Title

Pre-plant and early season irrigation productivity of cotton using subsurface drip irrigation

Investigators

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Summary

From 2002 to 2012, average irrigation water productivity of all field scale subsurface drip irrigation (SDI) research plots at Helms Research Farm at the Texas A&M AgriLife Research Center at Halfway was 0.35 kg of lint cotton per m^3 of irrigation (Bordovsky, et al., 2013). The installations at this site are representative of the approximately 100,000 ha of SDI where laterals are installed in alternate crop furrows in the Texas South Plains. The results of several experiments and observations at this and other research sites could be combined to significantly increase irrigation water productivity compared to most SDI system operations and all center pivot systems. Cotton will be planted where SDI laterals are 0.2 m below the level soil surface arranged in a traditional "1 lateral x 2 row" configuration (Halfway) and the more expensive "1 lateral x 1 row" configuration (Lubbock). The treatment factors will include pre-plant irrigation quantity and early growing season irrigation capacity resulting in six treatments plus "pre-plant only" check. At Halfway, crop rows will be planted directly above SDI laterals during dry periods to ensure germination. Irrigation intervals will be every seven days during cotton reproductive and maturation periods. By using a combination of recent research findings and observations, we believe that irrigation productivity greater than 0.45 kg m^{-3} or an increase of at least 25% can be consistently achieved using SDI.

Objective

The overall goal of this project is to develop and evaluate water management strategies and technologies that could reduce water withdrawals for irrigation by 20% in 2020 compared to 2012, while maintaining and/or enhancing the economic viability of the agriculture industry and the vitality of the Southern Ogallala Aquifer Region. The proposed experiment combines results of several experiments in an effort to define a SDI protocol that consistently maximizes water productivity for cotton grown in the Texas High Plains. Specifically, the objective is to determine cotton lint yield, fiber quality, and water use efficiency when pre-plant and early season irrigations are well below available irrigation capacity using the most efficient delivery system available. The SDI system will be managed such that cotton germination is assured and irrigation intervals are optimized.

Rationale

Due to declining irrigation capacity in the Texas High Plains, growers typically irrigate during pre-plant and the early season periods attempting to store profile water for crop water use during peak demand periods. In a recently completed LEPA irrigation study at the Texas A&M AgriLife Research Center at Halfway, irrigation water value was significantly reduced by attempting to store water in the soil profile or irrigating in excess of the evapotranspiration rate of cotton plants early in the growing season as compared to applying irrigation later (Bordovsky, et al., 2014b). The four-year experiment showed that up to 20% less seasonal irrigation was used with minor yield loss by reducing cotton irrigations during the vegetative period compared to traditionally irrigated treatments. This was attributed to 1) reducing high evaporation losses (high wind, low humidity, and high temperatures) that occur in May and June by minimizing irrigation and 2) eliminating excessive early season plant development that cannot be sufficiently supported with the irrigation capacities available later in the year.

Compared to pivot irrigation, SDI systems should drastically reduce early season evaporative loss. However, SDI losses can be very high due to heavy irrigations associated with crop stand establishment (Bordovsky, et al., 2012a). Successful methods of improving germination with SDI include lateral installations in every row or, in "1-lateral by 2-row" installations, reducing the depth below the soil surface of SDI laterals or planting crop rows directly over SDI laterals in a skip row pattern. As SDI research has progressed over a 14-year period at the Helms Research Farm (Halfway), lateral depth has decreased from 0.38 m in the initial plots to 0.20 m in the more recent installations. All installations are on clay-loam soils. Although there are notable problems associated with "shallow" lateral installations, the 0.2-m lateral depth greatly improved cotton germination compared to deeper installations using significantly less water to achieve germination. In a replicated test, 1.5-m row spaced cotton planted directly above laterals vs. 0.76- m rows spaced equidistant from the lateral resulted in a 10% reduction in cotton lint yield (1624 vs.1803 kg ha^{-1}, respectively, Bordovsky, et al., 2014a). Eight inches of pre-plant irrigation plus rain were needed to establish plant stands in 0.76-m cotton rows of the replicated experiment. It is hypothesized that similar or better yields could be achieved with less pre-plant irrigation by planting earlier with 1.5-m crop row spacing over the laterals instead of waiting for rain or until SDI system had dispensed enough water to achieve germination in the 0.76 m rows, particularly during low rain periods.

Also, in years of below average rain, deficit irrigation with SDI significantly increased cotton yield and loan values by irrigating at intervals of seven days compared intervals of two days or less at the Helm site (Bordovsky, et al., 2012b). Providing irrigation at approximately 80% of ET, 7-d yields averaged 1725 kg ha^{-1} compared to 1 and 2-d yields of 1590 kg ha^{-1} over the 4-year test period. More water was extracted from the 1.5-m soil profile during the growing season in 7-d than the 1-d interval treatments based on neutron soil water monitoring.

The persistent drought has accelerated water table declines in the Texas South Plains. If cotton can consistently and economically be established with minimum pre-plant and early season irrigation, or can be established with reasonable amounts of pre-plant irrigation not lost to evaporation or causing excessive plant growth, irrigation productivity could be significantly improved in low irrigation capacity areas.

