Lint Yield and Fiber Quality of Cotton (Gossypium hirsutum L.) under Fixed and Dynamic Regulated Deficit Irrigation Schemes in SW Texas

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ABSTRACT

The urban water demand in Southwest Texas has increased rapidly in recent years due to the population increase in this area. One possible way to assist in solving this problem is to reduce the agricultural water use; however, the crop yield should not be detrimentally affected. Regulated deficit irrigation (RDI) is a widely used measure for saving water and maintaining crop yield. An experiment with seven treatments, including five 'fixed' (X) and two 'dynamic' (D) irrigation schemes, were developed in summers of 2008 and 2009 to test on several different varieties whether more irrigation water could be saved by RDI method.

The data analyses showed that: 1) The fixed RDI threshold (the maximum water saving point) should remain between 70% and 80%. 2) With reference to the dynamic RDI, 50% of the irrigation water can be saved during the pre-flowering season without affecting the lint yield, which may make up to 30-35% water saving in total. 3) Dynamic schemes do not reduce fiber quality, compared to the fixed counterparts, according to the fiber quality data collected in 2008. Based on the results, it appears that scheduling irrigation application with a dynamic scheme is better than that for a fixed scheme in SW Texas for cotton production.

INTRODUCTION

The urban water demand in Southwest Texas has increased rapidly in recent years due to the population increase. Since the water resources in this area are limited, making a good plan for use of the available water supply is crucial. One possible way to assist in solving this problem is to reduce the agricultural water use. However, the economic crop yield, or the growers' profit, should at least be maintained. In other words, a well-designed water distribution plan needs to be developed to optimize the community's profit, based on the results of on-farm research. Once completed, the framework can be applied to other regions as well.

OBJECTIVE

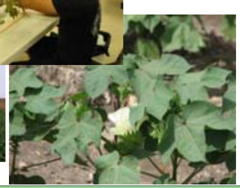
The objectives of the study were to estimate the water saving potential during the growing season, and to evaluate the lint (fiber) yield under different irrigation regimes.

MATERIALS & METHODS

The research was conducted at the AgriLIFE Research & Extension Center at Uvalde, TX in the summer seasons of 2008 and 2009. A strip-plot design experiment was assigned in a 90° wedge (approximately 16.2 ha). The irrigation was applied by a center pivot with a low energy precision application (LEPA) system. Seven irrigation regimes were applied, which included five fixed-ratio schemes replacing 100%, 80%, 70%, 60% and 50% of the net crop ET (ETc), respectively; and two "dynamic" regimes of 70% and 50% net ETc replacement (in the dynamic scheme, the irrigation is applied in different ETc ratios at different growing stages). Four widely planted commercial cotton varieties were selected to test the variety effect in each year.

The lint yield (economic yield) were determined by randomly sampling 12 m^2 from each experimental unit and estimating the total lint weight per hectare. These lint samples were then sent to the Fiber & Biopolymer Research Institute (Texas Tech Univ., Lubbock, TX) for USDA standard HVI test. The micronaire, fiber length, fiber uniformity index, fiber strength, elongation, fiber reflectance and fiber yellowness were tested as fiber quality parameters.

The yield as well as the fiber quality data were analyzed using PROC MIXED procedure in SAS 9.2. All marginal means among irrigation and variety were compared using the Tukey test at the 0.05 significant level.



RESULTS

Based on the ANOVA results, there was no significant irrigation-by-variety interaction detected in either year. As the major interest is the irrigation effect, we only present the marginal mean separation results of irrigation schemes.

The lint yield results of both years are demonstrated in Figure 1. In 2008, 80X showed no significant yield difference, while the yield of 70X was significantly lower, compared to the full irrigation treatment (100X). The yield of both dynamic schemes, 50D and 70D, were not significantly lower than that of 100X. The lint yield of 2009 was predicted by multiplying the seed cotton yield by *0.35*, as the samples are still being processed. The predicted lint yield showed that 100X had significantly higher yield than other treatments. Compared to 80X, 70X was not significantly different in yield, while 60X and 50X were lower; 70D and 50D were not significantly different from 80X as well. Considering the extreme (hot) weather in 2009, and that the traditional irrigation application locally is less than the 100X, we may still consider that 70% replacement might be acceptable for cotton production in this area in the year 2009. Regardless, the two dynamic irrigation schemes are no doubt more advanced in water saving.

