IMPACT OF TILLAGE, WATER MANAGEMENT, AND WELL WATER NITRATE ON SUBSURFACE DRIP IRRIGATED COTTON PRODUCTION

Paul DeLaune
John Sij
David Jones
Seong Park
Mark Belew
Texas AgriLife Research
Vernon, TX

Abstract

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 is critical as agriculture is a major consumer of water for food and fiber 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. The following report summerizes results of a two-year study that includes 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). Acceptable plant stands were obtained in all tillage systems. There were no significant differences among tillage treatments for estimated lint yield within irrigation treatments. With the exception of the no-till flat treatment, there were no significant differences in lint yields within tillage treatments across irrigation treatments above 66% ET replacement. When grouping tillage treatments together, there was no significant difference in lint yields averaged over 2 yrs at ET replacements >66%. The greatest net return was seen with the no-till cover crop system at 100% ET replacement. This study also showed that significant amounts of nitrogen can be applied in systems using well water high in nitrate.

Introduction

Agriculture accounted for nearly 65% of world's water consumption in 2000. Thus, efficient water delivery systems to crops are essential, in addition to utilizing the most drought-tolerant water-efficient crops, cropping systems, tillage practices, and plant genetic materials available in sustainable crop production. Water is the most limiting factor in stable cotton production in the semiarid Texas Rolling Plains. Even though irrigated cotton acreage amounts to less than 15% of total cotton production in this region, it can acount for 24 to 50% of total lint production, depending on the crop year (e.g. 2006 vs. 2007) . Irrigated crop yields can be 2 to 4 times higher than those from dryland production and much more stable from year to year. 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). Because one can precisely manage irrigation amounts through SDI, producers may be able to increase their irrigated acreage with existing well capacities and thereby increase overall economic returns. However, economic return also depends on additional inputs such as fertilizer, pest control, and tillage practices. 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 SDI cotton production in the Texas Rolling Plains.

Materials and Methods

Stoneville 4554 B2RF cotton was planted 15 May 2008 and 21 May 2009 directly over drip lines using a GPS/RTK autosteer system at a seeding rate of 4.2 seeds per foot of row. Drip lines are 12 to 14 inches deep on 40-inch centers. Plots were eight rows wide by 150 feet long. Tillage systems included conventional-till (bedded), conventional reduced-till (flat planted), no-till, and no-till in a terminated cover crop. Irrigation treatments included five rates: 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. Plots were irrigated from 4 June to 14 August in 2008 and from 19 June to 1 September in 2009. Water input to each plot was monitored with wireless flow meters so accurate application rates could be maintained. Plots were machine-harvested for yield. Treatments were replicated three times in a randomized complete block design. 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

Much of the 2008 data can be found in the 2009 Beltwide Proceedings (Sij et al., 2009) and most discussion will focus on 2009 data. There was no problem in obtaining acceptable stands in either year. 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). For 2009, there was a significant difference in the number of surviving seedlings at 133% ET replacement compared with lower ET replacement levels (data not shown). Apparently, excessive irrigation results in greater competition among plants to the point that some late-developing seedlings do not survive.

As seen in 2008, there were no significant differences among tillage treatments for lint yields within irrigation treatments (Figure 1). However, rate of irrigation did have a signicant impact on lint yields within tillage treatments (Figure 1). Lint yields were greatest at 100% ET replcacement for all tillage treatments. With the excpetion of the no-till falt treatment, there were no significant differences in lint yields at ET replcaement greater than 66%. Within the no-till flat treatment, lint yields were signficantly higher for the 100% ET replacement compared to the 133% ET replacement. Although boll counts were higher for the 133% ET treatment compared to the 66% ET treatment, yields were not significanlty different. As seen in 2008, increasing irrigation beyond 66% ET replacement delayed boll opening. Depending on the length of the growing season, delayed boll opening can result in problems with timely harvest as well as reduced lint quality, even though lint yields may be increased. These preliminary data indicate that there is no preferred tillage system that will result in higher cotton yields under SDI at either deficit or full irrigation. The type of tillage system used with SDI will be determined by inputs and other economic factors.

