EFFECT OF AN UPPER TEMPERATURE THRESHOLD ON HEAT UNIT CALCULATIONS, DEFOLIATION TIMING, LINT YIELD, AND FIBER QUALITY IN COTTON

A Dissertation

by

DANIEL D. FROMME

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2007

Major Subject: Agronomy

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Approved by:

Chair of Committee, J. Tom Cothren
Committee Members, Tom Gerik
Robert Lemon
Chris Sansone
Head of Department, David Baltensperger

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ABSTRACT

Effect of an Upper Temperature Threshold on Heat Unit Calculations, Defoliation Timing, Lint Yield, and Fiber Quality in Cotton. (August 2007)

Daniel D. Fromme, B.S., Texas Tech University;

M.Ed., Southwest Texas State University

Chair of Advisory Committee: Dr. J. Tom Cothren

Crop managers need to determine the most profitable time to defoliate cotton (*Gossypium hirsutum* L.) in a high rainfall environment such as the coastal region of Texas. In cotton production, delaying defoliation exposes open bolls to a higher probability of rainfall, and thus, reduces lint yield and fiber quality. Premature defoliation, however, has detrimental affects on lint yield and fiber quality.

A more recent method to determine defoliation is based on heat-unit (HU or DD15) accumulation after physiological cutout or five nodes above white flower (NAWF=5). Results have been inconsistent across a wide range of field environments when utilizing HU accumulation past cutout; therefore, adoption of this method has been limited. Many regions of the Cotton Belt have maximum day time temperatures during the growing season that are above optimum for maximum growth.

Field studies were conducted for three consecutive growing seasons in the Brazos River Valley and Upper Gulf Coast regions of Texas. The purpose of this research was to identify an upper temperature threshold (UTT) for calculating degree days for defoliation timing. The experimental design consisted of a split-plot design with four replications. The main plots consisted of three upper temperature thresholds (32°C, 35°C, and no upper limit) and the subplots were five HU timings (361, 417, 472, 528, and 583) accumulated from date of cutout.

Utilizing an UTT to calculate daily HU failed to explain differences in the optimum time to defoliate based on accumulated HU from cutout for the upper thresholds investigated. Accumulated HU had a significant impact, however, on defoliation timing. Comparison of the two locations showed that maximum lint yield was obtained at 472 HU and 52% open boll at Wharton County versus a maximum of 528 HU and 62% open boll for the Burleson County location. Employing the NACB=4 method to time defoliation at both locations would have resulted in premature application of harvest aids and reduced lint yields. No differences were observed in adjusted gross income values at Wharton County among the 417, 472, 528, and 583 HU treatments. For Burleson County, adjusted gross income peaked in value at 528 HU.

DEDICATION

This dissertation is dedicated to my beautiful wife and best friend, Dee, and to my late mother, Anna.

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I am grateful to my committee chair and advisor, Dr. J. Tom Cothren for providing the opportunity to pursue my graduate studies at Texas A&M University. His encouragement and guidance during the past five years has allowed me to obtain a life-long goal. I would like to recognize the following members of my graduate committee: Dr. Tom Gerik, Dr. Robert Lemon, and Dr. Chris Sansone. Their assistance and encouragement during the past five years was greatly appreciated. The implementation of this study would not have been possible without the funding provided by Cotton Incorporated.

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CHAPTER I

INTRODUCTION

Crop managers need to determine the most profitable time to defoliate cotton (*Gossypium hirsutum* L.) in a high rainfall environment such as the coastal region of Texas. In cotton production, delaying defoliation exposes open bolls to a higher probability of rainfall, thus reducing lint yield and fiber quality. However, premature defoliation has detrimental effects on lint yield, fiber quality, and can result in the need for additional defoliation applications. Therefore, defoliation timing is a production practice that is critical to the economic returns of cotton producers.

Several traditional methods exist to determine defoliation timing, including determining percent open bolls, counting nodes above the highest cracked boll, and examining the highest harvestable bolls to determine their maturity. However, these methods rely on subjective judgment; therefore, effectiveness may be reduced.

A more recent method to determine defoliation is based on heat-unit (HU or DD15) accumulation after physiological cutout or five nodes above white flower (NAWF=5). This is the only method that provides early prediction of crop maturity for crop managers to plan defoliation and schedule harvest operations in advance. Beginning at cutout, daily HUs are calculated by subtracting a base temperature of 15.6°C from the average daily temperature. This method recommends initiating defoliation once 472 HUs have accumulated from date of cutout. However, results have been inconsistent across a wide range of field environments when utilizing HU unit

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This dissertation follows the style and format of Crop Science.

accumulation past cutout. Many regions of the Cotton Belt have maximum day time temperatures during the growing season that are above the optimum for maximum growth. The rate of HU accumulation and crop growth or development rate increases with increasing temperature up to an optimum temperature value; however, temperatures above an optimum value or range will cause crop growth development rate to decrease or to even cease. In these environments, crop managers may be overestimating daily HUs without the use of an upper temperature threshold.

LITERATURE REVIEW

Temperature

Cotton grows as a perennial shrub and requires warm days and warm nights for optimum growth and development (Fryxell, 1986). Cotton growth and development are very sensitive to temperature at all stages of development. Temperatures that are less than optimum for growth occur both at the beginning and at the end of the growing season, and above optimum temperatures are known to occur during flowering (Reddy et al., 1999).

As temperature increases, net carbon gain in C_3 plants is affected partly due to the relationship between photorespiration and photosynthesis. Increased temperatures reduce the affinity of ribulose-1,5-bisphosphate carboxylase/oxygenase (rubisco) for CO_2 and enhance the affinity for O_2 (Cothren, 1999). At 22°C and 40°C, photorespiration in cotton was less than 15 percent and about 50 percent of net photosynthesis, respectively (Perry et al., 1983). Gross photosynthesis has a temperature optimum of 32 to 34°C (Perry et al., 1983). Net photosynthesis declined almost linearly from 25 to 37°C (Perry et al., 1983). Also light activation of rubisco was progressively inhibited as temperature became greater than 32°C. This decrease in activity is caused by a reduction in activity of rubisco activase, the enzyme that activates rubisco (Feller et al., 1998).

