Determining the Optimum Timing for the Final Drip Irrigation on Cotton Based on Crop Monitoring-West Texas 2006

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Summary:

The continued interest in expanding the use of heat unit (HU) calculations of COTMAN has initiated studies in the timing the last irrigation of the season. Preliminary work in 2002 indicated that yield losses can be substantial (up to 200 lbs of lint/acre) if irrigation is ended too soon and that water costs can increase with no yield benefit if irrigation is extended too long. All methods of irrigation have their own problems with determining the last irrigation and this study looked at subsurface or drip irrigation. Current recommendations are vague, depending on either percent open boll or nodes above cracked boll, and are poorly defined.

This study was designed to look at an easily measured component, heat units, and how it relates to ending irrigation. The intended treatments were 300, 400, 500 and 600 heat units (HU) accumulated after the cotton reached five (5) nodes above white flower (NAWF). However, extended drought and high temperatures were resulting in early cutout and we chose not to use the early treatment for concern about drastic yield reductions and so the irrigation was terminated at 398, 513 and 623 heat units. Evaluations included percent open boll, nodes above cracked boll (NACB) and yield. Late season water use was monitored using the Watermark® soil moisture sensor.

Previous studies indicated that irrigation should be terminated when the cotton reaches 5 NAWF and 400-500 HU are accumulated after that point. Because we chose not to use an early termination, no significant differences were apparent in the crop maturity measurements of NACB or percent open bolls. Differences expected to be seen with late irrigation were masked by the 6.1 inches of rain that occurred during rainfall events on August 27 and September 4, 2006.

The hand harvested data indicated a significantly greater yield at first harvest for the irrigation terminations of 398 HU (terminated 8/21) and 513 HU (terminated 8/26) than the later treatment of 623 HU (terminated 9/3). Machine harvested yields plateaued after irrigation was terminated at 398 HU.

As in the previous year studies, late season rain did affect the plots. Despite the complicating factors of additional rainfall and soil characteristics, four years of trials indicate that producers in West Texas should feel confident about terminating irrigation when 400-500 HU have accumulated after 5 NAWF (physiological cutout).

Objectives:

COTMAN has been under evaluation in Texas as a management tool for several years and is currently being incorporated into research trials and scouting programs to assist in making decisions associated with cotton production. COTMAN has both and early season component and a late season component with the late season component focused on end-of-season management decisions. Many of the rules for insecticide termination have been established and there is an interest in using COTMAN for other end-of-season decisions such as irrigation termination. Water costs are a major input and any savings by increasing efficiency or limiting additional water inputs will accrue to the producer immediately.

Current recommendations for timing of the final irrigation in subsurface drip irrigated cotton are based on a variety of factors. Some producers measure NAWF, rooting depth and soil water content of different soil types to refine their estimate. However, most producers make an educated guess based on firmness of bolls, percent open bolls and experience to time the last irrigation. A very small percentage still use a calendar date instead of the maturity of the crop.

A recommendation that relates final irrigation to physiological cutout and easily attained data should provide a more reliable measure and fit with other end-of-season management decisions such as insecticide termination and defoliation. This trial was the fourth year of a study designed to determine if the rules of COTMAN could be used to determine the final irrigation in subsurface drip irrigated cotton in West Texas. In 2002, a trial indicated that drastic yield reductions would occur when irrigation is terminated at 200 HU after cotton reaches five NAWF. The 2003 data indicated that no yield losses occurred from 400 HU to 700 HU. The 2004 data verified that yield losses will occur if irrigation is terminated before 400 HU and that there were no significant differences in yields with termination between 400 and 700 HU. This trial was established to refine the recommendations for irrigation termination on subsurface drip irrigation in West Texas.

Materials and Methods:

The study was conducted in a producer's commercial field near St. Lawrence, Texas. The design of the experiment was a randomized complete block design.

The variety was FiberMax 800 B2R planted on May 19, 2006 in 40 inch rows. The drip tape in this field is on 80 inch centers. Pre-plant irrigation was applied in the amount of 5 inches. In-season irrigation started on July 3. The plots were watered for 24 hours every three days. The field reached 5 NAWF on August 1. Table 1 shows a summary of the water applied, target HU accumulation, actual HU accumulation and date of treatment initiation. The growing season rainfall was well below average with 0.44 inches received from June 1 through August 1. The field received the first significant (above the potential evapotranspiration) rainfall on August 14 with 0.52 inches and 2.35 inches on August 27.