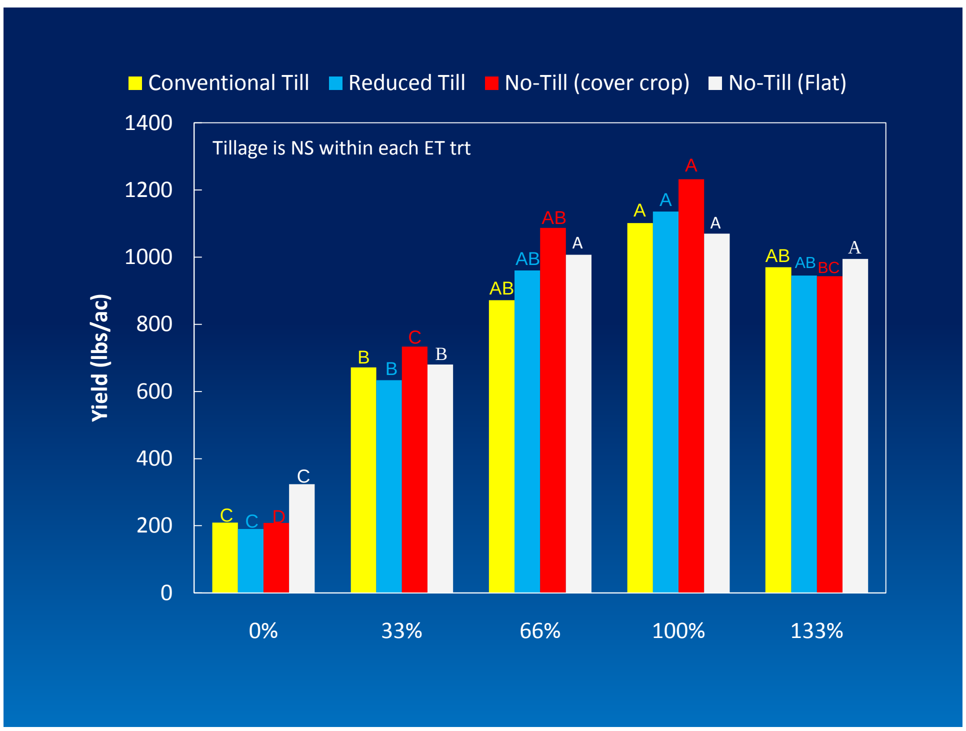

Figure 1. Effect of ET replacement on 2009 lint yields. Letters represent significant differences among ET treatments within a tillage system.

Since tillage did not have a significant effect on yield within irrigation treatments, lint yields averaged across all tillage treatments within each irrigation regime are presented (Figure 2). In general, for both years, yields generally increased up to an ET replacement of 66%. For 2008, there were no significant differences in lint yield for ET replacement rates 66% or greater. Lint yields were significantly lower from 66% and 133% ET replacements than the 100% ET replacement for 2009. However, there were no significant differences for ET replacements >66% for the 2-yr average (Figure 2). Based on these data, optimum irrigation rates probably range between 75 and 85%. Although there was substantial hail damage in 2008, lint yields were higher in 2008 than 2009. In contrast to 2008, 2009 was much drier with extreme temperatures including 35 days above 100 F^{o}.

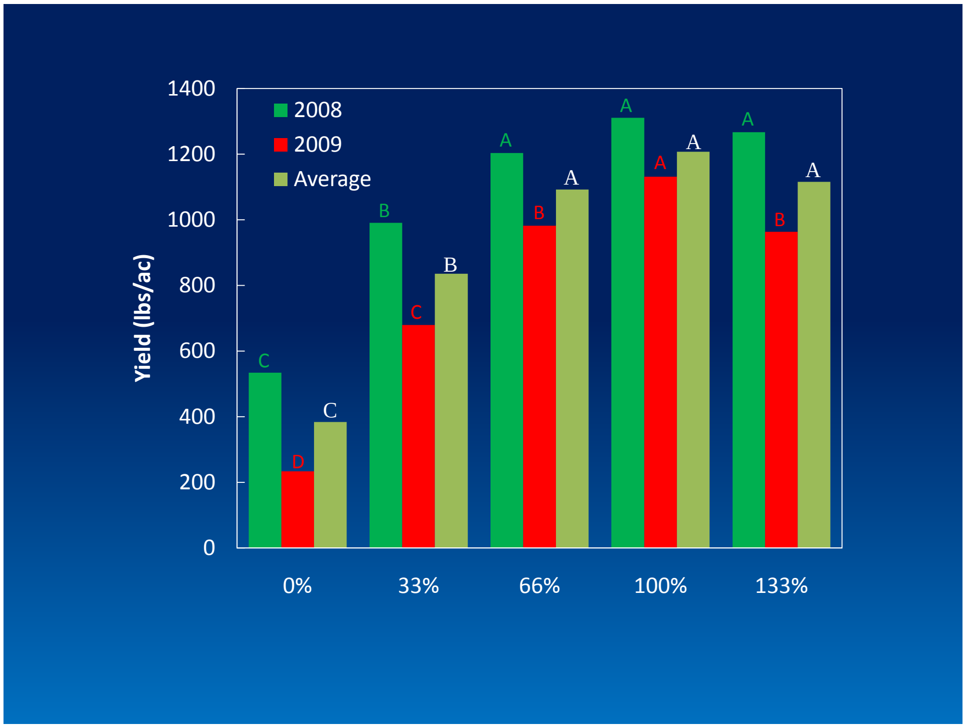

Figure 2. Effect of ET replacement on yield for 2008, 2009, and the average for both years.

