2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

THE EFFECT OF AN UPPER LIMIT TEMPERATURE THRESHOLD ON HEAT UNIT CALUCLATIONS, DEFOLIATION TIMING, YIELD AND FIBER QUALITY

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Abstract

Researchers from across the Cotton Belt have come to different conclusions on the optimum defoliation time based on COTMAN and the accumulated heat units from cutout (NAWF=5) method that the program utilizes. Currently daily heat units for cotton are calculated by adding the daily maximum and daily minimum temperature (^{0}F), dividing this value by two, and then subtracting by the base temperature of 60^{0}F. This method does not include an upper limit temperature threshold. Where daily temperatures exceed 90^{0}F and night temperatures are also high, calculated heat units may be overestimated and could possibly explain the differences in defoliation timing recommendations based on accumulated heat units from cutout. A defoliation timing study was implemented to compare the effects of utilizing three upper limit temperature (90^{0}F, 95^{0}F, and no upper limit) thresholds to calculate heat unit (HU; growing degree units) accumulation past cutout and the subsequent impact on defoliation timing, yield, and fiber quality. The study was conducted at three locations during 2003. Treatments consisted of the three different upper limit temperature thresholds in calculating daily heat units and defoliation at five maturity stages based on 650, 750, 850, 950, and 1050 accumulated HU from date of cutout. Nodes above white flower (NAWF) counts were recorded during bloom until cutout was reached. At the time of defoliation, nodes above cracked boll (NACB) and percent open bolls were recorded. Percent open boll and lint yield were determined at harvest. Lint samples were retained for HVI analysis. There were no differences in lint yield between the three upper limit temperature thresholds at all three of the locations. Two locations saw significant lint yield increases by waiting to defoliate until 950 accumulated heat units from cutout. The other location did not see a significant lint yield increase after 750 accumulated HU from cutout had been reached. Upper limit temperature thresholds failed to explain differences in results of defoliation timing at the three different locations.

Introduction

Since 1998, researchers from across the Cotton Belt have come to different conclusions on the optimum defoliation time based on HU accumulation from cutout (NAWF=5). COTMAN, a cotton-management expert system based on in-season plant monitoring recommends that defoliation be initiated at 850 accumulated HU from cutout. Utilizing an upper limit temperature threshold could possibly explain differences in results of defoliation timing and recommendations from across the Cotton Belt. An upper limit temperature threshold would impact the number of daily HU that are accumulated in the southern areas of the Cotton Belt.

Cotton, a C_3 plant, utilizes an enzyme (rubisco; ribulose-1, 5-bisphosphate carboxylase/oxygenase), to fix atmospheric CO_2. The dual affinity of this enzyme for O_2 (photorespiration) and CO_2 (photosynthesis) results in less net carbon fixation at higher temperatures. Higher temperatures promote oxygenation, and hence photorespiration, in two ways. First, the solubility of CO_2 in water declines more rapidly than that of O_2 as temperature increases. Also, because of the specificity factor of rubisco, oxygenation is more sensitive to temperature and increases faster than the carboxyl ion as the temperature rises. Cotton growing areas with high daytime temperatures may have reduced plant efficiency due to the enhanced level of photorespiration; subsequently, net carbon availability may be decreased. This reduction in net photosynthesis has been shown to occur at approximately 90^{0}F (Krieg, 1986). Therefore, utilizing an upper limit temperature threshold may be useful for calculating HU accumulations relative to boll development and maturation.

Feller et al. (1998) found that the enzyme rubisco activase which activates rubisco is inhibited by temperatures greater than approximately 90^{0}F and subsequently reducing photosynthetic productivity. Temperatures above 90^{0}F increase boll-fill period (Yfoulis and Fosoulas, 1978).

This study was designed to test the hypothesis that the existence of an upper limit temperature threshold could influence the optimum time to defoliate with accumulated HU from cutout and explain the variability in results and timing recommendations from across the Cotton Belt.

Objective

To compare the effects of utilizing different upper limit temperature threshold levels to calculate HU accumulation after cut-out and the subsequent impact on defoliation timing, yield, and fiber quality.

Materials/Methods

The following study was conducted in 2003 at the Glenn Emshoff farm located near Crescent in Wharton County. Treatments consisted of three different upper limit temperature thresholds (90^0F, 95^0F, and no upper limit) and defoliation at five maturity stages based on accumulated HU from date of cutout. Cotton was planted on 22 March at 60,000 seed per acre into a Lake Charles clay soil. Plots were four rows wide (40-inch centers) by forty feet in length. The study was arranged as a 3x5 split-plot design, with the main plot being the 90^0F, 95^0F, and no upper limit temperature thresholds and the sub-plot was the 650, 750, 850, 950, and 1050 accumulated HU. Each treatment was replicated four times. Texas Cooperative Extension guidelines were followed regarding insect control, weed control, and fertility. Statistical analysis used was the general linear model in SAS (8.02) and means were separated using Fisher's Protected LSD at the = 0.05 significant level.

