Irrigating Cotton in a Thermally-limited Area

Mahbub Alam[1]

[1]Extension Irrigation Specialist, Kansas State University, SW Research-Extension Center, Garden City, KS. Phone: 620-275-9164, Fax: 620-276-6028. Email:malam@ksu.edu

Paul D. Colaizzi[2]**, Danny H. Rogers**[3]**, and L. K. Shaw**[4]

[2]Agricultural Engineer, USDA-ARS, Bushland, TX; [3]Professor, Kansas State University, Manhattan, KS; and [4]Mobile Irrigation Lab Program coordinator, Kansas State University SWREC, Garden City, KS,.

Abstract: *Southwest Kansas is north of the traditional Cotton Belt and considered a thermally limited area for cotton; however cotton is being grown as an alternative to corn to stretch declining water resources. Producers in this region have adopted both sprinkler and subsurface drip irrigation (SDI), but SDI may result in greater soil temperatures due to less evaporative cooling compared with sprinkler. This is an important consideration for cotton production in a thermally-limited climate. A field demonstration was conducted in 2007 to compare soil temperatures for sprinkler and SDI planted in cotton. The season started with relatively low temperatures but rapidly increased. First bloom occurred on July 24 (63 days since emergence) when cumulative growing degree days (GDD; 60 °F base temperature) reached 847 °F, which was about 100 °F lower from areas in the traditional Cotton Belt. Total GDD from planting date of May 10 to September 30 was 1907 °F, which was about 250 °F less than that expected in the Cotton Belt. The daily average soil temperature was about 6 °F greater for SDI compared with sprinkler. However, lint yield was 1,164 lb ac^{-1} for the sprinkler irrigated field, slightly higher compared to 1,005 lb ac^{-1} for the SDI field. This differential in yield was contributed by timely and higher amount of soil water availability. The sprinkler irrigated field received about 5.7 inches of water input from rain and irrigation, whereas the SDI field received only 3.9 inches combined from irrigation and rain. The SDI field did not receive irrigation after mid-July, but the sprinkler field received irrigation in both late July and mid-August. Irrigation timing and amount applied had effect on yield. Amount of residue cover in no-till effected plant population, but plant population had no effect on yield.*

Keywords: Ogallala aquifer, thermally limited area, cotton, SDI, irrigation

Introduction: In Southwest Kansas, the capacities of irrigation wells are declining with the decline of the Ogallala Aquifer groundwater level. Producers are looking for alternative crops to conserve water and at the same time maintain economic sustainability. Farmers in Southwest Kansas and North Plains of Texas are considering cotton as an alternative crop, which has respectable revenue potential as corn but about half the irrigation requirement (Howell et al., 2004). Acreages were increasing, but in 2004 the heat units were low for cotton. This adversely impacted yield and quality, and as a result the acreage declined. It is also possible that cooling due to surface wetting of canopy and or soil surface from sprinkler or surface irrigation may lower the perceptible heat units for the cotton plant, especially in thermally limited areas. Subsurface drip irrigation (SDI) may result in less evaporative cooling from the soil surface and crop canopy compared with sprinkler irrigation, which could potentially result in earlier establishment and maturity of the crop. The objective of the study was to compare soil temperatures, plant development, and yield for cotton irrigated with sprinkler and SDI.

Procedures

Two fields within a one-mile radius operated by the same producer were selected for the field study and demonstration. One of the fields was irrigated by SDI and the other was irrigated by center pivot sprinkler system. The sprinkler-irrigated field was previously planted in corn and had good residual soil water when the cotton crop was planted. The SDI field was previously planted in grain sorghum for half the length and soybean in the remaining half of the field. Both fields were cultivated in a no-till method. At the time of cotton planting on May 10, 2007, the fields had different amounts of residue cover. The USDA-NRCS Line Transact method was used to determine the residue cover. The sprinkler irrigated cotton was planted with a 45% corn residue cover on the field. The SDI field had only 24% residue cover for the portion that grew grain sorghum. The other half that had soybeans had very little residue.

The residue cover had a big impact on plant stand. Plant population counted initially at emergence for the sprinkler irrigated field with no-till corn residue (45%) was about 20,000 plants ac^{-1}, whereas in the SDI field with Milo residue (24%) the population was more than 25,000 plants ac^{-1}. Plant population in the clean field area was 62,378 plants ac^{-1}, exceeding target plant population of 50,000 plants ac^{-1} (with a seeding rate of 55,000 plants ac^{-1} indicating that the planter dropped more seed then the calibrated rate).