Water use was monitored this year with Watermark® soil moisture sensors. The sensors provide a relative figure for the remaining moisture in the field. The sensors were place at two different depths (12 and 24 inches) at two locations ("wet" and "dry") within each treatment. The "wet" location would be 20 inches from the drip tape and the dry location would be 60 inches from the drip tape.

Table 1. Summary of treatment initiation for drip irrigation termination study. St. Lawrence, TX. 2006.

Treatment (HU)	Actual HU Accumulated	Date Irrigation Terminated	Pre-season Irrigation (in.)	In-season Irrigation (in.)	Total Inches Applied
400	398	August 21	5.0	10.18	15.18
500	513	August 26	5.0	11.38	16.38
600	623	September 3	5.0	12.58	17.58

Plots were hand harvested on three dates from 0.001 acres in each plot and also machine harvested. Percent open and NACB observations were made on adjacent rows on six dates. At the final harvest, 100 boll samples were taken on adjacent rows to determine boll characteristics. All harvest samples were ginned on a small lab gin and data were analyzed in SigmaStat by a one-way ANOVA and if differences in the mean values existed then separated by Fisher's LSD.

Results and Discussion:

This was the first year of the irrigation termination trial to monitor the soil moisture situation. The soil moisture monitors used provide a relative value of the soil moisture content-a low value indicates high moisture content and a higher value would indicate drier conditions. All the treatments had similar graphs (Figures 1-3). The downward trend indicates that the irrigation was in a deficit situation. Evapotranspiration readings at a nearby weather station were indicating that the crop needed 0.3 inches of water per day and the system was only able to provide 0.2 inches.

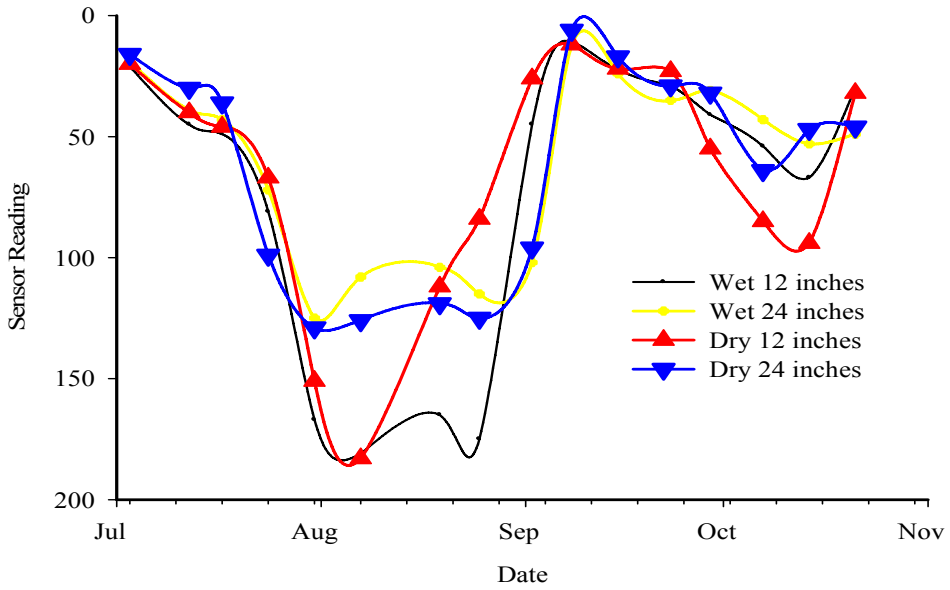

Figure 1. Watermark® soil moisture sensor readings for 398 HU after NAWF=5. St. Lawrence, TX. 2006.

