestern China (McVicar *et al.*, 2002; Ogola *et al.*, 2002). Furthermore, since the last decade, full collection and accumulated use of precipitation has developed as a new method for supplemental irrigation of rain catchment in dryland farming in the arid and semi-arid areas of China. Since its introduction, this new approach has already shown its potential and developed very quickly. On the other hand, related research such as mulch film to cover the soil

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surface, rainfall storage in the root zone by tillage measures, water-saving irrigation methods to reduce soil evaporation, and water percolation from the root zone and enhanced rainfall and irrigation water storage in the root zone has been done to improve water use efficiency (WUE) (Kang *et al.*, 2002a). In addition, the 7th International Conference on Rain Irrigation in Beijing during June 1995 has promoted further development and use of rain catchment, and thus enhanced the development of highly efficient techniques of supplemental irrigation in the rain catchment.

Water plays an important role in inhibiting the yields of crops and is, therefore, the most important ecological factor determining crop growth and development. Limited irrigation controls soil water deficit at certain stages of crop growth and is a very important practice in recent years in places where water resources are limited (Asseng *et al.*, 1998; Plant *et al.*, 1998; Stone *et al.*, 2001; Fabeiro *et al.*, 2002). Many studies on the effect of limited irrigation on yield performance and WUE have shown that proper supplemental irrigation can increase crop yield and WUE by improving the soil water conditions significantly (Howell, 1998; Kang *et al.*, 2002b). It has been found that yield of spring wheat can be significantly increased by 20%–45% with 30 to 60 mm of water irrigation during its jointing stage. Supplemental irrigation of maize during the early floret differentiation stage (EFDS) provided a yield increase of 89.2% and about 41.6% of irrigation productivity improvement (Zhang, 1998). These studies also suggested that on the basis of reasonable fertilizer application it was feasible to obtain a winter wheat yield of 6 750 kg ha^{-1} with 50 mm of irrigation during the critical period of water demand in semi-humid but seasonable drought areas.

In the traditional agricultural irrigation, yield increase was mainly attained from the amounts of water used in irrigation satisfying the biological characteristics of water demand (Ehdaie, 1995; Deng *et al.*, 2002). Various researchers also investigated how to attain the best productive effects through limited water in arid and semi-arid areas (Zhang J. *et al.*, 1998; Zhang H. *et al.*, 1998). Recently, it was the economic efficiency brought about per unit water that attracted the researchers (Fabeiro *et al.*, 2001; Kang *et al.*, 2002a). Therefore, improving crop yield and economic efficiency per unit water in agriculture is the essential and terminal aim both for sole cropping and relay intercropping.

This study aimed to evaluate the effect of limited single drip irrigation on the yield and water use of winter wheat and spring maize relay intercropping in a semi-arid area of northwestern China, to provide some information on how to control soil water and manage winter wheat together with spring maize in a relay-intercropping system under dryland farming through proper application of supplemental drip irrigation during various crop growth stages.

MATERIALS AND METHODS

A field experiment was conducted in Jingchuan County, Gansu Province of China (about 106° 44′–107° 36′ E, 35° 27′–36° 16′ N), in a semi-arid area of northwestern China. This area was characterized by a mean temperature of 5.89 °C, a total solar radiation ranging between 544.3 and 565.2 KJ cm^{-2}, an average precipitation of 525 mm per year, an accumulated temperature (> 10 °C) of 2 700 to 3 400 °C, and a total frost-free time of about 160 days. The soil, clay loam with moderate fertility and a pH of 8.4, contained 10.0 g kg^{-1} organic matter, 0.75 g kg^{-1} total nitrogen, 60 mg kg^{-1} available nitrogen, 8.5 mg kg^{-1} phosphorus, and 240 mg kg^{-1} potassium. Some selected physical and chemical properties of the soil at various depths determined by the traditional methods as described by Shi (1988) are presented in Table I.

The relay intercropping was initiated with wheat (cultivar Longjian No. 127), followed by maize (cultivar Zhongdan No. 2). The seasonal precipitation distribution for the experimental year is presented in Table II. The total precipitation from seedling of wheat to harvest of maize during the whole 2002/2003 growing season amounted to 364.6 mm, which was distributed extremely unevenly throughout the year. Furthermore, the precipitation from sowing of wheat to its turning green was only 46.5 mm, and that from grain filling of maize to its maturity was only 21.7 mm.

There were five winter wheat and spring maize relay-intercropping treatments (WC1–WC5) and two

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