Corn Irrigation with Reduced Well Capacity

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Summary

One major challenge for western Kansas irrigated corn producers is sustaining or enhancing yields under declining well capacities or limited water supplies. Irrigation systems in the Central Great Plains can no longer supply peak irrigation needs throughout the summer months. Producers should rely on soil water reserves to keep the crop from water stress. Irrigated crop production is essential for agriculture in Western Kansas. Corn is the most popular commodity crop grown under irrigation (around 50% of the irrigated acres). Nevertheless, with declining water levels in the Ogallala aquifer, optimal application of limited irrigation water and sustainability practices are necessary. This study evaluated how irrigation management can be used to improve productivity when well capacity is limited and insufficient to meet crop requirements fully. The objective of this study was to determine the grain yield response of corn to different irrigation capacities. Field studies were conducted at the Kansas State University Northwest Research and Extension Center near Colby, KS, during the 2023 growing season. The study was a factorial design of irrigation capacities (limited to 8, 9, and 10 inches per season and a dryland treatment) with a corn hybrid (DeKalb DKC62-69RIB) with excellent drought tolerance. Grain yields increased by using a drought-tolerant hybrid with a planting rate of 28,000 seeds/a. Average grain yields increased from 194.7 bu/a to 202.3 bu/a when irrigation capacity increased.

Introduction

Almost all the groundwater pumped from the Ogallala Aquifer is used for irrigation in the Western Kansas region. However, farmers are facing the challenge of declining well capacities due to water withdrawals from the Ogallala aquifer for irrigation that are higher than the mean annual recharge. In addition to limited well capacities, public policy may also limit the total amounts of water that can be pumped. Policies include the 20% reduction in pump water that is being put into operation as part of a Local Enhanced Management Area (LEMA) policy in parts of Groundwater Management District (GMD) 4 and in several Water Conservation Areas - in GMD 1 and GMD 3 (Schlegel et al., 2018).

The flowering stage of corn overlaps with the period of greatest water demand. Therefore, a limited irrigation capacity during this important stage can noticeably affect the anthesis to silk interval and, thus, the grain yield. Seed companies have done massive hybrid improvement efforts to develop drought-tolerant hybrids that have shown outstanding performance potential and are broadly adapted across different yield environments. Corn hybrids in the market have strong standability and late-season harvest features. They will not suffer a yield reduction under ideal growing conditions, but they will stabilize yield under water-stressed environments. Corn yield increase can also be attributed to higher plant densities; however, Lobel et al. (2014) reported that greater plant densities can result in more sensitivity to drought. Linear irrigation systems travel back and forth across the field instead of around a central point as a center pivot does. Linear irrigation systems offer great advantages; they are one of the most efficient farm irrigation methods. A linear system reduces labor expenses by 50% compared with subsurface drip irrigation while irrigating up to 98% of the field. This study aims to determine corn grain yield response to different irrigation capacities. Field studies were conducted at the Kansas State University Northwest Research-Extension Center in Colby, KS, for the 2023 growing season. Corn was irrigated under a Valley linear irrigation system. The study was a factorial design with limited irrigation capacities (8, 9, and 10 inches per season and a dryland treatment). Results show average grain yields increased when irrigation capacity was increased.

Experimental Procedures

The study was conducted at the Northwest Research and Extension Center (NWREC) in Colby, KS, to evaluate multiple irrigation capacities (limited to 8, 9, and 10 inches/season and a dryland treatment). The soil type is a Keith silt loam. 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 average seasonal total crop evapotranspiration (ETc) for corn is 23 inches. The experimental design was a randomized complete block design with three replications. Weather data were measured using automated weather stations. Soil samples were taken and sent to the K-State Soil Testing Lab to determine the best fertilization recommendations. Strip tillage was done while fertilizer (140 lb of N and 20 lb of P) was applied in mid-April at a rate of 43 gal/a. An early pre-emergence herbicide was applied in late April (AMS at 17 lbs/100-gal water tank), atrazine (40 oz/a), mesotrine (3 oz/a), dicamba (16 oz/a), and glyphosate (32 oz/a), at a spraying rate of 15 gal/a.

DeKalb DKC62-69RIB corn hybrid was planted at 28,000 seeds/a in early May. Second herbicide application was done (early post, after plating when corn was up) in late May (AMS at17 lbs/100-gal water tank, atrazine + acetochlor at 72 oz/a, mesotrine at 4 oz/a, diflufenzapyr + dicamba at 30 oz/a, glyphosate at 32 oz/a, and crop oil at 32 oz/a). The second fertilization (remaining 40 lb of N and 25 lb of P at a rate of 21 gal/a) was applied in early June.

