Evaluation of Combined Irrigation Capacity for SDI Corn Production

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Summary

Subsurface drip irrigation (SDI) is recognized as an efficient irrigation method that minimizes or eliminates water losses typical of sprinkler irrigation systems. Its adoption has increased in the Ogallala aquifer region. It has been reported that SDI allows reductions in irrigation by up to 25% without significant corn grain yield reduction. This corn intensification study was conducted under SDI for the 2023 growing season at the Kansas State University Northwest Research-Extension Center in Colby, KS. One corn hybrid (DeKalb DKC62-69RIB) was grown with fertilization and weed control techniques at a plant density of 28,000 plants/a using three irrigation levels (100%, 85%, and 75% of calculated well-watered ET minus rain). Average yields were 201, 200, and 198.2 bu/a for the 100%, 85%, and 75% ET minus Rain irrigation levels, respectively, indicating that irrigation does not have to increase with this crop planting arrangement when using SDI. The corn hybrid yielded well, and plant density attained good yields. Crop production under limited irrigation has been identified as a critical activity necessary to meet projected food needs in 2050. Additionally, the proposed strategies are well aligned with Ogallala aquifer conservation goals and the needs of the region's farmers.

Introduction

Intensified but sustainable crop production will be a critical factor in addressing one of the most significant challenges of this century: feeding 9.5 billion people by the year 2050. Inherent to this challenge are the limitations of arable land and a shortage of fresh water needed for crop irrigation, such as the Ogallala Aquifer. However, intensifying irrigated production does not necessarily mean more water is required. Lamm (2018) reported no significant differences in corn grain yields between subsurface drip irrigation levels, replacing 85% to 115% of ET minus Rain while the intensification procedures (hybrid selection, increased plant density, and advanced fertilization) were able to achieve grain yields of 289 bu/acre. Earlier research at this location concluded that SDI replacement of 75% of regular irrigation would result in optimum yields (Lamm, 2016). Another means of intensification is to narrow the row spacing. In the proposed research, conventional 30-inch spaced rows were used.

Overall, the study attempts further to improve efficient SDI corn production and better crop establishment while reducing irrigation by 25%. This will further enhance SDI's economic competitiveness. Simulations of the profile volumetric water content to a depth of 8 ft and comparison with measured data provide a better understanding of the soil water redistribution progression around a buried point source that can improve corn water use and, consequently, the success of the SDI system. One goal is to develop and evaluate water management strategies and technologies that could reduce water withdrawals for irrigation by 25% in 2025 compared to 2012. A related goal is to maintain and enhance the economic viability of the agriculture industry and the vitality of the Southern Ogallala Aquifer Region.

Experimental Procedures

The study was conducted on a field site at the Kansas State University Northwest Research-Extension Center at Colby, KS, within a field with an existing SDI system. The medium textured, deep, well-drained, loessial Keith silt loam soil (Aridic Argiustoll; fine silty, mixed, mesic) can supply about 17.5 inches of available soil water for an 8 ft soil profile. The soil is typical of many High Plains soils.

The location climate is semi-arid with a summer precipitation pattern and a long-term average annual rainfall of approximately 18.8 inches. Average long-term precipitation is approximately 16 inches during April through October, the typical active period. The latitude is 39.39° north, and the longitude is 101.07° west, with an elevation of 2,273 ft above sea level. The average seasonal total crop evapotranspiration (ETc) for corn is 23 inches.

A corn hybrid of approximately 112-day relative maturity (Dekalb DCK62-69RIB) was planted with a planter spaced at 30-inch rows at a planting density of 28,000 plants/a on May 3, 2023. Strip tillage was done during fertilization prior to planting. Treatments were in a complete randomized block design. Irrigation was scheduled with a weather-based water budget but was limited to the three treatment capacities of 100%, 85%, or 75% of calculated well-watered ET minus rain. The weather-based water budget was constructed using data collected from an NOAA weather station located approximately 0.37 miles northeast of the study site. The reference evapotranspiration (ETr) was calculated using a modified Penman combination equation. The specifics of the ETr calculations used in this study are fully described by Lamm et al. (1987). Alfalfa-based ETr gives better estimates than short-grass ETo in this region (Howell et al., 2008). Each irrigation capacity (whole plot) was replicated four times in plots of 110 ft length by 40 ft wide with 12 plots. Fertilization was done to aid in intensifying corn production. Typical herbicide control procedures were used to minimize weeds.