Beginning at first bloom (June 3), nodes above white flower (NAWF) counts were taken on a bi-weekly basis until cutout was reached (July 5). Ten plants per plot were sampled in order to obtain an accurate NAWF count. At cutout, daily heat units were recorded until the day of defoliation. Heat units were calculated by the following equation [(daily high ^{0}F + daily low ^{0}F/2)] – 60^0F. Each day, heat units were calculated using the three upper limit temperature thresholds. For example, if the daily high was 101^0F; then 90^0F, 95^0F, and 101^0F would be used in the heat unit equation to determine the daily heat units for the three upper limit temperature thresholds. Daily temperatures were obtained from a Campbell Scientific Weather Station located in a nearby field. NACB counts were recorded on the day of defoliation application. NACB measurements were recorded from 10 plants per plot. Percent open boll at defoliation and harvest were determined by plant mapping (PMAP 4.0) ten plants per plot. Defoliation applications consisted of a tank-mix of Dropp 50WP (0.1 lb/A) + Def 6EC (6 oz/A) + Prep 6EC (21.33 oz/A). All defoliation applications were delivered using a Lee Spider sprayer. The boom sprayed four rows and nozzles used were wide angle flat spray tips (TT11001's) at 40 psi. All treatments were harvested ten days after defoliation. Seed cotton yield was determined by hand harvesting one-thousandth of an acre from each plot. To determine lint yield, seed cotton was processed by using a 10-saw small plot research gin. Fiber quality measurements were determined by sending samples to the International Textile Center at Lubbock, Tx.

Results

When comparing the defoliation dates for the three upper limit temperature thresholds, the 90^0F threshold defoliation dates were 1, 2, 3, 4, and 4 days later for the 650, 750, 850, 950, and 1050 accumulated HU treatments, respectively. Due to the moderate summer temperatures in 2003, no differences in defoliation dates were observed between the 95^0F and no upper limit temperature thresholds (Table 1). There was no upper limit temperature threshold by accumulated HU interaction, meaning that all three thresholds exhibited the same response to all the treatments.

At defoliation, there were no differences in NACB between the three upper limit temperature thresholds. Differences in NACB between the five accumulated heat unit treatments were significant. NACB for the 950 and 1050 accumulated HU were significantly lower compared to the 650, 750, and 850 accumulated HU treatments (Table 2). There were no differences in percent open boll at defoliation between the three upper limit temperature thresholds. Differences in percent open boll between the five accumulated HU treatments were significant. Percent open boll for the 950 and 1050 accumulated HU were significantly higher compared to the 650, 750, and 850 accumulated HU treatments (Table 3).

At harvest, there were differences in percent open boll between the three upper limit temperature thresholds. Percent open boll was significantly higher for the 90^0F threshold versus the 95^0F and no upper limit thresholds. Differences in percent open boll between the five accumulated HU treatments were significant. Percent open boll for the 1050 accumulated HU was significantly higher versus the other four accumulated HU treatments (Table 4).

There were no differences in lint yield between the three upper limit temperature thresholds. Differences in lint yield were found when comparing the accumulated HU treatments. Lint yield was significantly less for the 650 accumulated HU treatment when compared to the 750, 850, 950, and 1050 treatments. No differences in lint yield were found between the 750, 850, 950, and 1050 accumulated HU treatments (Table 5).

Differences in length between the three upper limit temperature thresholds were not found. However, significant differences in length were found between the five accumulated HU treatments. Length values were significantly higher for the 650 and 750 accumulated HU compared to the 950 and 1050 accumulated HU treatments (Table 6).

There were no differences in micronaire, strength, elongation, and uniformity properties when comparing the three upper limit temperature thresholds or the five accumulated HU treatments.

In addition to the study conducted in Wharton County, two additional studies were conducted in Burleson County, Texas and near Winnsboro, Louisiana. Materials and methods followed by the investigators of these two studies were identical to the Wharton County location. There were no differences in lint yield between the three upper limit temperature thresholds at both the Burleson County and Winnsboro, Louisiana locations. Differences in lint yield were found between the five accumulated HU treatments at both locations. At the Winnsboro location, lint yields were significantly higher at 950 and 1050 accumulated HU when compared to the 650, 750, and 850 accumulated HU treatments. At the Burleson County location, lint yields were significantly higher at 950 accumulated HU versus the 650, 750, 850, and 1050 accumulated HU treatments (Tables 7, 8).