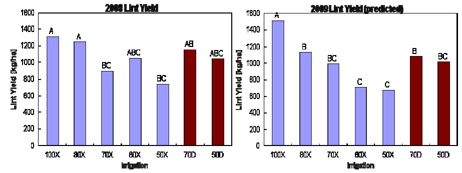


Figure 1. The lint yield of each irrigation scheme.

Figure 2 illustrated the five major fiber quality parameters for each irrigation scheme, based on 2008 data. All parameters were standardized ranging from 0 to 1, based on the major fiber quality classification categories. For example, all seven treatments produced long fiber cotton (fiber length), which ranges from 1.11 to 1.28 inches; all fiber length values are standardized using this base range ((fl – 1.11)/(1.28 – 1.11) = (fl – 1.11)/0.17). The full replacement, 100X, was used as the standard. For other schemes, the parameter names were marked with asterisks (*) if they were significantly different from the related parameter in 100X radar plot.

The plots comparison showed that:

- Fiber Length (LENGTH) [inch]: 50X is significantly lower than the reference.
- Uniformity Index (UNIFORM): 70X and 50X are significantly lower than the reference.
- Fiber Strength (STRENG) [g/ tex]: 60X and 50X are significantly lower than the reference.
- Grayness (Rd) [%]: 60X and 50X are significantly lower than reference.
- Yellowness (+b): 70X and 70D are significantly lower than reference.

For fixed ratio schemes, beside yellowness, the other four parameters indicated the effect of reducing fiber quality under extreme water deficiency (50X and 60X). On the contrary, both dynamic irrigation schemes did not reduce the fiber quality regarding to 100X.

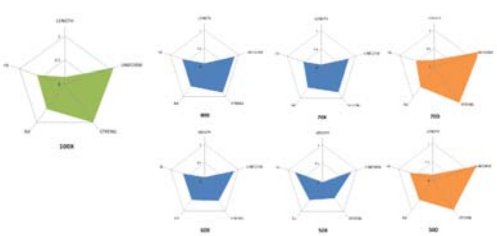


Figure 2. Five major fiber quality parameters (fiber length, uniformity index, fiber strength, grayness (Rd), and yellowness (+b)) under different irrigation schemes. X and D stand for fixed and dynamic schemes, respectively. Numbers prior to the X/D are replacement ratio relative to ET, in percent (%).

DISCUSSION

In order to save more water from irrigation, we need to determine the threshold of the water application without reducing the yield. In this study, we found that the threshold should stay between 70% and 80% (by traditional irrigation schemes). Combined with the previous research in Uvalde, this threshold should be 0.70 to 0.75, which means the water saving potential can be as much as 25-30%. The newly introduced "dynamic" irrigation schemes showed an even higher potential for water conservation with a savings of 35-40%. However, dynamic irrigation scheduling is highly affected by rainfall distribution in a specific year. The growing stages in which more water can be saved include the pre-flowering stage and after 25% open-boll. If considerable rainfall is received during these two stages, water savings would more likely approximate 10-15%. Nevertheless, from a long-term view, it is still possible to save more irrigation water compared to the ordinary or traditional scheme.

Examination of the fiber quality parameters showed that dynamic irrigation schemes did not reduce the fiber quality. This is another advantage of dynamic irrigation schemes. Further studies should focus on the threshold of water saving under dynamic schemes rather than fiber quality improvement, as the fiber quality improved through dynamic schemes is very limited.

CONCLUSIONS

- The ordinary RDI threshold should be between 0.7 and 0.8. With dynamic RDI, even more irrigation water could be saved in cotton production (without affecting the yield) in SW Texas.
- The variety effect is not as obvious as irrigation scheme. No irrigation-by-variety interaction was detected.
- Dynamic irrigation schemes did not reduce the cotton fiber quality.

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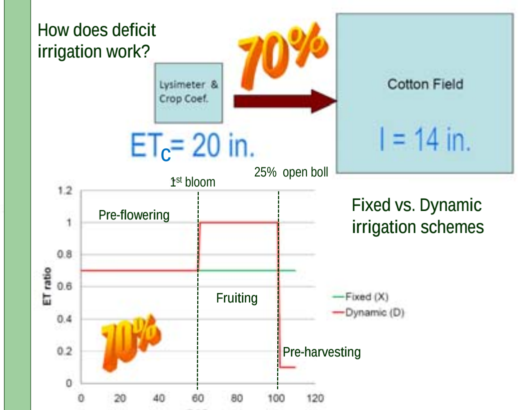
APPENDIX: "RDI for Dummies"



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