The SDI system is installed at a depth of 6 ft with a dripline spacing of 5 ft. The emitter spacing for this system is 12 inches, and the average flow rate is 1 GPM. Since this system is subsurface, the irrigation frequency did not affect evaporative losses. Soil water was measured in the complete root zone (8 ft) with a neutron probe periodically throughout the season (2 times monthly) to help quantify periods of water stress and to determine crop water use. Corn grain yield was determined by hand harvesting the representative corn samples at the physiological maturity of each treatment at the four repetitions, which enabled the determination of corn yield components (grain yield, plant density, ears/plant, and kernels/ear). Crop water use was calculated as the sum of rainfall, irrigation, and the seasonal change in available soil water within an 8-ft soil profile. Crop water productivity was calculated as the crop grain yield divided by the total crop water use. Data analyses included the correlation of corn yield, seasonal water use, and water productivity as affected by the irrigation regimes.

Results and Discussion

Growing conditions were favorable for good corn production during the 2023 growing season. Average precipitation in 2023 was approximately 17.17 inches during April through October, and 16.98 inches since the corn was planted until it was harvested. The seasonal total crop evapotranspiration (ETc) for corn was 23.93 inches. Thus, the irrigation amounts applied were 11, 9.3, and 8.15 inches for the 100, 85, and 75% ET - Rain treatments. Corn hybrid DeKalb DKC62-69RIB yielded well. Average corn yields were 201, 200, and 198.2 bu/a for the 100, 85, and 75% ET - Rain treatments. A minimal yield difference demonstrates that replacing irrigation at 85% of ET - Rain would be an acceptable irrigation strategy. Water productivity averaged 26.5, 24.8, and 23.9 inches for the 100, 85, and 75% ET - Rain treatments, respectively. Crop water productivity was also high for this study, averaging 425.4, 452.1, and 469.7 lb/a-inch for the 100, 85, and 75% ET - Rain treatments, respectively. These high yields and the high water productivity indicate that this population number, 28,000 seeds/a, in combination with these irrigation strategies, is a realistic cropping scenario for the region's farmers.

Acknowledgments

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Table 1. Corn yields, total crop water use, and water productivity (WP)

Irrigation Treatment	Repetition	Yield	Water Use	WP
		bu/a	inches	lb/a-inch
1 - 100% ET	1	200.2	26.23	427
2 - 85% ET		199.0	24.53	454
3 - 75% ET		197.6	23.38	473
1 - 100% ET	2	201.4	26.43	427
2 - 85% ET		200.5	24.73	454
3 - 75% ET		199.1	23.58	473
1 - 100% ET	3	202.7	26.33	431
2 - 85% ET		200.3	24.63	455
3 - 75% ET		199.0	23.48	475
1 - 100% ET	4	200.2	26.93	416
2 - 85% ET		200.4	25.23	445
3 - 75% ET		197.0	24.08	458

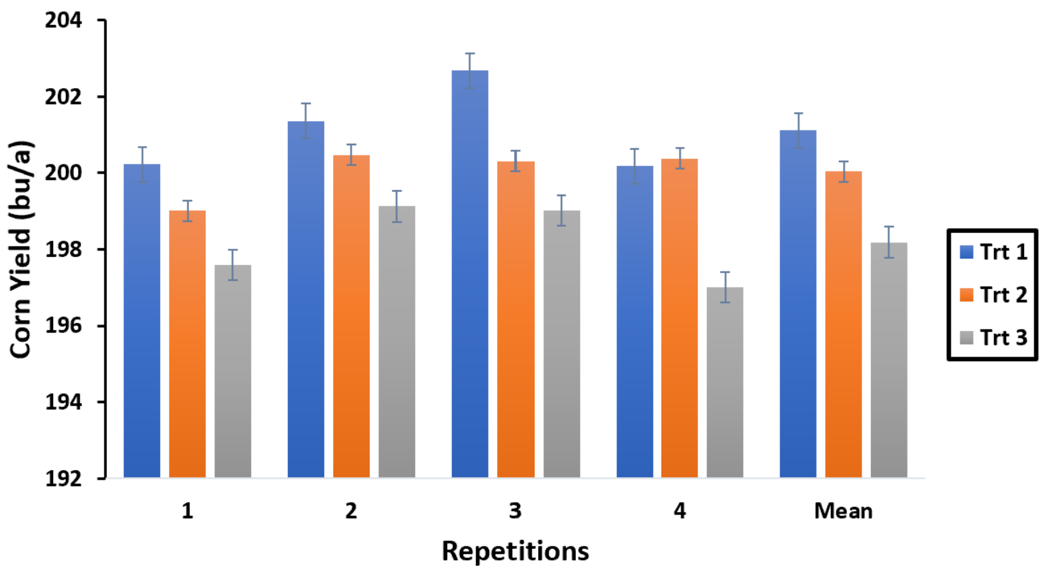

Figure 1. Corn grain yields (bu/a) for the three irrigation treatments designed to match 100%, 85%, and 75% of well-watered corn ET minus rain.

