

TILLAGE SYSTEMS AND IRRIGATION STRATEGIES FOR SDI COTTON PRODUCTION IN THE TEXAS ROLLING PLAINS

John Sij

Texas AgriLife Research

Vernon, TX

David Jones

Texas AgriLife Research

Chillicothe, TX

Mark Belew

Paul DeLaune

Texas AgriLife Research

Vernon, TX

Abstract

Since agriculture is a major consumer of water for food and fiber production, it becomes critical to use efficient water delivery systems to crops in addition to utilizing the most drought-tolerant water-efficient crops, cropping systems, tillage practices, and plant genetic materials available in sustainable crop production. The objective of this research is to develop conservation tillage and water management strategies that enhance crop stand establishment, water-use efficiency, and yield in a subsurface drip irrigation (SDI) system for cotton production in the semi-arid Texas Rolling Plains. Five irrigation regimes (0, 33, 66, 100, and 133% ET replacement) and four tillage systems (conventional-till, reduced-till, no-till flat, and no-till with a terminated cover crop) were included in the study. Acceptable plant stands were obtained in all tillage systems. Bolls ft^{-1} increased up to 66% ET replacement and remained constant at 100% and 133% ET replacement. Irrigation levels at 100% and above delayed boll opening, due to prolonged vegetative development and late boll set. Plant heights increased in a linear fashion with increased amounts of irrigation. Lint yields increased up to 66% ET replacement, while increased irrigation above 66% ET replacement did not significantly ($P < 0.05$) increase yield. There were no significant differences among tillage systems under any ET treatment. Under our environmental conditions in 2008, estimated net economic returns favored the no-till flat-planted system.

Introduction

Both surface and ground water are vital natural resources critical to a healthy Texas economy and the well-being of all its citizens. Predictions that global climate change may increase in drought-prone regions, mandates that ground water resources be used ever more prudently. Since agriculture is a major consumer of water for food and fiber production, it becomes critical to use efficient water delivery systems to crops, in addition to utilizing the most drought-tolerant water-efficient crops, cropping systems, tillage practices, and plant genetic materials available in sustainable crop production. Subsurface drip irrigation (SDI) is perhaps the most efficient water delivery system to roots of plants, producing crop yields equal to or greater than other irrigation methods and, in many cases, requiring less water and improved water-use efficiencies (Bhattarai et al., 2005; Camp, 1998; Lamm and Trooien, 2003).

Water is the most limiting factor in cotton production in the semi-arid Rolling Plains. Only 5 to 8% of the agricultural land is irrigated in the Rolling Plains, yet cotton yields from irrigated production can be 3 to 6 times higher and much more stable than dryland production, thereby accounting for a significant portion of the region's farm revenue. Expanding irrigated acreage using current irrigation systems is extremely limited. Since ground water resources from the area's Seymour Aquifer are fragmented and restricted, irrigated cotton production can only expand through the use of more efficient irrigation systems and increased management of those water resources. Furrow and pivot irrigation are relatively inefficient water delivery systems compared with SDI, particularly under limited water supplies. Furthermore, irregular-shaped fields cannot be efficiently irrigated with pivots and furrow irrigation systems. Utilizing SDI technology has the potential to measurably increase cotton yields and expand irrigated production acreage in hard-to-water fields, thereby increasing the standard of living for rural families and strengthening rural economies. However, little acreage has been placed under drip in the Rolling Plains compared with the High Plains region. Current irrigation work at Lubbock, TX that included pre-plant irrigation strategies showed an increase in water-use efficiency of the SDI system of 16% and 30% over LEPA and spray, respectively, with the least pre-plant water loss with SDI (Bordovsky, 2006). At Bushland, TX, Colaizzi (2006) and Colaizzi, et al. (2004) showed that SDI resulted in greater lint yield at 50% or less evapotranspiration (ET) replacement, whereas

LEPA and spray performed equal to or greater than SDI at greater irrigation treatments. Preliminary studies with SDI at the Munday, TX station in 2002 to 2005 indicated that reducing irrigation water 50% (based on 50% evapotranspiration demand) reduced cotton yields only 18% without a reduction in fiber quality (Sij et al., 2006). Bhattarai et al. (2005) also concluded that 100% crop ET replacement is not necessary to optimize plant productivity and water-use efficiency. Over irrigation can lead to excessive runoff when a high rainfall event occurs and increased internal drainage that can transport nitrates and other nutrients deeper into the soil profile and ground water. Moreover, SDI appears to be a more efficient delivery system for nitrogen, so less nitrogen fertilizer is needed to maximize yield (Sorensen et al., 2004). However, one noted problem with SDI in semi-arid environments is poor stand establishment some years (Charlesworth and Muirhead, 2003; Enciso et al., 2005). Current studies on the High Plains have focused on bed design or soil amendments to enhance crop emergence, and in Australia, scientists studied SDI configurations and an experimental polyethylene/geotextile product laid with the drip tape to enhance water movement away from the source to the seed.