The maximum rate of hypocotyl elongation in cotton was determined to occur at 32°C (Arndt, 1945). The optimum temperature for the relative rate of leaf initiation and expansion per plant ranges between 30 to 33°C (Hesketh and Low, 1968). Plants gained more total biomass and partitioned more of it to bolls and squares at 30/20°C day/night temperatures than any other temperature regimes examined (Reddy et al., 1991). The maximum number of bolls and squares retained occurred at 30/22°C day/night temperatures (Reddy, et al., 1992a). High temperature environments of 35 to 40°C are frequently associated with cotton sterility and boll retention problems (Reddy et al., 1992b). Number of bolls produced, bolls retained, and percent retention were progressively reduced as number of hours per day at 40°C was increased. Mean maximum temperatures in the range of 27 to 32°C are more desirable during the period of boll development and maturation (Mauney, 1974; Gipson and Joham, 1968). When the day temperature did not exceed a certain maximum limit, its rise hastened boll maturation, but when it exceeded this limit, the effect of day temperature became adverse. This maximum temperature limit varied from 30.5 to 32°C depending on genotype (Yfoulis and Fasoulis, 1978). Depending on genotype, boll periods were shortened by 1.2 to 5.0 days as mean temperature increased by 1°C within the limits of 15 to 32°C (Yfoulis and Fasoulis, 1973). The rate of boll filling increased with temperature up to 25°C while maximum boll weight was obtained at 17 to 18°C (Reddy et al., 1999).

Degree-Day Units

The growth and development of plants can be characterized by the number of days between observable events, such as cotton seedling emergence and first square. The number of days between events, however, may be misleading because growth rates vary with temperatures. The measurement of events can be improved by expressing development units based on accumulated degree days per unit time above a lower temperature representing a threshold for growth (Fry, 1983). Growing degree days are currently obtained by adding the daily maximum and daily minimum temperature (C), dividing this value by two, and then subtracting a base temperature (15.6°C for cotton) for the particular crop in question (Witten and Cothren, 2002). The current method does not take an upper threshold into consideration. Extreme high temperatures to which plants are sometimes subjected have negative effects on their rate of development and the growth curve becomes sigmoidal and not linear (Wang, 1960). Substantial errors in calculation of day degrees can occur when lower and upper threshold temperatures are not determined correctly (Fry, 1983). The use of heat unit cotton growth models without upper temperature thresholds results in an overestimation of the favorableness of the growing season and the time required to complete various physiological events (Kerby, 1985). Gilmore and Rodgers (1958) stated that above an upper threshold or optimum temperature, the rate of plant or insect growth may be constant or may even decrease. During the boll maturation period, an upper temperature threshold of 30 to 35°C should be utilized when calculating degree days (Kerby, 1985). A warmer or longer growing season (more accumulated degree days) does not necessarily mean that the crop yield will be higher because excessive high daily temperatures can result in crop stress and affect plant-water status (Sevacharian and El-Zik, 1983). An upper limit threshold of 31 to 32°C is the limit for reproductive growth of cotton. The high temperature injury is probably influenced by both extreme temperature and length of exposure to the high temperatures (Reddy et al., 1995). The rate of degree day accumulation and the crop growth rate increase with increasing temperature up to an optimum temperature value or range of values. Above the temperature value or plateau, the rate of degree day accumulation and the crop response decrease with further increases in temperature until no further accumulation occurs and crop development ceases (Hodges, 1991). Due to the extreme maxima and minima temperatures in the western Cotton Belt, a 30/13°C threshold is used to increase the precision of growth monitoring and management (Unruh and Silvertooth, 1997).

Monitoring NAWF

After about 431 to 472 degree days, or approximately 60 to 70 days after planting, cotton begins to produce flowers (Oosterhuis, 1992). A well-managed cotton plant should have at least eight sympodia when the first flower appears on the plant (Bourland et al., 1992). Monitoring NAWF not only enhances the precision and confidence in end-of-the-season management decisions (Bourland et al., 1992), but monitoring NAWF values during the bloom period also gives an insightful measurement of the growth status of the crop (Oosterhuis, et al., 1992).

As the season progresses, white flowers located in the first position on sympodia grow progressively closer to the plant apex (Oosterhuis et al., 1992). A white flower in the plant apex is indicative of the termination of square and flower production and is precluded by termination of nodal extension; this stage of growth is commonly referred to as cutout (Guinn, 1979). The term cutout is used extensively throughout the U.S. Cotton Belt and it is defined in many ways. When cotton producers observe white flowers in the tops of the cotton plants this is the first signal of cut-out or crop maturity (Waddle, 1982). Cutout was defined as the time when a marked decrease in growth, flowering, and boll retention occurs (Patterson et al., 1978). The point at which demand for photosynthate exceeds the crop's ability to meet this supply for the vegetative and reproductive demands is likewise known as cutout (Guinn, 1984). In the lower southeastern portion of the Cotton Belt, late season weather patterns and insect pressure are not as troublesome as in some locations and effective flowering may proceed to NAWF=3 (Bednarz and Nichols, 2005). Kerby (1996) defines the effective fruiting period as the time required to set 95% of all harvestable bolls. The last effective flower or boll population was defined as those that have a high probability of retention and capacity to reach an adequate size (Oosterhuis et al., 1996). Based on Arkansas research, it was determined that a critical value of five nodes above the highest first position white flower (NAWF=5) was the last effective boll population to contribute to economic yield (Bourland et al., 1992). At NAWF values less than five, boll size and boll retention were reduced significantly (Bourland et al., 1992). As NAWF approaches five, the economic value of flowers that were produced at higher nodal positions decreased (Bourland et al., 1992).

Harvest Aid Timing

Timeliness may be the most significant factor contributing to profitability in cotton production and marketing (Brooking, 1997). Early harvest of cotton is economically beneficial for producers as long as yield is not sacrificed (Mauney, 1986). Some of the detrimental effects of premature crop termination on lint yield and fiber quality have been reported. Snipes and Baskin (1994) reported defoliation before 60% open bolls resulted in yield losses of 7 to 15%. However, delaying harvest can increase the weathering of open bolls which decreases the quality and weight of lint (Waddle, 1984). The most significant factor influencing yield and grade was rainfall occurring after the cotton was open (Williford, 1992). The average weight loss of open cotton has been reported as 0.64% per day (Parvin, 1990).

Several methods exist to determine crop maturity and defoliation readiness, including determining percentage open bolls, counting nodes above the highest cracked boll, and examining the highest harvestable bolls to determine their maturity (Brecke et al., 2001). None of these methods provide sufficiently early prediction of crop maturity for producers to plan defoliation and operations in advance (Gwathmey et al., 2004).