Irrigation was performed under a linear irrigation system to apply irrigation water in the desired treatment combination in the prescription. The prescriptions were made in the VRI software Valley VRI 5.55 and then uploaded to the AgSense website. Irrigation was scheduled as needed according to weather but was limited to the irrigation capacity treatments (8, 9, and 10 inches per season and a dryland treatment). Soil water was monitored periodically with a soil moisture sensor, Acclima True TDR-315N; a fully integrated digital time-domain reflectometry TDR soil water content sensor (a.k.a., soil moisture sensor, probe, or meter) that has demonstrated outstanding accuracy.

Corn grain yield was determined by hand harvesting representative samples of each treatment and every replication at physiological maturity. The components of corn yield were determined (grain yield, plant density, ears/plant, and kernels/ear). Crop water use was calculated by the sum of soil water depletion (soil water at planting minus soil water at harvest) plus in-season irrigation and precipitation. Crop water productivity (WP) was calculated by dividing grain yield (lb/a) by crop water use (inches).

Results and Discussion

The growing conditions were reasonable for good corn production in the 2023 growing season. The average precipitation in 2023 was near 17.17 inches during April through October and 16.98 inches of rain from planting until harvest. The seasonal total crop evapotranspiration (ETc) for corn was 23.93 inches. The irrigation amounts were limited to 10 inches, 9 inches, 8 inches, and a dryland treatment. Corn hybrid DeKalb DKC62-69RIB yielded well, showing good performance and being broadly adapted across the treatments. The hybrid has responded well to drought stress under harsh conditions. Average corn yields were 202.6, 199.9, 198.6, and 194.8 bu/a for the limited to 10-inch, 9-inch, 8-inch, and dryland treatments, respectively.

Crop water productivity was also high for this study, averaging 420, 429, 446, and 630 lb/a-inch for the limited to 10-inch, 9-inch, 8-inch, and dryland treatments. (Table 1). The results demonstrate no significant differences in corn grain yield within the irrigated treatments, demonstrating 8 inches of irrigation in a year with reasonable precipitation amounts, as in 2023, could be an acceptable irrigation strategy to save water and attain a high yield. Nevertheless, the good precipitation and good water holding capacity for this deep, silt loam soil during the 2023 growing season could be buffering variances that would possibly occur between irrigation treatments in drier years.

References

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

Irrigation treatment	Rep	Yield	Water use	WP
		bu/a	inches	lb/a-inch
Trt 1: 10 inches	1	202.5	27.22	417
Trt 2: 9 inches		199.3	26.22	426
Trt 3: 8 inches		199.1	24.95	447
Trt 4: dryland		194.6	17.22	633
Trt 1: 10 inches	2	201.8	26.65	424
Trt 2: 9 inches		199.8	25.81	433
Trt 3: 8 inches		198.2	24.97	444
Trt 4: dryland		194.9	17.22	634
Trt 1: 10 inches	3	203.4	27.22	418
Trt 2: 9 inches		200.6	26.22	428
Trt 3: 8 inches		198.7	24.89	447
Trt 4: dryland		194.9	17.51	623

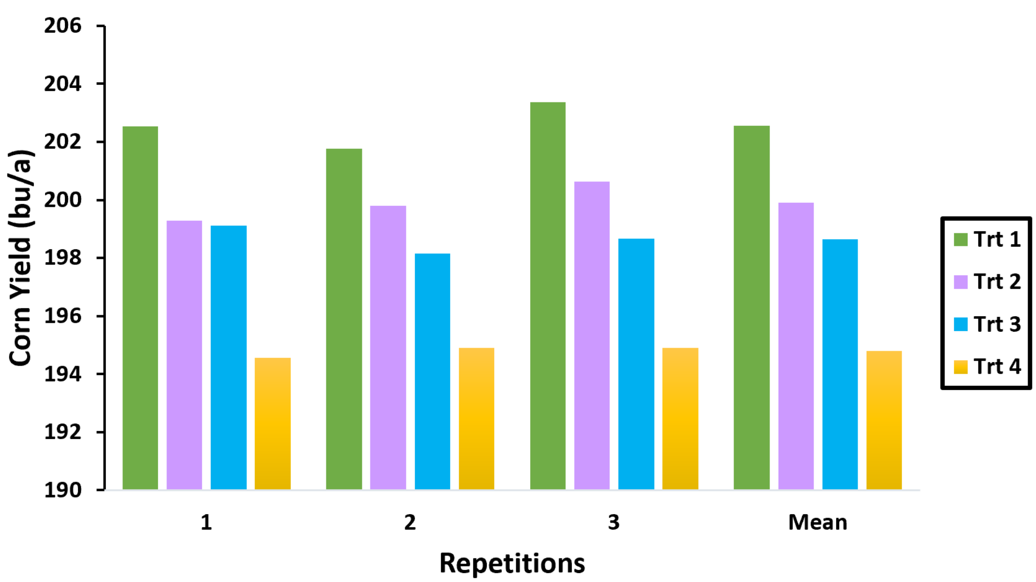

Figure 1. Corn grain yields (bu/a) with different irrigation treatments.