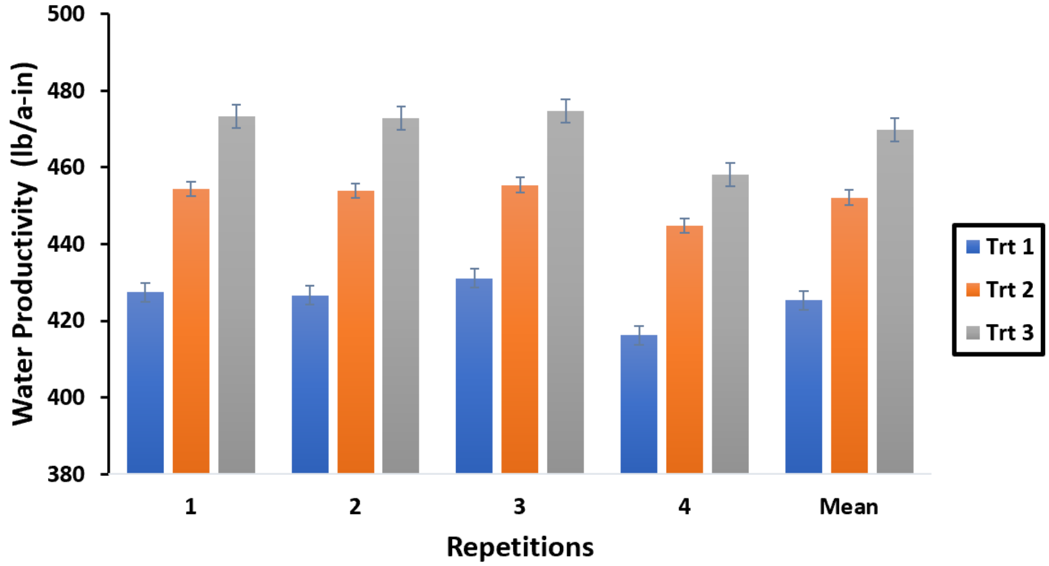

Figure 2. Water productivity (lb/a-inch) for the three irrigation treatments designed to match 100%, 85%, and 75% of well-watered corn ET minus rain.

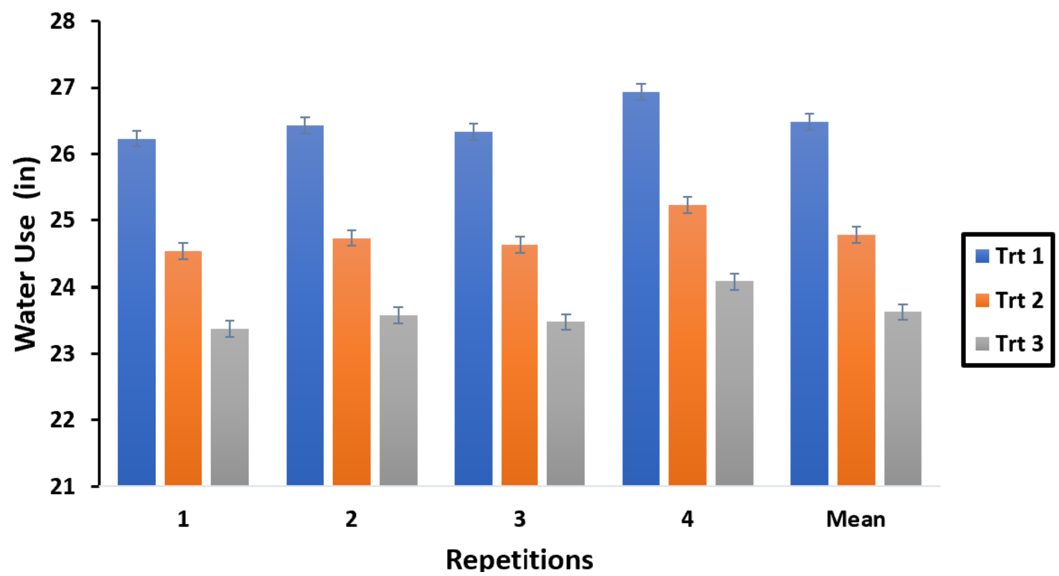

Figure 3. Water use (inches) for the three irrigation treatments designed to match 100%, 85%, and 75% of well-watered corn ET minus rain.