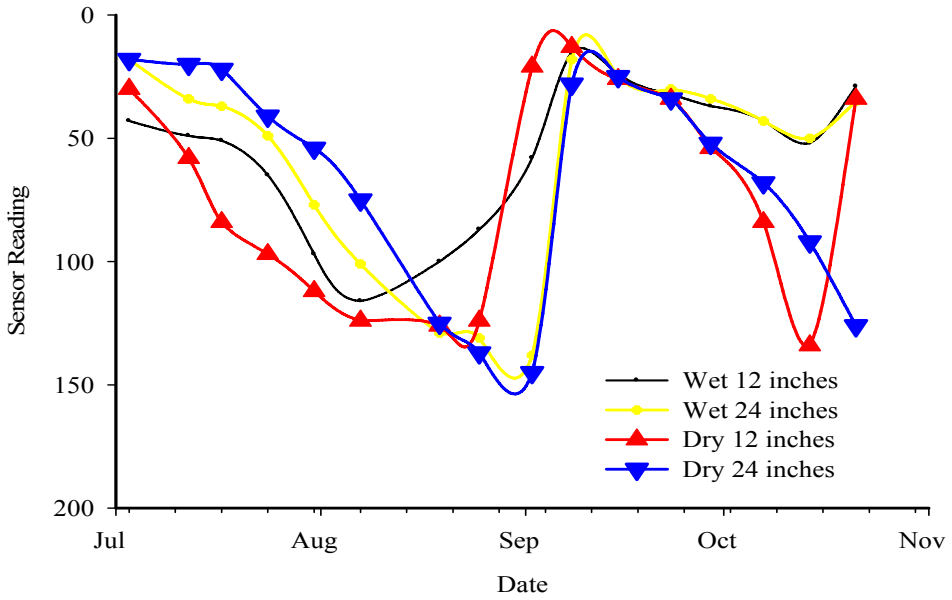

Figure 2. Watermark® soil moisture sensor readings for 513 HU after NAWF=5. St. Lawrence, TX. 2006.

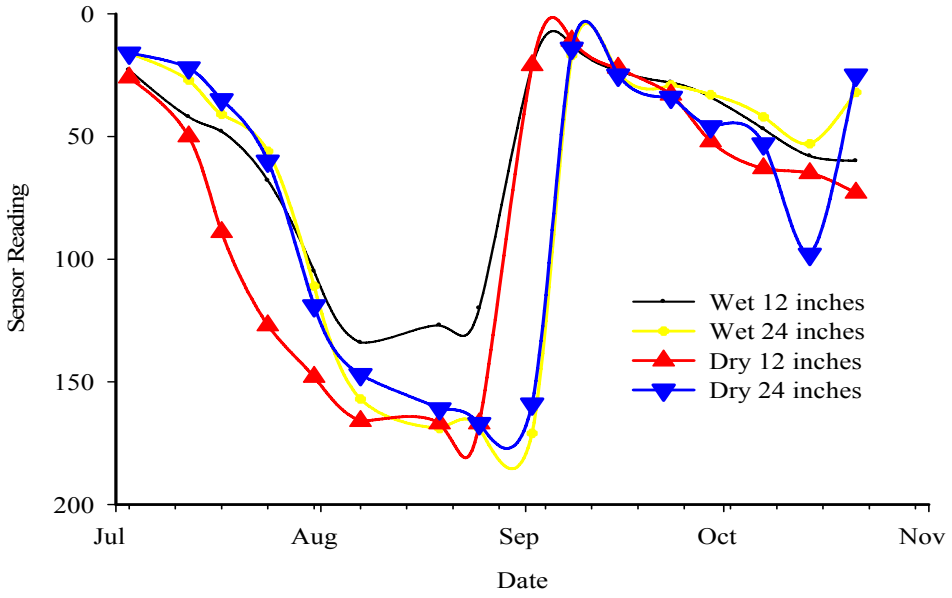

Figure 3. Watermark® soil moisture sensor readings for 623 HU after NAWF=5. St. Lawrence, TX. 2006.

One method of measuring the impact termination of irrigation is to look at NACB and percent open bolls. The trial this year did not include the early irrigation treatment over concern about significant yield losses with the deficit irrigation and drought. As such, no earliness was evident in any of the

treatments (Table 2). The trial was surprising in that the later irrigations were not able to extend the season and this again may have been a result of the drought and deficit irrigations.

Table 2. Nodes Above Cracked Boll (NACB) for each irrigation termination treatment, FM 800 B2R. St. Lawrence, TX. 2006.