There is limited information of using no-till and conservation tillage with terminated cover crops in an SDI system (Camp et al., 1999). We are unaware of any research in Texas or nationally that combines conservation tillage practices with a range of deficit irrigation regimes. Yet there may be significant advantages in doing so by capturing and retaining limited rainfall to save ground water, improving stand establishment, reducing soil erosion from wind and water, aiding weed control, and enhancing water-use efficiency. The objective of this study is to develop conservation tillage and water management strategies that enhance crop stand establishment, water-use efficiency, and yield in SDI cotton production in the Rolling Plains.

Materials and Methods

A SDI system was installed on an Abilene clay loam near Chillicothe, TX in 2006 (Fig. 1).

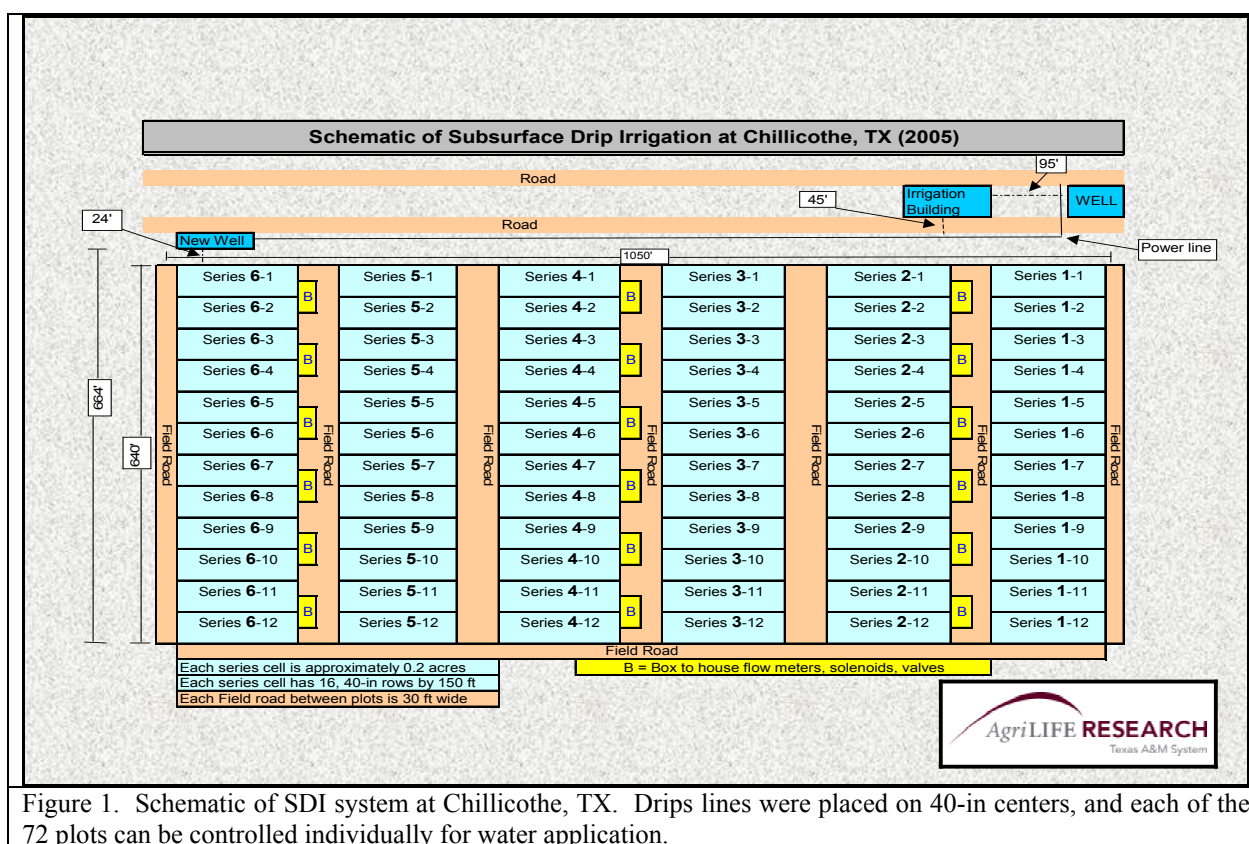


Figure 1. Schematic of SDI system at Chillicothe, TX. Drips lines were placed on 40-in centers, and each of the 72 plots can be controlled individually for water application.