Irrigation was done by the producer as and when available. For the first year no control was imposed. The sprinkler field received 2.5 inches of irrigation and was applied at the critical stages. Rainfall in this site was recorded as 6 inches. The SDI field received 1.7 inches of irrigation at the rate 0.08 inches per day, which was far below the ET rate. Irrigation was not available after July 15 for the SDI irrigated field, a very critical period when the field was in bloom. Rainfall amount at this site was about 4 inches. There was also severe damage from 2-4-D herbicide drift in the SDI field. The sprinkler field experienced no damage from herbicide drift and was irrigated until mid-August which helped the crop at critical bloom stage. A summary of the field conditions are shown in table 1.

Thermocouples were laid in three rows in each site at 4 different depths- at 0, 2, 4, and 6 inches below surface. Temperature was averaged for each field from 24 hours data collected at 15 minutes interval. A solar panel installed at each site provided power to recharge batteries that powered the data logger. Plant growth data were recorded. Yield reported was based on lint weight from total field production. Hand harvested yield is also shown in table 1.

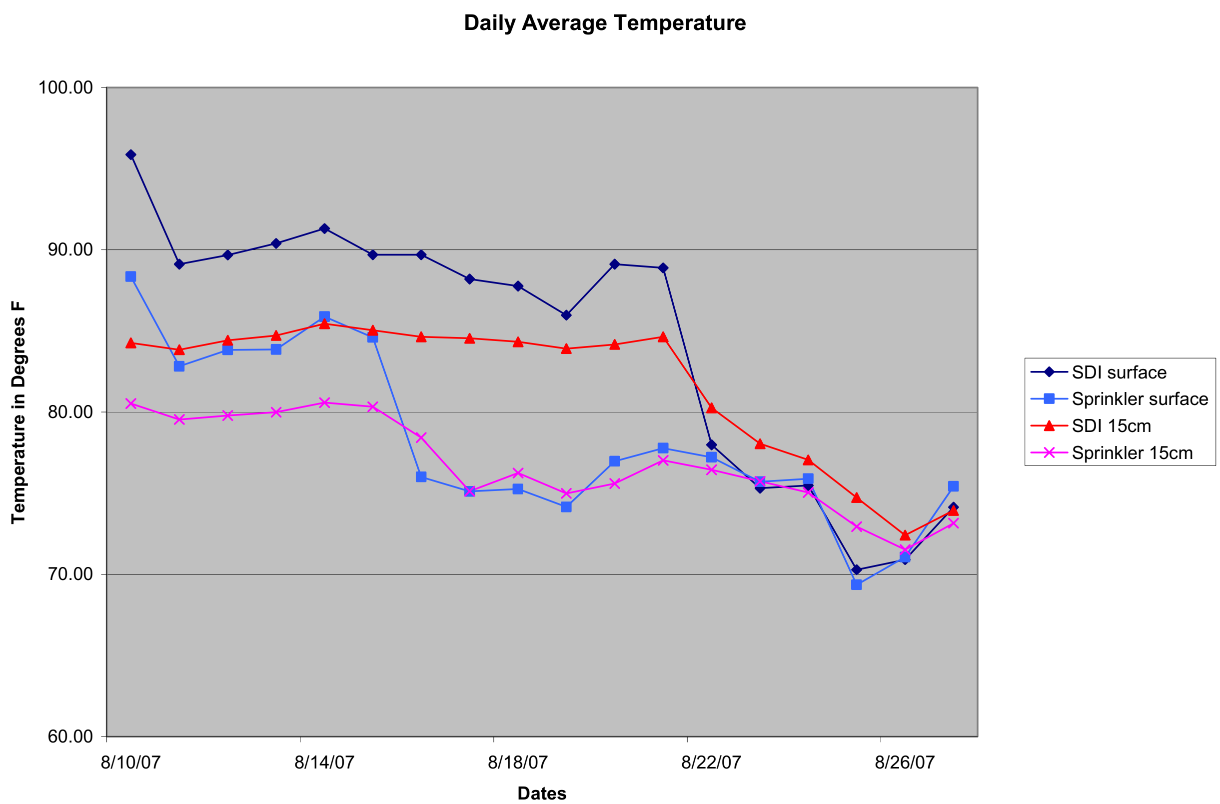
Table 1: Summary of field conditions for the study sites