Discussion

Number of days to defoliation was increased by the 90^0F upper limit temperature threshold when compared to the 95^0F and no upper limit temperature threshold. With the exception of percent open boll at harvest, utilizing an upper limit temperature threshold had no significant affect on NACB and percent open boll at defoliation, lint yield, and fiber properties. However, accumulated HU treatments significantly impacted the results of this study. Significant differences in NACB at defoliation, percent open boll at defoliation and harvest, lint yield and in fiber length were found. Lint yield was significantly reduced when defoliation applications were made prior to 750 accumulated HU past cutout.

Lint yield results at the Burleson County and Winnsboro location were not affected by the three upper limit temperature thresholds which are similar to the conclusions found at the Wharton location. However, the Burleson County and Winnsboro locations saw significant lint yield increases by waiting to defoliate until 950 accumulated HU from cutout. The Wharton County location did not see a significant lint yield increase after 750 accumulated HU from cutout had been reached.

Upper limit temperature thresholds failed to explain differences in results of defoliation timing at the three different locations. Other abiotic stress factors that need to be included and compared at the different locations include: humidity, solar radiation, and night temperatures.

Acknowledgements

Appreciation is expressed to Cotton Incorporated for providing the research funds and to Glenn Emshoff for providing the land for the implementation of this study. We would also like to thank Joel Faircloth, Extension Agronomist from Louisiana Cooperative Extension for providing the results from the Winnsboro, Louisiana location.

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Table 1. Defoliation timing dates, Wharton County, TX.

dd60's	90^0F	95^0F	No Limit
650	8/6	8/5	8/5
750	8/12	8/10	8/10
850	8/16	8/13	8/13
950	8/22	8/18	8/18
1050	8/26	8/22	8/22

Table 2. Nodes above cracked boll, Wharton County, TX.

dd60's	90°F	95°F	No Limit	Pr>F <.0001
650	5.08	4.58	4.60	4.75 a
750	4.93	4.04	4.56	4.51 a
850	4.41	3.42	5.06	4.29 a
950	2.60	3.60	3.85	3.32 b
1050	0.80	1.57	1.43	1.23 c
Pr>F .1713	3.56 a	3.44 a	3.90 a	

Table 3. Percent open boll at defoliation, Wharton County, TX.

dd60's	90°F	95°F	No Limit	Pr>F <.0001
650	34.78	38.03	37.67	36.83 c
750	49.40	53.82	53.88	52.64 b
850	53.03	48.20	59.86	53.76 b
950	64.05	63.43	64.85	64.17 a
1050	69.07	71.96	67.77	69.39 a
Pr>F .8190	54.38 a	53.69 a	56.80 a	

Table 4. Percent open boll at harvest, Wharton County, TX.

dd60's	90°F	95°F	No Limit	Pr>F <.0001
650	72.20	63.74	63.63	66.52 d
750	79.64	73.60	73.22	75.11 c
850	86.65	87.96	80.91	85.04 b
950	93.73	84.83	86.34	88.62 b
1050	100.00	97.62	97.14	98.31 a
Pr>F .0363	86.81 a	80.48 b	80.28 b	

Table 5. Lint yield (lbs/acre), Wharton County, TX.

dd60's	90°F	95°F	No Limit	Pr>F <.0001
650	654.25	695.50	650.25	667.67 b
750	745.33	893.25	857.33	838.10 a
850	824.00	818.50	841.50	828.36 a
950	899.50	871.00	909.25	895.27 a
1050	920.75	902.00	917.50	914.45 a
Pr>F .6334	811.44 a	830.44 a	834.00 a	

Table 6. Length (32nds), Wharton County, TX.

dd60's	90°F	95°F	No Limit	Pr>F .0106
650	1.13	1.13	1.15	1.13 a
750	1.13	1.12	1.16	1.13 a
850	1.12	1.12	1.14	1.12 ab
950	1.12	1.11	1.11	1.11 b
1050	1.10	1.11	1.11	1.11 b
Pr>F .1277	1.12 a	1.12 a	1.13 a	

Table 7. Lint yield (lbs/acre), Burleson County, TX.

dd60's	90°F	95°F	No Limit	Pr>F <.0001
650	717.00	732.66	710.15	720.83 c
750	790.92	716.16	678.28	728.45 c
850	868.00	803.30	741.91	804.40 bc
950	985.03	1096.36	1034.42	1038.60 a
1050	822.64	807.84	1021.95	891.08 b
Pr>F .9577	836.72 a	832.50 a	844.04 a	

Table 8. Lint yield (lbs/acre), Winnsboro, LA.

dd60's	**90^{0}F**	**95^{0}F**	**No Limit**	**Pr>F**
650	949	1099	997	1015 b
750	1036	922	909	956 b
850	1026	971	1095	1031 b
950	1279	1196	1241	1239 a
1050	1155	1305	1076	1179 a
Pr>F	1089 a	1099 a	1064 a	