Research has shown that cotton defoliation and harvest can be scheduled on the basis of heat-unit accumulation after physiological cutout (five nodes above white flower). The COTMAN Expert System Computer Program (Cochran et al., 1998) uses degree-day accumulation after cutout as a criterion to schedule cotton fields for defoliation. This system can help producers plan crop termination and harvest operations as early as mid-season (Larson et al., 2002). Bourland et al. (1997) suggested that 472 degree-day units, based on 15.6°C, should be accumulated after the last effective flowering date prior to defoliation. The COTMAN defoliation timing rules (472 DD15 after NAWF=5) have been repeatedly validated in Arkansas (Benson et al., 2000; Robertson et al., 2003), but reports from other parts of the U.S. Cotton Belt have shown inconsistent yield responses with this method. In the Brazos River Valley region of Texas, defoliation at 472 DD15 after NAWF=5 significantly reduced lint yield relative to defoliation at 528 or 583 DD15, in a single harvest 14 days after each harvest-aid application (Witten and Cothren, 2002). In the coastal region of Texas, yield was not significantly different when defoliation was initiated at 417 DD15 after NAWF=5 or later (Fromme, 1999). In Tennessee, defoliation at 472 DD15 after NAWF=5 significantly reduced lint yields relative to 528 DD15 at 14 days after treatment (Larson et al., 2002).

These reports also varied with respect to fiber quality responses to defoliation timing. There was no difference in fiber quality from defoliation timing ranging from 367 to 527 DD15 after NAWF=5 (Benson et al., 2000). Robertson et al. (2003) indicated that loan values associated with fiber quality were greatest with the 472 DD15 timing in Arkansas. Loan value in Texas however was reduced by defoliation earlier than 583 DD15 after NAWF=5 due to fiber quality discounts (Witten and Cothren, 2002). Micronaire was also reduced by defoliation at 417 DD15 after NAWF=5 or earlier, relative to later defoliation timing in Texas (Fromme, 1999). Micronaire values increased with DD15 accumulation prior to defoliation in Tennessee, but price differences due to fiber quality did not differ significantly in cotton defoliated between 417 and 528 DD15 after NAWF=5 (Larson et al., 2002).

OBJECTIVES

The primary objective of this research was to identify an upper temperature threshold for calculating degree days for defoliation timing. Identification of an upper temperature threshold may help explain the inconsistent results that have been observed when utilizing degree days to schedule defoliation timing across a wide range of field environments. More importantly, a clear delineation of the proper upper limit threshold should improve scheduling defoliation timing based on heat unit accumulation and result in wider adoption of this practice throughout the U.S. Cotton Belt.

CHAPTER II

MATERIALS AND METHODS

Field studies were conducted for three consecutive growing seasons (2003-2005) at the Texas Agricultural Experiment Station (TAES) Research Farm located in Burleson County near College Station, TX, and Emshoff Farms located in Wharton County near Wharton, TX. Soil types are a Weswood silt loam (fine-silty, mixed, superactive, thermic, Udifluventic Haplustepts) and a Lake Charles clay (fine, smectitic, hyperthermic Typic Hapluderts) at the College Station and Wharton sites, respectively.

Cotton cultivars utilized in this study were Delta and Pine Land 20B (2003 and 2004) and Delta and Pine Land 444BG/RR (2005). Cultivars were seeded at 123, 500 plants ha^{-1} with a John Deere 1700 MaxEmerge Plus Vacuum planter. Planting dates for the Wharton sites in 2003, 2004, and 2005 were March 22, March 29, and April 2, respectively. The planting dates for the Burleson sites for 2003, 2004, and 2005 were May 12, April 8, and April 12, respectively. Planting was delayed in 2003 at Burleson due to dry soil moisture conditions in the spring. Furrow irrigation was provided to alleviate water deficit stress throughout the growing seasons. Management decisions pertaining to fertility, weed control, insect scouting and control measures were based on Texas Cooperative Extension guidelines.

The experimental design consisted of a split-plot design with four replications. The main plots consisted of three upper temperature thresholds (32°C, 35°C, and no upper limit) and the subplots were five HU timings (361, 417, 472, 528, and 583) accumulated from date of cutout (defined as NAWF=5). Treatments were arranged in a randomized complete block design. Each plot was four rows (1.01-m spacing) wide and 9.7 m long (College Station) and four rows (1.01-m spacing) and 15.2 m long (Wharton). Monitoring and recording of plant growth and development data was obtained from rows one and four from each of the plots, while rows two and three were utilized at harvest to determine lint yield.

Beginning at cutout and continuing through the day that defoliation was initiated, ambient daily high and low temperatures were recorded for the calculation of daily HU from nearby weather stations. Calculation of HUs was obtained by the following equation: [(daily high °C + daily low °C/2)] – 15.6°C. When ambient daily high temperatures exceeded either the 32°C or 35°C upper temperature thresholds, the daily high for the HU equation was fixed at 32°C and 35°C, respectively.

A harvest aid application consisting of thidiazuron (Dropp®) (0.11 kg ha^{-1}), tribufos (Def®/Folex®) (0.44 L ha^{-1}), and ethephon (Prep™) (1.56 L ha^{-1}) was applied to each plot at the designated accumulated degree days. Harvest aids were applied using a compressed air small plot sprayer delivering 93.5 L ha^{-1} of water using Tee Jet® (Spraying Systems Inc.) TX-VS 10 hollow cone nozzles with 50.8-cm nozzle spacing.

During the bloom period, bi-weekly NAWF counts were recorded for each of the plots until date of cutout. NAWF counts were determined by selecting ten representative plants per plot. Prior to harvest aid application, these ten plants were removed and plant mapped to determine percent open boll, total fruit per plant, plant height, total nodes, and first fruiting node. Height measurements were obtained from the cotyledonary node to the terminal of the plant. Total and first fruiting nodes were determined from the cotyledonary node to the terminal of the plant with the cotyledonary node considered as node zero. In addition, nodes above cracked boll were assessed on an additional ten representative plants per plot. Data for total fruit per plant, plant height, total nodes per plant, and first fruiting node are not shown. Prior to harvest, these procedures were repeated with the exception of nodes above cracked boll to assess the effect of harvest aid applications.