The proposed study will quantify differences in water productivity of SDI cotton during the irrigation periods having the highest environmental demand on the South Plains, or more specifically, answer the question of "how much cotton, if any, is lost by reducing irrigations at pre-plant and early cotton growth stages" in field scale SDI experiments. Germination will be assured by planting cotton in a test area were lateral depths are 0.2 m and, in years of little or no rain, directly over drip laterals. Information concerning total water use, water use efficiency, and effects on fiber quality and lint value for the factors being evaluated will be determined. Documenting the economic significance of reduced irrigation at these cotton growth periods will give producers additional information on how to manage water as irrigation supplies are reduced or as opportunities for alternative water uses present themselves.

Approach and Research Procedures

AgriLife Research at Halfway

The treatment factors for this experiment will include irrigation amount during pre-plant irrigation (maximums of 51 mm and 102 mm) and irrigation capacity early in the growing season (0.0, 2.5, and 5.1 mm d^{-1}) resulting in six treatments plus a pre-plant only check. Irrigations during the reproductive and maturation periods of all treatments will be at 5.1 mm d^{-1}. Table 1 provides a summary of proposed irrigation treatments and the maximum annual irrigation totals. Within each treatment, water will be applied at specified irrigation capacities during specific growth periods (defined by heat unit accumulation) in an attempt to increase soil profile water to approximately 80% of field capacity subject to the protocol described by Bordovsky and Lyle (1996).

The field experiment will be conducted at the Texas A&M AgriLife Helms Research Farm, 2 miles S of Halfway, TX (1071 m elev., 340 9'N, 1010 56' W). This farm provides the means to evaluate replicated irrigation treatments on a field scale having representative soil types and slopes of much of the Texas South Plains. The field is located adjacent to a playa in a transitional soil changing from a Pullman clay loam (fine, mixed, thermic Torrertic Paleustolls) at higher elevations to an Olton loam (fine, mixed, thermic Aridic Paleustolls) at lower elevations.

The experiment will be in a 6.3-ha area with SDI laterals located in alternate furrows between 0.75-m wide crop rows oriented N-S. Plot size will be 400-m long by 6.1-m wide.

Table 1. Proposed irrigation capacities and probable irrigation amounts of an early season subsurface drip irrigation experiment at Texas A&M AgriLife Research, Halfway, Tex.

Treat. No.	Irrigation Capacity (mm/d)			Probable Irrigation Amounts (mm)				
	Vegetative Period	Reproductive Period	Maturation Period	Pre-plant Period	Vegetative Period	Reproductive Period	Maturation Period	Total
T0	0.0	0.0	0.0	51	0	0	0	51
T2	0.0	5.1	5.1	51	0	107	152	310
T5	2.5	5.1	5.1	51	76	107	152	386
T6	5.1	5.1	5.1	51	152	107	152	462
T3	0.0	5.1	5.1	102	0	107	152	361
T1	2.5	5.1	5.1	102	76	107	152	437
T4	5.1	5.1	5.1	102	152	107	152	513

Drip laterals were manufactured with emitter spacing of 0.61 m and emitter flow rates of 0.60 L hr^{-1} at 69 kPa (Typhoon 0.16 gph emitter, Netafim Irrigation, Inc., Fresno, CA). Drip laterals were installed from 0.20 to 0.24 m below the level soil surface using a standard drip tape injection plow. Irrigation interval and frequency will be programmed using a standard valve controller (Sterling 18, Superior Controls Co., Inc., Valencia, CA). Flow to each treatment group will be measured using 25.4 mm diameter water meters with accumulating mechanical registers. Flow meter readings will be recorded and head pressures will be recorded during all irrigation periods.

Pre-plant irrigations will be applied based on the treatments outlined in Table 1. During the growing season, soil water balances will be calculated for each treatment using data from the Texas High Plains ET network (Porter, et al., 2005) or other local weather stations, local rainfall, irrigation quantity from the previous irrigations and a locally derived water use function. Irrigations will begin as early as practical with irrigation termination no later than 10 Sept. Irrigation interval during reproductive and maturation periods will be once per week. The field layout will provide a complete randomized block experimental design with four replications.

Cotton will be planted and soil water monitored by the neutron scatter method. Plant developed during the growing season including final plant mapping will be documented. Cotton yield, fiber quality and water use efficiency will be determined for each treatment. Data analysis will be with standard AOV and means separation.

Texas Tech University Farms at Lubbock

Research will be conducted at the Texas Tech University Quaker Avenue Research Farm or the New Deal Research Farm on experimental plots having 1-m wide rows and SDI installed at 0.20 to 0.24 m depth, 61 cm emitter spacing, and in every crop row. Irrigation treatments will include T2, T5, and T6 (Table 1) with up to four cultivars in each irrigation treatment. In season plant height, total node measurements, and final plant mapping measurements will be recorded. Yield, fiber quality and water productivity will be determined.

Expected Outcomes

This project will further define methods to consistently get the highest possible value from every drop of water removed from the Ogallala Aquifer by reducing or eliminating irrigation losses due to evaporation and deep percolation, ensuring timely crop establishment without the expense of "every row" SDI installation, reducing irrigations in periods when plant stress may be less harmful to cotton yield, and utilizing rainfall effectively. An economic evaluation will be made at the conclusion of the field experiments. Results will be made available at field days, local cotton conferences, irrigation workshops, Beltwide Cotton Conferences, national and international conferences, as well as appropriate targeted mass media. Papers will be published in suitable journals at the conclusion of these experiments. Two journal articles are currently being prepared related to reducing early season irrigations using LEPA irrigation (variable irrigation capacity, supported by OAP) and one paper on SDI irrigation intervals (also supported by OAP).

Relevant Publications of Investigators

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