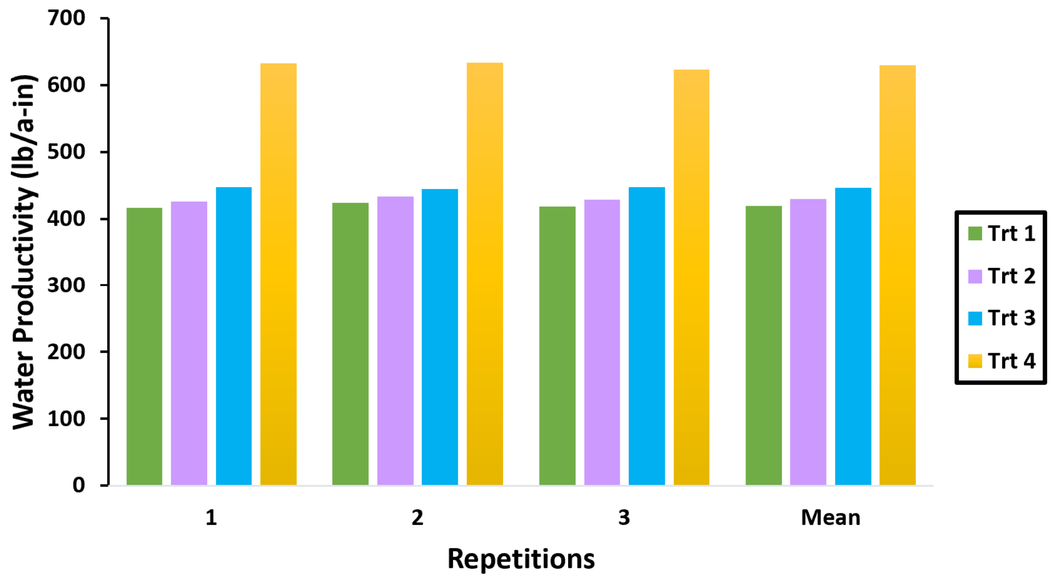

Figure 2. Water productivity (lb/a-inch) with different irrigation treatments.

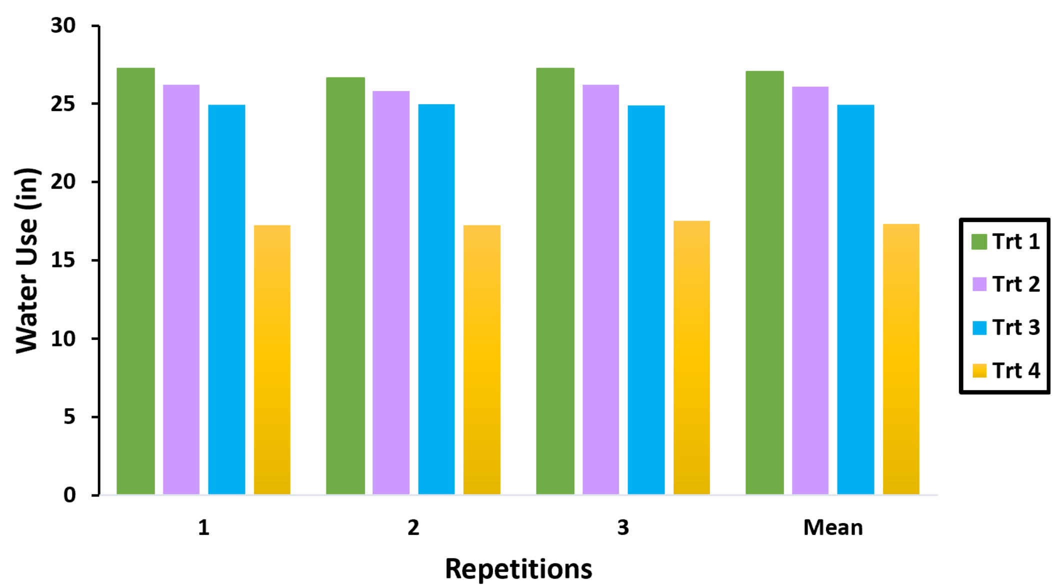

Figure 3. Water use (inches) with different irrigation treatments.