Plots were harvested ten and fourteen days after harvest aid application for the Wharton and College Station sites, respectively. Seedcotton yields were determined by harvesting the middle two rows of each plot. A sub-sample consisting of 150 g of seedcotton were collected from each plot for ginning to determine percent ginout and lint yield. Each sample was ginned using a ten-saw, hand-fed portable gin. After ginning, a 50-g fiber sample from each plot was subjected to High Volume Instrument (HVI) testing at the International Textile Center in Lubbock, Texas. Results from HVI classing were utilized to calculate the Commodity Credit Corporation (CCC) loan value for each treatment. For all three years of the study, loan value calculations were based on the 2006 loan rate schedule for upland cotton. High volume instrument color and leaf grades were not considered reliable as the seed cotton was not ginned with lint cleaners. Therefore, all treatments were assigned a 41-4 value for color and leaf grades. Adjusted gross income values for each treatment were calculated by multiplying the yield by the base loan value price plus the total fiber premiums and discounts.

An analysis of variance (ANOVA) appropriate for split-plot design (McIntosh, 1983) was conducted using PROC Mixed of SAS, ver. 9.1.3 (SAS, 2004). Main plots, subplots and locations were treated as fixed effects. Years, blocks, and interactions involving these terms were considered random. Years were combined at each location for analysis. When a significant interaction existed for location x treatment for a specific parameter, those means were presented separately by location. A combined analysis across locations and years was calculated. The ANOVA was used to test the main effects and their interactions on nodes above cracked boll, percent open boll, lint yield, turnout, micronaire, strength, length, uniformity, loan value, and adjusted gross income. Mean separations for main plots and subplots were conducted using LSD tests at the 5% probability levels (Steel et al., 1997). The probability difference (PDIFF) option within the LSMEANS statement was used to report p-values for all possible pairwise comparisons among the three upper temperature thresholds and five HUs. LSD values were computed by utilizing the highest standard error value of all the combinations from the differences of least square means and multiplying that value by the t-value obtained from t-distribution table. The correct degrees of freedom were obtained from the highest standard error value.

Finally, PROC REG of SAS was utilized to measure the relationship between percent open boll at defoliation and average daily high temperature from cutout to defoliation.

CHAPTER III

RESULTS AND DISCUSSION

INTRODUCTION

Date of harvest aid application, number of days following planting, and HU accumulations corresponding to the three upper temperature thresholds for each location and year are listed in Tables 1-6. During the three-year study and at both locations, initial NAWF values recorded at first bloom ranged between eight and nine. Bourland et al. (1992) stated plants should possess a minimum of eight sympodia at first bloom under optimal conditions. Differences between target and actual defoliation timing were due to rainfall events. Cutout dates at Wharton County were reached 107, 99, and 85 days after planting for 2003, 2004, and 2005, respectively. At Burleson County, cutout dates were reached 70, 98, and 79 days after planting for 2003, 2004, and 2005, respectively. The data in Table 7 illustrates the number of times the daily temperature exceeded the 90 and 95 upper limit temperature thresholds between cutout and defoliation. Daily temperatures at Burleson County were higher in 2003 and 2005, whereas temperatures at Wharton County were higher in 2004 (Table 7). Total heat unit accumulations (DD15s) from planting to harvest at Wharton County were 1692, 1524, and 1420 for 2003, 2004, and 2005, respectively. For Burleson County, total heat unit accumulations (DD15s) from planting to harvest were 1525, 1621, and 1461 for 2003, 2004, and 2005, respectively.

When both locations were combined and defoliation, harvest, and fiber quality parameters were analyzed, there was significant interaction for either location x HU, location x upper temperature threshold or location x upper temperature threshold x HU for percent open boll at defoliation and harvest, lint yield, turnout, strength, length, uniformity, and adjusted gross income (Tables 8 and 9). Due to these interactions, each location was analyzed separately (Tables 10 and 11).

Table 1. Date of harvest aid application and heat unit accumulation from NAWF=5, Wharton County, 2003.

	Upper Temperature Threshold								
Target HU	32°C†			35°C			No Upper Limit		
	Date	DAP‡	Actual HU§	Date	DAP	Actual HU	Date	DAP	Actual HU
361	6-Aug	137	347	5-Aug	136	361	5-Aug	136	361
417	12-Aug	143	419	10-Aug	141	429	10-Aug	141	434
472	16-Aug	147	474	13-Aug	144	462	13-Aug	144	466
528	22-Aug	153	534	18-Aug	149	524	18-Aug	149	529
583	26-Aug	157	590	25-Aug	156	612	25-Aug	156	618

† 32°C represents the upper temperature utilized to calculate daily heat units.
‡ DAP corresponds to days after planting.
§ HU refers to accumulated heat units beyond reaching cutout; base 15.6°C.

Table 2. Date of harvest aid application and heat unit accumulation from NAWF=5, Wharton County, 2004.

	Upper Temperature Threshold								
Target HU	32°C†			35°C			No Upper Limit		
	Date	DAP‡	Actual HU§	Date	DAP	Actual HU	Date	DAP	Actual HU
361	7-Aug	131	374	4-Aug	128	362	4-Aug	128	368
417	12-Aug	136	429	9-Aug	133	427	9-Aug	133	434
472	17-Aug	141	473	13-Aug	137	473	13-Aug	137	481
528	22-Aug	146	528	19-Aug	143	528	19-Aug	143	536
583	27-Aug	151	590	24-Aug	148	591	24-Aug	148	599

† 32°C represents the upper temperature utilized to calculate daily heat units.
‡ DAP corresponds to days after planting.
§ HU refers to accumulated heat units beyond reaching cutout; base 15.6°C.

Table 3. Date of harvest aid application and heat unit accumulation from NAWF=5, Wharton County, 2005.

Target HU	Upper Temperature Threshold								
	32°C†			35°C			No Upper Limit		
	Date	DAP‡	Actual HU§	Date	DAP	Actual HU	Date	DAP	Actual HU
361	27-July	116	361	25-July	114	362	25-July	114	367
417	1-Aug	121	432	30-July	119	426	30-July	119	432
472	5-Aug	125	481	3-Aug	123	478	3-Aug	123	484
528	10-Aug	130	539	7-Aug	127	529	7-Aug	127	536
583	15-Aug	135	600	12-Aug	132	594	12-Aug	132	601

† 32°C represents the upper temperature utilized to calculate daily heat units.
‡ DAP corresponds to days after planting.
§ HU refers to accumulated heat units beyond reaching cutout; base 15.6°C.

Table 4. Date of harvest aid application and heat unit accumulation from NAWF=5, Burleson County, 2003.