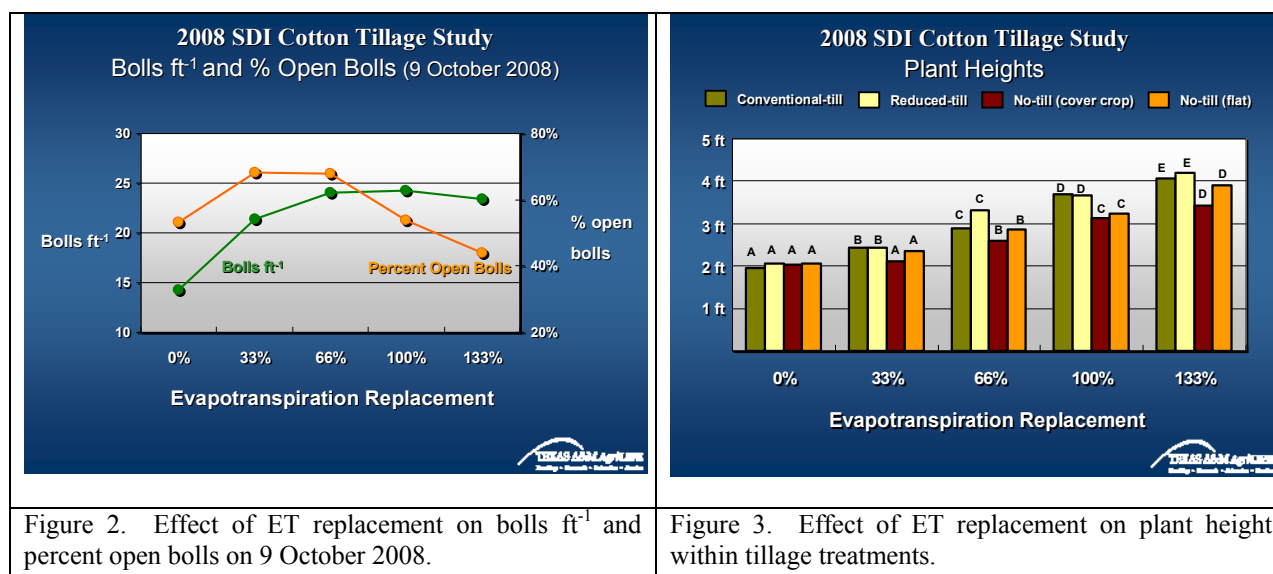
Drip lines were placed 12 to 14 inches deep on 40-inch centers using a GPS/RTK autosteer system that provided sub-inch accuracy. Plots were eight rows wide by 150 feet long. Stoneville 4554 B2RF cotton was planted 15 May 2008 directly over the drip lines at a seeding rate of 4.2 seeds per foot of row. Irrigation began June 4 and ended

August 14. Treatments included five irrigation regimes: 0, 33, 66, 100, and 133% ET replacement (ET data obtained from the High Plains PET network) and adjusted weekly based on the previous 7-day moving average and rainfall. Water input to each plots was monitored with wireless flow meters so accurate application rates could be maintained. Tillage systems included conventional-till (bedded), conventional reduced-till (flat planted), no-till, and no-till in a terminated cover crop. Treatments were replicated three times. Parameters measured included bolls ft^{-1} , opens bolls ft^{-1} . Data were analyzed using Proc GLM of SAS (SAS Institute, Version 9.1). Means were considered significantly different when $P < 0.05$.

Results and Discussion

Differences in plant population were minimal across tillage treatments. In 2008 there did not appear to be a problem with obtaining acceptable stands. In the semiarid Rolling Plains, there is usually enough rainfall in May and June to establish a crop most years, unlike the more arid areas in the west where stand establishment is more problematic under SDI (Charlesworth and Muirhead, 2003; Enciso et al., 2005).