Sprinkler	Subsurface drip
Hybrid: Paymaster 2145-PGR 4 Cruiser	Hybrid: Paymaster 2145-PGR 4 Cruiser
Seed rate: 55,000 per acre	Seed rate: 55,000 per acre
Target plant population: 50,000	Target plant population: 50,000
Planted in no-till corn residue	Planted in no-till grain sorghum and soybean residue
Residue cover measured using NRCS line transact method was about 45%	Residue cover in grain sorghum was 24% and minimal in soybean residue area
Planting Date: 5/10/2007	Planting Date: 5/10/2007
Start of Emergence: 5/23/07	Start of Emergence: 5/18/07
Plant population per acre at emergence in the count row - 19,863; in harvest row -22,900	Plant population at emergence in count row in grain sorghum – 25,090 and in harvest row 24,891; soybean area at emergence in count row – 62,378 and in harvest row – 51,276
Herbicide: Prowl H2O – 5/12/07 Acephate – 6/2/07, Dual magnum & Omex 22 – 6/19/07, Acephate – 7/5/07,	Prowl – 5/12/07, Omex – 6/2/07, Dual magnum and Omex – 6/19/07, Acephate – 7/3/07
Growth control: Pix (10 oz) – 7/10/07	Growth control: Pix (12 oz) – 7/18/07
Water use: Crop ET – 14.3” (5-23 to 9-30) Reference ET – 33.24” Irrigation: 2.25”, Rain: 3.46” (effective) out of 6.53” (Total water input: 5.71”)	Crop ET – 12.95” (5-23 to 9-30), Reference ET – 33.24” Irrigation: 1.76”, Rain: 2.19” (effective) out of 4.6” (Total water input: 3.95”)
The daily average of 6 degrees lower	The daily average of 6 degrees higher
Av. Bolls/plant as of 9/12/07 is 14.5	Average number 14
Plant height – 30.25”	Plant height 33.7”
2-4-D damage: None	Extensive 2-4-D damage
Cotton GDD = 1907 by Sept. 30	Cotton GDD - 1907
Yield 2.2 bales (average harvest value per acre for the total field). Hand harvest value about 2.6 bales lint.	Yield 1.93 bales (average harvest value per acre for the total field). Hand harvest yield for grain sorghum area 1.3 and soybean area 2.2 bales.

The field trial failed in 2008 due to the lack of initial soil water for planting in the SDI field. The producer delayed planting as the moisture in the planting depth was insufficient. Later, the soil surface was scraped aside and seed planted in the favorable moist zone, but a heavy rainfall event caused soil crusting, which prevented emergence, and the crop was abandoned.

Results and Discussion:

The cotton crop began to emerge 5 days earlier for the SDI field (May 18) compared with the sprinkler field (May 23). This may have been more related to fewer residues in the SDI field resulting in greater daytime soil heating early in the season. Temperatures recorded for August 10-27, 2007 are presented in Figure 1. Soil temperatures were about 5-6 °F greater for SDI compared with sprinkler until August 21. Greater soil temperatures in SDI irrigated fields in the Texas High Plains were also reported by Colaizzi et al. (2006). In this study it was observed that with the cooling of the season the soil temperatures came closer and the difference between surface and 15 cm depth also shrank.



The yield in the sprinkler field was a little better indicating that irrigation at full bloom is more critical for yield. The sprinkler irrigated field received irrigation in late July and early to mid-August, which were critical periods. There was no water available for SDI field after mid-July, and the total water input was less for SDI field. Although soil temperatures were greater for the SDI field, final lint yield was probably limited by water stress during full bloom. It has been reported that use of SDI has resulted in greater crop yields, greater water use efficiency, better cotton fiber quality, and enhanced crop maturity compared with typical sprinkler packages (Bordovsky and Porter (2003), and Colaizzi et al. (2005)

Conclusion

One year field study indicates that a higher soil temperature is maintained in fields irrigated by SDI. This has potential in contributing to yield and quality of cotton, especially in a thermally limited area.

Acknowledgements

The authors thank the Ogallala Aquifer Program of USDA-ARS for partial funding and the participating producer Ron Lucas of Triple L Farms in Haskell County, Kansas.

References

Bordovsky, J. P., and D. Porter. 2003. Cotton response to pre-plant irrigation level and irrigation capacity using spray, LEPA, and subsurface drip irrigation. Presented at the 2003 ASAE International Meeting, Las Vegas, NV, 27-30 July. ASAE Paper No. 032008.

Colaizzi, P. D., S. R. Evett, and T. A. Howell. 2005. Cotton Production with SDI, LEPA, and spray irrigation in a thermally-limited climate. CD-ROM. Irrigation Association Annual Meeting, 6-8 Nov, Phoenix, AZ.

Colaizzi, P. D., S. R. Evett, and T. A. Howell. 2006. Near-surface soil water and temperature for SDI, LEPA, and spray irrigation. Irrigation Association 27th Annual International Show, San Antonio, TX, 5-7 November, 2006.

Howell, T. A., S. R. Evett, J. A. Tolk, and A. D. Schneider. 2004. Evapotranspiration of full-, deficit-irrigation, and dryland cotton on the Northern Texas High Plains. J. Irrig. Drain. Engrg., Am. Soc. Civil Engrgs. 130(4): 277-285.