Target HU	Upper Temperature Threshold								
	32°C†			35°C			No Upper Limit		
	Date	DAP‡	Actual HU§	Date	DAP	Actual HU	Date	DAP	Actual HU
361	21-Aug	101	367	18-Aug	98	364	17-Aug	97	368
417	25-Aug	105	413	22-Aug	102	414	21-Aug	101	424
472	30-Aug	110	475	27-Aug	107	481	25-Aug	105	476
528	4-Sept	115	531	31-Aug	111	531	29-Aug	109	532
583	10-Sept	121	588	4-Sept	115	579	3-Sept	114	589

† 32°C represents the upper temperature utilized to calculate daily heat units.
‡ DAP corresponds to days after planting.
§ HU refers to accumulated heat units beyond reaching cutout; base 15.6°C.

Table 5. Date of harvest aid application and heat unit accumulation from NAWF=5, Burleson County, 2004.

Target HU	Upper Temperature Threshold								
	32°C†			35°C			No Upper Limit		
	Date	DAP‡	Actual HU§	Date	DAP	Actual HU	Date	DAP	Actual HU
361	19-Aug	133	367	17-Aug	131	372	17-Aug	131	372
417	23-Aug	137	413	21-Aug	135	422	21-Aug	135	422
472	28-Aug	142	476	26-Aug	140	481	25-Aug	139	473
528	2-Sept	147	527	30-Aug	144	533	29-Aug	143	528
583	7-Sept	152	578	4-Sept	149	580	3-Sept	148	578

† 32°C represents the upper temperature utilized to calculate daily heat units.
‡ DAP corresponds to days after planting.
§ HU refers to accumulated heat units beyond reaching cutout; base 15.6°C.

Table 6. Date of harvest aid application and heat unit accumulation from NAWF=5, Burleson County, 2005.

Target HU	Upper Temperature Threshold								
	32°C†			35°C			No Upper Limit		
	Date	DAP‡	Actual HU§	Date	DAP	Actual HU	Date	DAP	Actual HU
361	30-July	109	366	27-July	106	364	26-July	105	366
417	4-Aug	114	422	1-Aug	111	424	30-July	109	418
472	9-Aug	119	479	5-Aug	115	476	4-Aug	114	482
528	13-Aug	123	526	10-Aug	120	534	8-Aug	118	533
583	18-Aug	128	586	15-Aug	125	597	13-Aug	123	591

† 32°C represents the upper temperature utilized to calculate daily heat units.
‡ DAP corresponds to days after planting.
§ HU refers to accumulated heat units beyond reaching cutout; base 15.6°C.

Table 7. Total number of days, number of days above 32°C and 35°C, average daily temperature, and average daily high temperature from cutout to defoliation.

	Cutout to defoliation†	Temperature			
Location	total	>32	>35	average daily	average daily high
a. Wharton	d			°C	
2003	37	25	5	27.83	33.17
2004	38	34	11	28.09	34.33
2005	38	33	9	28.27	34.01
b. Burleson					
2003	35	28	23	29.17	35.67
2004	40	32	9	27.43	33.77
2005	34	32	20	28.93	35.41

† based on 472 HU past cutout and no upper limit threshold.

NODES ABOVE CRACKED BOLL

At defoliation, nodes above cracked boll (NACB) were calculated as the node position difference between the uppermost harvestable boll and that of the uppermost first position cracked boll. Upper temperature threshold (UTT) treatments at both locations had no affect on NACB (Table 10). However, NACB were significantly affected by HU treatments (Table 10). As expected, NACB value decreased as accumulated HUs increased. NACB value at the Wharton County decreased linearly from 5.51 for 361 HUs to 0.92 for 583 HUs (Table 12). Similar findings were recorded in Burleson County; NACB values decreased from 6.56 for 361 HUs to 2.06 for 583 HUs (Table 13). Kerby et al. (1992) stated that harvest aid materials should be applied at NACB=4. When comparing the two locations, Wharton County and Burleson County reached NACB=4 at 417 and 472 HUs, respectively. For each of the locations, there were no significant lint yield interaction effects between UTT and HU timings.

PERCENT OPEN BOLL

The percent of open bolls (POB) was obtained by plant mapping on the day of harvest aid application followed by a subsequent plant mapping at harvest. Upper temperature threshold treatments had no effect on POB at defoliation for Wharton County; however, POB was significantly affected at Burleson County (Table10).

Table 8. Variance components for defoliation and harvest parameters; combined across three years (2003-2005) and two locations, Wharton and Burleson County.

Main Effects‡	Defoliation		Harvest		
	nodes above cracked boll	open bolls	lint yield	turnout	open bolls
	no.	%	kg ha^{-1}	%	%
UTT	NS†	NS	NS	NS	NS
HU	***	***	***	NS	*
UTT x HU	NS	NS	NS	NS	*
L	NS	NS	NS	***	NS
L x UTT	NS	NS	NS	NS	**
L x HU	NS	***	***	*	NS
L x UTT x HU	NS	NS	NS	NS	NS

*, **, *** Significant at the 0.05, 0.01, and 0.0001 probability levels, respectively.
† NS, no significant differences at P≤0.05.
‡ UTT, HU, and L represent upper temperature threshold, heat units, and location, respectively.

Table 9. Variance components for fiber quality parameters, loan value and adjusted gross income; combined across three years (2003-2005) and two locations, Wharton and Burleson County.

Main Effects‡	———High Volume Instrument Testing———				Loan —Value—	Adjusted Gross —Income—
	Micronaire	Strength	Length	Uniformity	¢	$
	value	g tex^{-1}	100^{ths} of an inch	%	kg^{-1}	ha^{-1}
UTT	NS†	NS	NS	NS	NS	NS
HU	*	***	NS	NS	NS	**
UTT x HU	NS	NS	NS	NS	NS	NS
L	NS	NS	NS	NS	NS	NS
L x UTT	NS	NS	NS	NS	NS	NS
L x HU	NS	*	***	NS	NS	***
L x UTT x HU	NS	NS	NS	***	NS	NS

*, **, *** Significant at the 0.05, 0.01, and 0.0001 probability levels, respectively.
† NS, no significant differences at P≤0.05.
‡ UTT, HU, and L represent upper temperature threshold, heat units, and location, respectively.

Table 10. Variance components for defoliation and harvest parameters; combined across three years (2003-2005) for each location, Wharton and Burleson County.

Main Effects‡	Defoliation		Harvest		
	nodes above cracked boll	open bolls	lint yield	turnout	open bolls
a. Wharton	no.	%	kg ha^{-1}	%	%
UTT	NS†	NS	NS	NS	NS
HU	**	***	***	NS	***
UTT x HU	NS	NS	NS	NS	NS
b. Burleson					
UTT	NS	*	NS	NS	*
HU	***	***	**	NS	NS
UTT x HU	NS	*	NS	NS	***

*, **, *** Significant at the 0.05, 0.01, and 0.0001 probability levels, respectively.
† NS, no significant differences at P≤0.05.
‡ UTT and HU represent upper temperature threshold and heat units, respectively.