Treatment	Sept 16	Sept 23	Sept 29	Oct 7	Oct 14	Oct 21
398	4.25a	3.25a	2.75a	2.50a	1.75a	1.25a
513	3.75a	3.50a	2.50a	2.50a	1.50a	1.50a
623	3.75a	3.75a	2.25a	1.75a	1.00a	1.75a
p-value	0.634	0.622	0.622	0.141	0.100	0.440

Means followed by the same letter are not significantly different (α=0.05)

As with NACB, there were no significant differences in percent open bolls (Table 3).

Table 3. Percent open bolls for each irrigation termination treatment, FM 800 B2R. St. Lawrence, TX. 2006.

Treatment	Sept 16	Sept 23	Sept 29	Oct 7	Oct 14	Oct 21
398	18.0a	29.0a	48.2a	57.0a	68.5a	86.3a
513	21.0a	27.5a	47.2a	57.3a	71.0a	82.5a
623	20.0a	29.7a	52.5a	62.8a	75.8a	84.3a
p-value	0.761	0.791	0.397	0.343	0.244	0.384

*Percent open was transformed for analysis and then retransformed to show the data
Means followed by the same letter are not significantly different (α=0.05)

Yield data by hand harvest and machine show similar trends indicating that irrigation termination should be after 400 HU have accumulated when cotton reaches physiological cutout. The hand harvested data indicates that ending termination at 398 to 513 HU significantly increased the amount of cotton at the first hand harvest date (Table 4). The proper termination of irrigation may be able to get the producer into the field earlier than watering later. No other significant differences between the hand harvests existed. No significant yield differences existed between the total hand harvest and machine harvest for the three irrigation terminations. The lack of a yield response to later irrigations indicates that producers should be able to end their drip irrigation earlier under the conditions experienced in this region.

Table 4. Lint yields (lbs. lint per acre) of hand harvest and machine harvest of FM 800 B2R for each irrigation termination treatment. St. Lawrence, TX. 2006.

Treatment	13 October	19 October	31 October	Tot. Hand Harvest	Gms. Per 100 bolls	Machine Harvest
398	932.00b	107.25a	96.50a	1135.75	597.50a	1226.50a
513	993.75b	89.25a	129.25a	1212.25	604.00a	1158.00a
623	744.75a	116.25a	212.75a	1103.75	616.25a	1137.50a
p-value	0.036	0.791	0.324		0.819	0.169

Means followed by the same letter are not significantly different (α=0.05)

Conclusions:

Although irrigation termination is a complicated production practice involving soil type, rooting depth and crop maturity, this trial in combination with data from 2002-2005 indicate that using physiological cutout in combination with accumulated heat units can be a viable tool for terminating irrigation at the end of the season. All five studies were done in conjunction with proper irrigation during the season. The five production seasons varied from above average rainfall to below average.

Data from 2002 indicated that terminating irrigation after 200 HU had accumulated after physiological cutout resulted in severe yield losses. Watering up to 700 HU resulted in a two week crop delay and a slight yield increase with optimum yields when irrigation was terminated at 550 HU. In 2003, the earliest cutoff was 400 HU accumulated after physiological cutout. The 2003 data showed that the highest yield was achieved at that point and there was no benefit to extending the irrigation.

The 2004-2006 data supported the previous year studies. Yield data indicates that the yield tend to plateau after 400 HU have been accumulated. Irrigation terminated before that time resulted in high yield losses. Although it is difficult to explain where the yield advantages are coming from, 100 boll samples indicate that boll size increases with the additional irrigations.

Under the assumption that water costs average $8.00 per acre inch in West Texas, a producer could have saved $5.60 to $19.20 per acre by ending irrigation at 400 HU rather than 500 or 600 HU. More importantly, the producer made 181 lbs. lint per acre by using 1.5 inches more water to extend irrigation to 400 HU during the studies from 2002-2004.

These studies show that irrigation termination can make a big difference to the producer. Despite the additional rainfall during the four years of the study, the data show that producers cannot end their watering regime too early in drip irrigation. On the other hand, the producer benefits very little from extending his drip irrigation past 500 HU accumulated after physiological cutout. This is especially true in the Southern Rolling Plains and St. Lawrence production regions when September is usually a wet month.

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