Cotton's Reactions to Irrigation Management Strategies Applied by Various Irrigation Technologies in Southwest Kansas

F. Moghbel, J. Aguilar, F. Fazel

Summary

Investigating effective methods in agricultural water management could be a potential solution to address the water scarcity issue and its consequences in the economy of semi-arid regions. A study was conducted in 2023 to identify the benefits of different irrigation technologies and irrigation water management strategies for cotton production in western Kansas. Effects of two configurations of the new mobile drip irrigation (MDI) system (1 gal/h and 2 gal/h) on cotton yield and yield components were compared with a LEPA bubbler and a LESA sprayer to apply 7-day and 14-day irrigation interval strategies. This study so far has revealed the superiority of the combination of either a LESA sprayer or MDI-1 gal/h irrigation with 14-day irrigation intervals in achieving the highest cotton yield in the region.

Introduction

Water scarcity and continued droughts in semi-arid regions such as western Kansas necessitate pursuing water conservation techniques in irrigated agriculture to preserve the economic sustainability of the region (Perez-Quesada and Hendricks, 2021). There are several factors involved in agricultural water management that could lead toward water conservation if they are properly studied. The first element is finding a suitable replacement for high water demanding crops such as corn (O'Shaughnessy et al., 2019) with those that require less water and are adaptable to prevailing climate conditions of the region. Cotton is one the most convenient crops in terms of water and nutrient efficiency, and its reasonable tolerance to water-limited conditions has been proven multiple times in the literature (Ale et al., 2020; Howell et al., 2004; Pereira et al., 2009). However, cotton's tolerance to water deficit conditions varies under different soil types and weather characteristics. Therefore, exploring the responses of cotton productivity to deficit irrigation conditions is instrumental in water scarce regions. Deficit irrigation could be implemented through various approaches depending on availability of labor and equipment. Increasing irrigation intervals (J.M. Enciso et al., 2003) throughout the crop growing season or at specific growth stages is one of the reasonable ways of applying deficit irrigation. Extending the irrigation intervals or, in other words, decreasing irrigation frequency, exposes the crop to certain water stress levels with varying effects in each region with specific precipitation patterns.

Another element that could be vital in irrigation water management is the selection of irrigation technology, which could potentially make a significant difference in application and water use efficiency. Mobile drip irrigation (MDI) is one the most novel irrigation technologies that has combined the concepts of drip irrigation and sprinkler irrigation systems to reduce water loss through wind draft and evaporation (Kisekka et al., 2017; Oker at al., 2018; Olson and Rogers, 2007.) Previous studies investigated the aspects of MDI under different crop conditions. However, few published results compared the efficiency of this protype in irrigation technologies with previously available ones. Thus, the primary goal of this study was identifying the interaction effects of irrigation technologies and irrigation scheduling strategies on cotton production in western Kansas.

Experimental Procedure

Factorial experiments with three replications were conducted in 2023 to explore two irrigation scheduling strategies interacting with four irrigation technologies on cotton production at the Kansas State University Southwest Research-Extension Center, near Garden City, KS. A four-span center pivot irrigation system equipped with a Variable Rate Irrigation (VRI) device was used to achieve the goals of the study. The first span by the pivot point was kept functional during the growing season as an alternate replacement in case of failure in any experimental plots. However, the data were not obtained by the end of the experiment. The irrigation scheduling strategies included 7-day and 14-day irrigation intervals. Four irrigation technologies included two MDI drip lines that were able to deliver equal irrigation depth using 1 and 2 gal/h flow rate in-line emitters, and a LEPA bubbler and a LESA sprayer.