Table 11. Variance components for fiber quality parameters, loan value, and adjusted gross income; combined across three years (2003-2005) for each location, Wharton and Burleson County.

Main Effects‡	High Volume Instrument Testing				Loan Value	Adjusted Gross Income
	Micronaire	Strength	Length	Uniformity	¢	$
	value	g tex^{-1}	100^{ths} of an inch	%	kg^{-1}	ha^{-1}
a. Wharton						
UTT	NS†	NS	NS	NS	NS	NS
HU	NS	***	***	NS	*	**
UTT x HU	NS	NS	NS	NS	NS	NS
b. Burleson						
UTT	NS	NS	NS	NS	NS	NS
HU	**	NS	NS	NS	NS	**
UTT x HU	NS	NS	NS	***	NS	NS

*, **, *** Significant at the 0.05, 0.01, and 0.0001 probability levels, respectively.
† NS, no significant differences at P≤0.05.
‡ UTT and HU represent upper temperature threshold and heat units, respectively.

Table 12. Overall study means for defoliation and harvest parameters, combined across three years (2003-2005), Wharton County.

	Defoliation		Harvest		
HU§	nodes above cracked boll	open bolls	lint yield	turnout	open bolls
	no.	%	kg ha^{-1}	%	%
361	5.51a†	25.05d	862c	38.46a	73.37d
417	3.79 ab	41.57cd	1144b	39.21a	81.54c
472	2.67bc	52.07bc	1205ab	38.92a	87.45bc
528	1.73c	67.07ab	1221a	38.81a	91.33ab
583	0.92c	78.58a	1241a	38.81a	95.76 a
Pr>f‡	0.0028	0.0003	0.0002	0.6076	0.0008
LSD	1.92	16.54	92.17	NS	7.32
UTT¶					
32°C	2.60a	56.15a	1154a	39.02a	88.14a
35°C	2.98a	51.24a	1105a	38.71a	84.55a
no upper limit	3.19a	51.23a	1144a	38.79a	84.99a
Pr>f‡	0.0586	0.2350	0.4191	0.4500	0.2589
LSD	NS#	NS	NS	NS	NS

† HU and UTT values within a single column followed by the same letter are not different at a 5% probability level.
‡ Probability of the ANOVA.
§ HU = heat units.
¶ UTT = upper temperature threshold.
# NS = not significant.

Table 13. Overall study means for defoliation and harvest parameters, combined across three years (2003-2005), Burleson County.

	Defoliation	Harvest	
HU§	nodes above cracked boll	lint yield	turnout
	no.	kg ha^{-1}	%
361	6.56a†	997d	38.63a
417	5.11b	1095cd	39.00a
472	3.73c	1176bc	38.60a
528	2.59cd	1391a	38.68a
583	2.06d	1266ab	39.07a
Pr>f‡	0.0002	0.0064	0.4304
LSD	1.25	156.98	NS
UTT¶			
32°C	3.67a	1201a	38.55a
35°C	4.16a	1176a	39.12a
no upper limit	4.20a	1177a	38.72a
Pr>f‡	0.3286	0.8821	0.0574
LSD	NS#	NS	NS

† HU and UTT values within a single column followed by the same letter are not different at a 5% probability level.
‡ Probability of the ANOVA.
§ HU = heat units.
¶ UTT = upper temperature threshold.
# NS = not significant.

Percent open boll for Burleson County was significantly higher at 54.52% for the 32°C threshold compared to 48.08% for the no upper limit threshold (Table 14). Accumulated HUs significantly affected POB at both study locations (Table 10). Percent open bolls at Wharton County reached 52 and 67% at the 472 and 528 HU treatments, respectively. The POB value for the 583 HU treatment was significantly higher compared to all other HU treatments with the exception of the 528 HU treatment (Table 12). At Burleson County, HU treatment means exhibited full separation, with 361 HUs having the lowest POB and 583 HUs having the highest. Percent open boll values at Burleson County, reached 50.38 and 62.40% at 472 and 528 HU treatments, respectively (Table 14). McCarty et al. (2000) stated that it is acceptable to defoliate when 50 to 60 percent of the bolls are open and the youngest boll you expect to harvest is mature. Although UTT and HU significantly affected POB at Burleson County, the UTT x HU interaction was significant. This interaction was explained by the following observation: Percent open boll for the 35°C and no upper limit thresholds produced a higher value than the 32°C threshold at 417 HUs. Also, the 35°C threshold produced a higher value than the 32°C threshold at 583 HUs (Table 14). However, from a biological perspective these differences were numerically small.

Percent open boll at defoliation was strongly correlated to average daily high temperatures from cutout to 472 HUs and no upper limit threshold. As temperatures increased, the rate of boll opening decreased (Figure 1). In a study conducted in Greece, when day temperature exceeded a maximum of 30.5 to 32°C, boll maturation was not hastened and became adverse (Yfoulis and Fasoulis, 1978).

Table 14. Upper temperature threshold x heat unit interaction for percent open boll at defoliation, combined across three years (2003-2005), Burleson County.

UTT x HU‡ = .0241	Upper Temperature Threshold (UTT)			Pr>f‡ = <.0001
Heat Units (HU)	—32°C—	—35°C—	—no upper limit—	
361	39.19	30.97	27.20	32.45†§e
417	40.16	43.68	40.44	41.43d
472	55.03	50.29	45.81	50.38c
528	65.70	64.92	56.97	62.40b
583	72.53	73.46	69.97	71.98a
Pr>f‡ = .0394	54.52†§a	52.59ab	48.08b	

† HU and UTT values within a single column followed by the same letter are not different at a 5% probability level.
‡ Probability of the ANOVA.
§ To compare means in a column, LSD = 5.72; and in a row, LSD = 4.57.