Within an irrigation treatment, there was no interaction between bolls ft^{-1} or percent open bolls and tillage treatment. Bolls ft^{-1} increased up to 66% ET replacement (Fig. 2). There were fewer open bolls at the 0, 100, and 133% ET replacement treatments on 9 October. With the 0% ET treatment, August rainfall stimulated late-season vegetative growth and additional boll set, resulting in delayed boll opening. Plants in the 100 and 133% ET replacement treatments continued to develop throughout the fall; flowering and setting late-season bolls. Within each tillage treatment, plant height increased in a near linear fashion with increasing ET replacement (Fig. 3).



Within an ET treatment, conventional-till and reduced-till generally responded to a greater extent to increasing ET replacement than no-till with cover crop and no-till flat (Fig. 4). It is not known whether allelopathy (Hicks, et al., 1989) was responsible for the comparatively reduced plant height in the no-till/cover crop tillage system among ET replacement treatments. There was no interaction for yield between tillage and ET treatment. Although there were numerical differences, there were no significant differences ($P < 0.05$) for yield among tillage systems within an ET replacement treatment (Fig. 5).

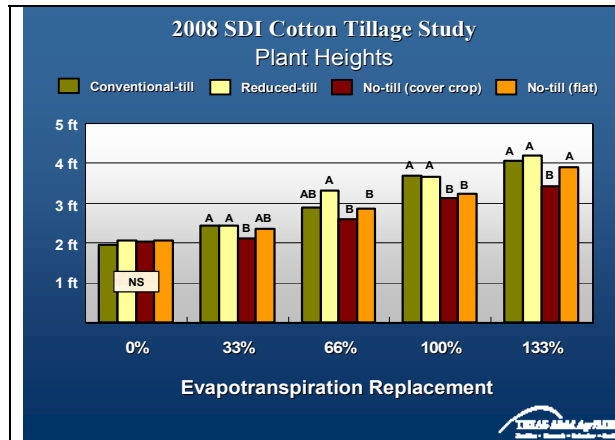


Figure 4. Effect of ET replacement on plant height within irrigation treatments.

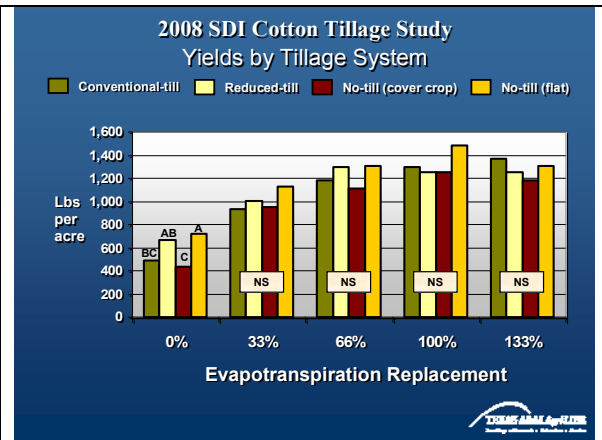


Figure 5. Effect of ET replacement on lint yield within irrigation treatments.

However, there was a significant yield increase from 33% to 66% ET replacement, but no significant yield difference above the 66% ET replacement treatment (Fig. 6). Estimated net returns favored the no-till flat tillage system (Fig. 7). This system also had the least number of field operations, which enhanced net return. The study will be repeated next year and in the same plots.

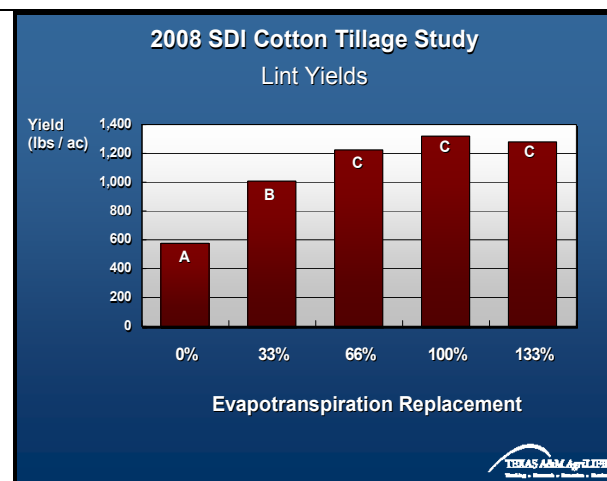


Figure 6. Effect of ET replacement treatment on lint yield across all tillage treatments.