Cotton PHY205 seeds were planted on May 10, 2023, in the experimental field covered with corn stubble with 150,000 seeds/a density. The cotton planting was followed by irrigation to facilitate the seeds' germination. Soil type in the field is well-drained Ulysses silt loam (fine-silty, mixed, mesic Aridic Haplustoll). The volumetric soil moisture content down to the 8-ft soil depth was monitored during the growing season using the neutron attenuation technique. The agronomic practices including fertilizer, herbicide, pesticide, plant growth regulator, cotton boll opener, and defoliant application followed the local guidelines in the U.S. Great Plains. The total rainfall during the growing season was 17 inches. The cotton was hand harvested on November 8, 2023, over 30-ft plant rows. The statistical analysis including analysis of variance (ANOVA) was performed in the R 4.0.5 environment.

Results and Discussion

Cotton lint and seed yield

As depicted in Figure 1, the highest cotton lint yield (1323.9 lb/a) was detected by implementing a 14-day irrigation interval using LESA sprayer irrigation technology. Similar lint yield was found as result of using MDI-1 gal/h drip lines in western Kansas. The results indicate that in general, pursuing a 14-day irrigation interval resulted in higher cotton lint yield. This yield bump could be due to rainfall interaction (17 inch) during the 2023 growing season from May to the end of October. Applying the 14-day irrigation interval must have provided the cotton crops with an extra heat unit that favored cotton growth and, consequently, its final lint yield. Kansas is thermally limited for cotton growth and therefore any irrigation or agronomic practices that can provide additional heat would be beneficial and could result in an increase in cotton fiber (lint) yield. The highest reduction in cotton lint yield was found with utilization of LEPA bubblers as the irrigation technology to implement irrigation water management strategies.

The highest cotton seed yield (1528.9 lb/a) was obtained by pursuing 14-day irrigation intervals and using LESA. An almost identical cotton seed yield was observed with implementation of 7-day irrigation intervals under MDI-2 gal/h and 14-day irrigation intervals under MDI-1 gal/h and LEPA irrigation technologies. In a similar way to lint yield, the lowest cotton seed yield was found for interactions of a 7-day irrigation scheduling strategy and LEPA bubbler.

Cotton yield was presented as number of bales/a as well, to provide additional insight regarding the response of cotton to irrigation technology and irrigation water management. The number of cotton bales affected by the experimental treatments followed the same pattern as seed and lint yield. The number of bales ranged from 5 to 6 bales/a, which indicated the success of the conducted irrigation study toward cotton establishment in western Kansas.

Irrigation water use efficiency and water use efficiency

Irrigation water use efficiency (IWUE) was defined as the ratio of cotton lint yield to seasonal irrigation depth. As expected, the IWUE values were significantly higher under 14-day irrigation interval strategies compared to the corresponding values under 7-day irrigation intervals. Obviously, the seasonal irrigation under 14-day irrigation intervals was 50% less than seasonal irrigation depth under the 7-day- strategy. The detected difference in IWUEs would have been different if the precipitation was less extensive for cotton production. No considerable difference was found between obtained IWUEs under 7-day irrigation intervals applied by various irrigation technologies. However, the difference between irrigation technologies' effects on IWUEs was more detectable when the 14-day irrigation interval was implemented. The highest irrigation IWUE (682.62 lb/a-inch) value was related to LESA sprayer, which applied the 14-day irrigation interval strategy. The IWUE values were 661.97 and 633.68 lb/a-inch for using MDI-1 gal/h and the LEPA bubbler and 14-day irrigation interval application, which were significantly different from the obtained value under LESA sprayer technology.

The water use efficiency (WUE) was defined as the ratio of cotton lint yield to seasonal evapotranspiration. The obtained values were compared accordingly and like other yield components and indices, the highest value of WUE (68.97 lb/a-inch) was obtained with the LESA sprayer for the 14-day irrigation interval application. The difference between the 7-day and 14-day irrigation intervals again indicated the superiority of increasing the irrigation intervals. However, continuation of this study for future growing season is highly recommended as the stochastic weather conditions could have significant effects on the outcomes of the field experiments.