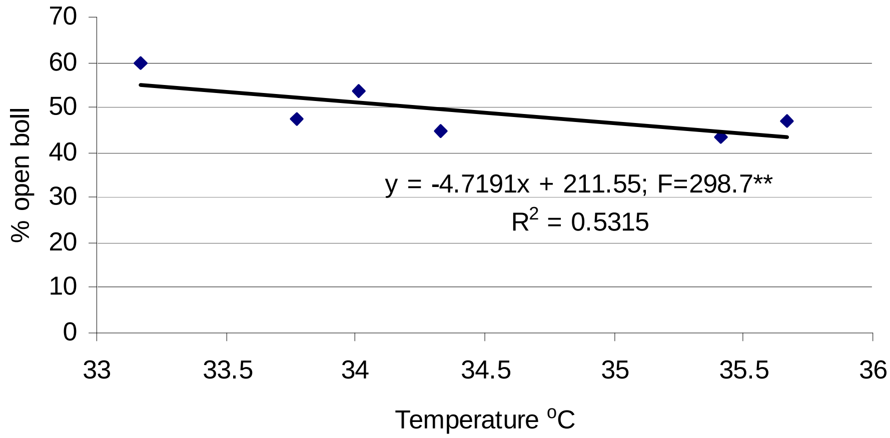

Figure 1. Linear relationship of percent open boll (POB) at defoliation to average daily high temperature from cutout to 472 accumulated heat units (HU) and no upper limit threshold.

Upper temperature threshold treatments at Wharton County had no effect on POB at harvest; however, POB at Burleson County was significantly affected (Table 10). Percent open boll for the 32°C threshold at Burleson County was significantly higher compared to the 35°C and no upper limit thresholds (Table 15). Accumulated HU significantly affected POB at Wharton County; however, there was no affect on POB at Burleson County (Table 10). Percent open bolls at Wharton County increased significantly ranging from 73.37% for 361 accumulated HUs to 95.76% for 583 HUs (Table 12). At Burleson County, numerical values for POB increased as accumulated HU treatments increased from date of cutout (Table 15). Significant differences in POB were not found due to variability among the three years. Although UTT significantly affected POB at Burleson County, the UTT x HU interaction was significant. An explanation of the interaction is summarized from the following observation: Percent open boll for the 35°C threshold produced a higher value than the 32°C threshold at 472 and 528 HUs (Table 15). However, differences were numerically small from a biological perspective.

LINT YIELD

Upper temperature thresholds at both locations had no effect on lint yield; however, accumulated HUs significantly affected lint yield (Table 10). Maximum lint yield for Wharton County was reached at 472 HUs (Table 12). There were no significant differences in lint yield among the 472, 528, and 583 HU treatments at this location. For Burleson County, maximum lint yield was reached at 528 HUs. Lint yield

Table 15. Upper temperature threshold x heat unit interaction for percent open boll at harvest, combined across three years (2003-2005), Burleson County.

UTT x HU‡ = <.0001	Upper Temperature Threshold (UTT)			Pr>f‡ = .1494
Heat Units (HU)	—32°C—	—35°C—	—no upper limit—	
361	86.27	84.47	72.10	80.95†§a
417	89.67	89.47	82.54	87.23a
472	92.07	92.79	90.68	91.85a
528	97.14	98.08	96.57	97.26a
583	100.00	100.00	99.94	99.98a
Pr>f‡ = .0128	93.03†§a	92.96b	88.37b	

† HU and UTT values within a single column followed by the same letter are not different at a 5% probability level.
‡ Probability of the ANOVA.
§ To compare means in a column, LSD = not significant; and in a row, LSD = 2.65.

for the 528 HU treatment was significantly higher than all other treatments with the exception of the 583 HUs (Table 13). Possible explanations for the differences in the optimum time to defoliate between the two locations as reflected in yield may be attributed to: contribution of lint yield above NAWF=5, light intensity, or the utilization of a UTT lower than 32°C. In a study conducted in Arkansas, bolls produced after NAWF=5 did not contribute to economic yield (Bourland et al., 1992). However, research in Georgia found that 15% of total lint was contributed after NAWF=5 (Bednarz and Nichols, 2005). Leffler (1976) reported that bolls did not gain mass during a period of overcast skies. This period of low light intensity (199 ly/day) occurred during secondary wall deposition at 31-39 days post anthesis. Studies by Reddy et al. indicated that daytime temperatures of 30°C were optimum for total biomass and a higher percentage was partitioned to bolls and squares (1991); also, this was the temperature at which the maximum number of bolls and squares were retained (1992a). In Greece, when day temperature exceeded a maximum of 30.5, boll maturation was not hastened and became adverse in some genotypes (Yfoulis and Fasoulis, 1978). Therefore, utilizing 30°C as the UTT to calculate HUs is an option that should be considered when attempting to explain differences between the two locations. For each of the locations in our study, no significant lint yield interaction effects were found between UTT and HU timings.

TURNOUT

Turnout represents the percent of lint obtained or produced from a known amount of seedcotton. For both of the locations, UTT and HUs had no affect on turnout

(Table 10). Numerical values for turnout at Wharton County ranged from 38.46 to 39.21% (Table 12). For Burleson County, numerical values for turnout ranged from 38.60 to 39.07% (Table 13).

FIBER QUALITY

Micronaire values at both locations were not affected by the UTT treatments (Table 11). Accumulated HU significantly affected micronaire values at Burleson County; however, there was no affect on micronaire values at Wharton County (Table 11). At Burleson County, micronaire increased from 4.28 at 361 HU to 4.42 at 583 HU (Table 17). Both of these values were within the acceptable range for micronaire (USDA-AMS, 2001). Micronaire tended to increase numerically at Wharton County as defoliation was delayed (Table 16). Increases in micronaire with later defoliation timing support the hypothesis that delayed defoliation allows for more carbon assimilation and/or partitioning of photoassimilates to developing cotton bolls. For both of the locations, there were no significant micronaire interaction effects between UTT and HU timings.

Fiber strength at both locations was not affected by the UTT treatments (Table 11). Accumulated HU at Burleson County did not affect strength; however, at Wharton County there was a significant affect on strength (Table 11). When comparing the accumulated HU treatments at Wharton County, fiber strength value decreased from 30.06 at 361 HUs to 28.68 at 583 HUs, or as defoliation was delayed (Table 16). Fiber strength tended to decrease at Burleson County as defoliation was delayed, but again these values were not significant (Table 17). These findings suggest that with delays in defoliation, weathering was instrumental in reducing fiber strength. For both of the locations, no significant strength interaction effects between UTT and HU timings were observed.

Upper temperature thresholds treatments at both locations had no affect on fiber length (Table 11). Length at Burleson County was not affected by the accumulated HU treatments; however, length at Wharton County was significantly affected by the accumulated HU treatments (Table 11). When comparing the accumulated HU treatments, length values at Wharton County decreased from 1.14 at 361 HUs to 1.12 at 583 HUs as defoliation was delayed (Table 16). The reduction in fiber length as defoliation was delayed cannot be explained. Fiber length values at Burleson County remained at 1.12 among all five accumulated HU treatments (Table 17). For both of the locations, no significant length interaction effects between UTT and HU timings were observed.