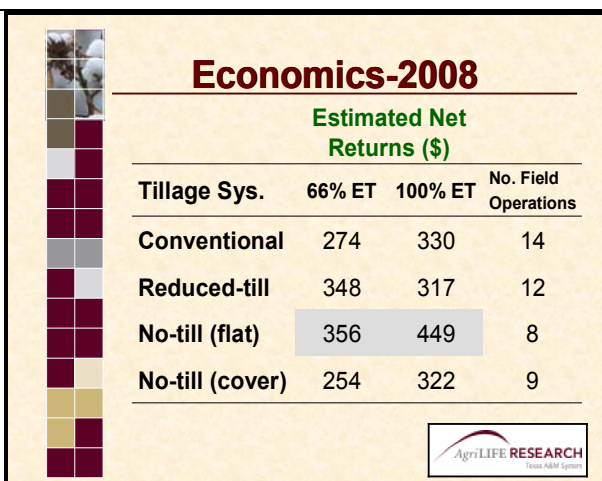


Figure 7. Estimated returns from 66% and 100% ET replacement from four tillage systems.

Summary

A subsurface drip system was established in 2006 at Chillicothe, TX to study cotton production and cotton production systems in the semi-arid Rolling Plains under controlled irrigation regimes and various tillage systems. Five irrigation regimes (0, 33, 66, 100, and 133% ET replacement) and four tillage systems (conventional-till, reduced-till, no-till flat, and no-till with a terminated cover crop) were included in the study. Acceptable plant stands were obtained in all tillage systems. Bolls ft^{-1} increased up to 66% ET replacement and remained constant at 100% and 133% ET replacement. Irrigation levels at 100% and above delayed boll opening, due to prolonged vegetative development and late boll set. Plant heights increased in a linear fashion with increased amounts of irrigation. Lint yields increased up to 66% ET replacement, while increased irrigation above 66% ET replacement did not significantly ($P < 0.05$) increase yield. There were no significant differences among tillage systems under any irrigation treatment. Under our environmental conditions in 2008, estimated economic returns favored the no-till flat-planted system.

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References

- Bhattarai, S.P., A.D. McHugh, G. Lotz, and D.J. Midmore. 2005. The response of cotton to subsurface drip and furrow irrigation in a vertisol. *Expl Agric.* 42:29-49.
- Bordovsky, J. 2006. Irrigation timing, method affects producers' bottom line. *Research in Review*. May 29. Texas Agric. Exp. Stn. MKT 3536.
- Camp, C.R. 1998. Subsurface drip irrigation: A review. *Trans. ASAE*. 41(5):1353-1367.
- Camp, C.R., P.J. Bauer, and W.J. Busscher. 1999. Evaluation of no-tillage crop production with subsurface drip irrigation on soils with compacted layers. *Trans. ASAE* 42(4): 911-917.
- Charlesworth, P.B., and W.A. Muirhead. 2003. Crop establishment using subsurface drip irrigation: a comparison of point and area sources. *Irrig. Sci.* 22:171-176.
- Colaizzi, P.D., A.D. Schneider, S.R. Evett, and T.A. Howell. 2004. Comparison of SDI, LEPA, and Spray Irrigation performance for grain sorghum. *Trans. ASAE* 47(5): 1477-1492.
- Colaizzi, P.D. 2006. Subsurface drip irrigation (SDI) research at Bushland, TX. *Wetting Front - Soil and Water Management Research Unit News*. USDA ARS Conservation and Production Research Laboratory. May.
- Enciso, J.M., P.D. Colaizzi, and W.L. Multer. 2005. Economic analysis of subsurface drip irrigation lateral spacing and installation depth for cotton. *Trans. ASAE* 48(1): 197-204.
- Hicks, S.K., C.W. Wendt, J.R. Gannaway, and R.B. Baker. 1989. Allelopathic effects of wheat straw on cotton germination, emergence and yield. *Crop Sci.* 29:1057-1061.
- Lamm, F.R. and T.P. Trooien. 2003. Subsurface drip irrigation for corn production: a review of 10 years of research in Kansas. *Irrig. Sci.* 22:195-200.
- Sij, J.W., J.E. Slosser, W.A. Albeldano, and D.G. Bordovsky. 2006. Utilizing subsurface drip irrigation and conservation tillage in crop production systems in the Texas Rolling Plains. Final Report. The Cotton Foundation. July.
- Sorensen, R.B., M.J. Bader, and E.H. Wilson. 2004. Cotton yield and grade response to nitrogen applied daily through subsurface drip irrigation. *Applied Engineering in Agriculture* 20(1): 13-16.