Acknowledgments

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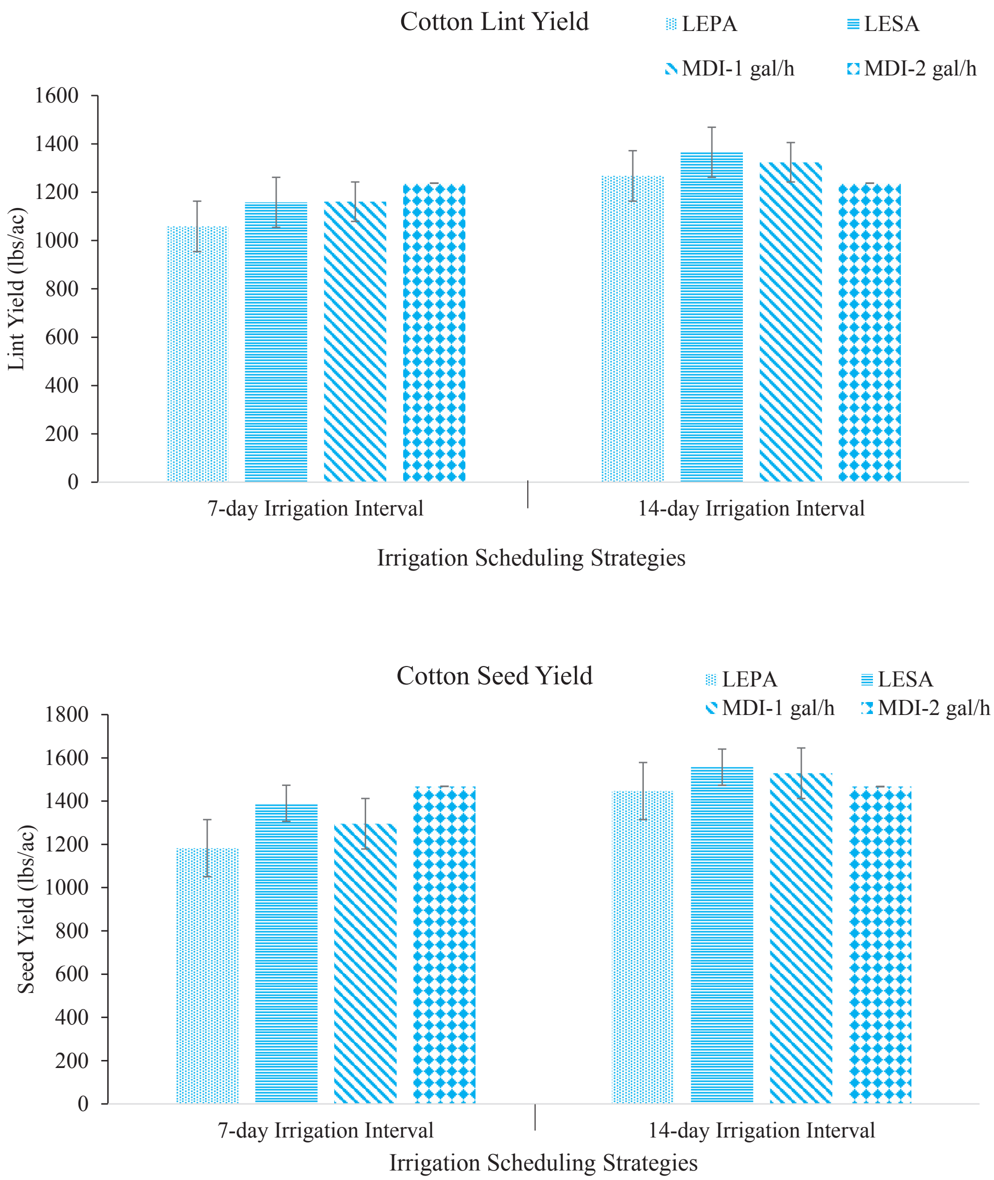