Estimated net returns favored the no-till tillage systems (Table 1). These systems also have the least number of field operations, which enhanced net return. The greatest net return for 2009 was from the no-till cover crop system at 100% ET replacement (Table 1). Within each ET treatment, no-till (either cover or no cover) had the greatest net return. This differs from 2008, which showed that the greatest return was from the no-till (flat) system without a cover crop (Sij et al., 2009). This is only the second year of production in no-till. With time, this trend may continue as the benefits of no-till with a cover crop become more evident once the system has become well established.

Table 1. Estimated net returns for the production year 2009 (loan value not included).

ET Replacement	Conventional till	Reduced till	No-till (flat)	No-till (cover-crop)
0%	**-$77**	**-$82**	**-$13**	**-$79**
33%	**$135**	**$121**	**$149**	**$162**
66%	**$224**	**$270**	**$298**	**$323**
100%	**$327**	**$347**	**$323**	**$386**
133%	**$261**	**$254**	**$283**	**$271**

Rainfall during the 2008 growing season totaled 17.2 inches in 2008, but only 10.1 inches in 2009. Thus, the amount of water added in 2009 was much higher (Figure 3A). Approximately 15 inches of water was applied with the 100% ET treatment. The groundwater at the Chillicothe Research Station has elevated nitrate levels averaging 20 mg L^{-1} NO_3-N, which exceeds the EPA drinking water standard of 10 mg L^{-1} NO_3-N. As a result, significant amounts of N are supplied by the well water. For example, nearly 70 lbs NO_3-N ac^{-1} was supplied with the 100% ET treatment (Figure 3B). Almost 100 lbs N were added with the 100% ET treatment, adequate N to produce nearly 2-bale cotton. In areas where elevated levels of nitrate exist, nitrate crediting should be considered in nutrient management plans.

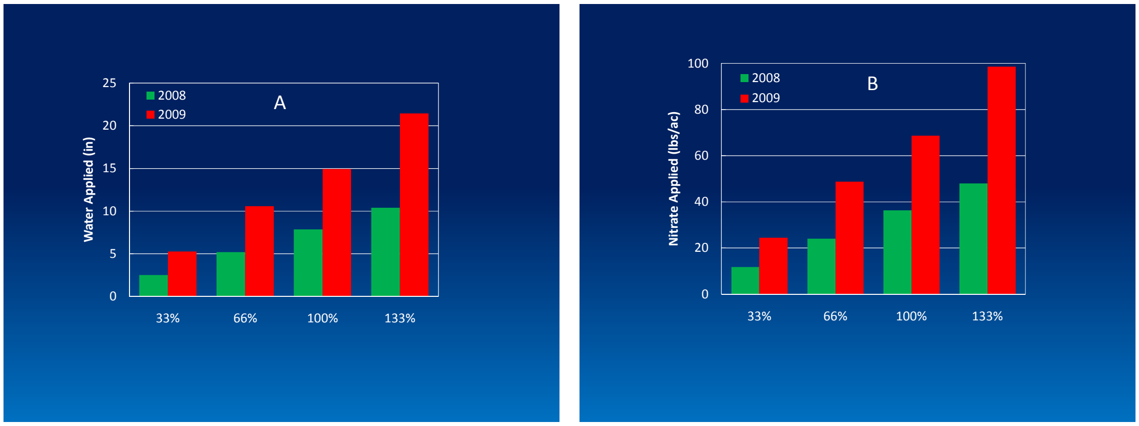

Figure 3. The amount of A) water; and B) nitrate applied during 2008 and 2009. Nitrate applied is a result of elevated nitrate levels in the well water.

Summary

Four tillage systems and five subsurface irrigation regimes have been evaluated for two years at the Chillicothe Research Station. Acceptable plant stands were obtained in all tillage systems. Tillage treatments did not significantly differ within irrigation treatments. Data indicate that there is no preferred tillage system that will result in higher cotton yields under SDI at either deficit or full irrigation. The type of tillage system used with SDI probably will be determined by inputs and other economic factors. In general, lint yields increased up to 66% ET replacement, while increased irrigation above 66% ET replacement did not significantly increase yield. Highest yields were achieved under 100% ET replacement treatments. The greatest estimated net return for 2009 favored the no-till system with a cover crop at 100% ET replacement. The highest net return within each irrigation ET treatment was from a no-till system. As a result of elevated nitrate levels in the well water, 49, 69, and 99 lb N ac^{-1} were added with ET repalcement rates of 66, 100, and 133%, respectively.

Acknowledgements

The authors wish to acknowledge the Texas State Support Committee of Cotton Incorporated and the Texas State Soil and Water Conservation Board [under CWA Section 319(h), EPA] for their financial support of this project.

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.

Camp, C.R. 1998. Subsurface drip irrigation: A review. Trans. ASAE. 41(5):1353-1367.

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.

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.

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., D. Jones, M. Belew, and P. DeLaune. 2009. Tillage Systems and Irrigation Strategies for SDI Cotton Production in the Texas Rolling Plains. Proceedings: Beltwide Cotton Conference. 5-8 Jan. San Antonio, TX.