Figure 1. The cotton lint yield, seed yield, and number of bales/a affected by the experimental treatments

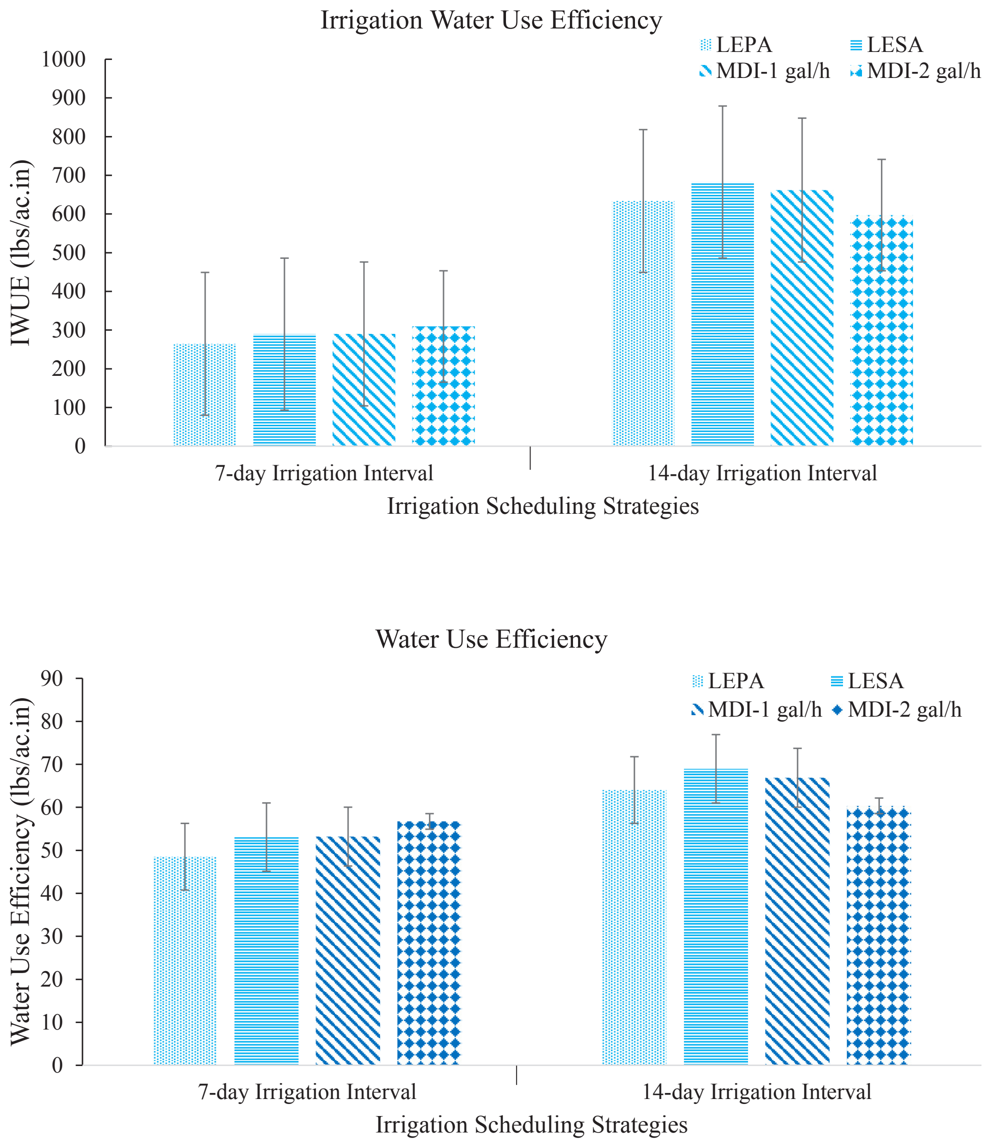

Figure 2. The cotton irrigation water use efficiency (IWUE) and water use efficiency affected by the experimental treatments.