Table 16. Overall study means for fiber quality parameters, loan value, and adjusted gross income, combined across three years (2003-2005), Wharton County.

	High Volume Instrument Testing				Loan Value	Adjusted Gross Income
HU§	Micronaire	Strength	Length	Uniformity	¢	$
	value	g tex^{-1}	100ths of an inch	%	kg^{-1}	ha^{-1}
361	4.16a†	30.06a	1.14a	84.04a	120.31a	926.17b
417	4.20a	29.69ab	1.13a	84.03a	119.92a	1,223.34a
472	4.19a	29.31bc	1.13ab	83.88a	119.86ab	1,289.75a
528	4.21a	29.07cd	1.12b	83.72a	119.12bc	1,298.63a
583	4.23a	28.68d	1.12b	83.54a	119.04c	1,320.21a
Pr>f‡	0.7335	<.0001	<.0001	0.3080	0.0230	0.0002
LSD	NS#	0.42	0.01	NS	0.79	114.44
UTT¶						
32°C	4.23a	29.38a	1.13a	83.84 a	119.76a	1,233.60a
35°C	4.19a	29.32a	1.12a	83.88 a	119.72a	1,181.97a
no upper limit	4.17a	29.39a	1.13a	83.81 a	119.46a	1,219.29a
Pr>f‡	0.6643	0.9319	0.7366	0.8866	0.5491	0.4072
LSD	NS	NS	NS	NS	NS	NS

† HU and UTT values within a single column followed by the same letter are not different at a 5% probability level.
‡ Probability of the ANOVA.
§ HU = heat units.
¶ UTT = upper temperature threshold.
# NS = not significant.

Table 17. Overall study means for fiber quality parameters, loan value, and adjusted gross income, combined across three years (2003-2005), Burleson County.

	—High Volume Instrument Testing—			—Loan Value—	Adjusted Gross —Income—
HU§	Micronaire	Strength	Length	¢	$
	—value—	—$g\ tex^{-1}$—	–100^{ths} of an inch–	—kg^{-1}—	—ha^{-1}—
361	4.28c†	29.46a	1.12a	118.69a	1,058.73c
417	4.24c	29.42a	1.11a	117.96a	1,160.07bc
472	4.29bc	29.51a	1.12a	118.06a	1,244.82b
528	4.40ab	29.38a	1.12a	117.59a	1,465.27a
583	4.42a	29.12a	1.12a	117.76a	1,388.19ab
Pr>f‡	0.0054	0.7426	0.6923	0.5846	0.0094
LSD	0.11	NS	NS	NS	192.14
UTT¶					
32°C	4.30a	29.46a	1.11a	118.04a	1,271.49a
35°C	4.31a	29.35a	1.11a	117.92a	1,242.25a
no upper limit	4.37a	29.33a	1.12a	118.08a	1,246.50a
Pr>f‡	0.2264	0.8709	0.1112	0.9184	0.8744
LSD	NS#	NS	NS	NS	NS

† HU and UTT values within a single column followed by the same letter are not different at a 5% probability level.
‡ Probability of the ANOVA.
§ HU = heat units.
¶ UTT = upper temperature threshold.
# NS = not significant.

Fiber length uniformity at both locations was not affected by UTT or accumulated HU treatments (Table 11). However, at Burleson County there was significant UTT x HU interaction detected for uniformity. Representation of results in Table 18 indicates that uniformity responded at different rates and not necessarily in the same direction for any of the three UTT or five HU levels. At Wharton County, uniformity values decreased numerically from 361 to 583 HUs or as defoliation timing was delayed (Table 16).

LOAN VALUE

Upper temperature thresholds at both locations did not affect loan values (Table 11). Accumulated HUs had no affect on loan value at Burleson County; however, there was a significant decrease in loan value at Wharton County as accumulated HUs increased (Table 11). Loan values at Wharton County decreased from 120.31 ¢ kg^{-1} at 361 HUs to 119.04 ¢ kg^{-1} at 583 HUs (Table 16). When comparisons were made, loan values for 361 and 417 HU treatments were significantly higher than all other treatments with the exception of the 472 HU treatment. For both of the locations, no significant loan value interaction effects between UTT and HU timings were observed.

Table 18. Upper temperature threshold x heat unit interaction for uniformity, combined across three years (2003-2005), Burleson County.

UTT x HU‡ = <.0001	Upper Temperature Threshold (UTT)			Pr>f‡ = .1166
Heat Units (HU)	——32°C——	——35°C——	—no upper limit—	
361	83.08	83.49	83.70	83.43†§a
417	83.28	83.03	83.05	83.12a
472	82.72	82.73	83.78	83.08a
528	83.33	82.67	82.98	82.99a
583	82.82	83.81	82.79	83.14a
Pr>f‡ = .2624	83.05†§a	83.15a	83.26a	

† HU and UTT values within a single column followed by the same letter are not different at a 5% probability level.
‡ Probability of the ANOVA.
§ To compare means in a column, LSD = not significant; and in a row, LSD = not significant.

ADJUSTED GROSS INCOME

Adjusted gross income at both locations was not affected by UTT (Table 11). However, adjusted gross income at both locations was significantly affected by accumulated HU treatments (Table 11). For Wharton County, adjusted gross income increased as accumulated HUs increased. Values ranged from 926.17 at 361 HUs to 1,320.21 at 583 HUs. However, there were no significant differences in adjusted gross income between the 417, 472, 528, and 583 HU treatments. The 361 HU was significantly lower compared to all other treatments (Table 16). Adjusted gross income at Burleson County peaked in value at 528 HUs. With the exception of the 583 HU treatment, the 528 HU treatment was significantly higher than all other HU treatments (Table 17). For both of the locations, no significant adjusted gross income effects between UTT and HU timings were observed.

CHAPTER IV

CONCLUSIONS

Utilizing the designated UTTs for our study to calculate daily HUs failed to explain differences in the optimum time to defoliate based on accumulated HU from cutout. Accumulated HUs had a greater impact on defoliation timing. In comparison of the two locations, maximum lint yield was obtained at 472 HUs and 52% open boll at Wharton County versus 528 HUs and 62% open boll at Burleson County. In a typical year, the difference between 472 and 528 HUs in the two production regions means delaying defoliation by four to five days. Additional research that might contribute to the explanation of location differences should include contribution of lint yield above NAWF=5, differences in light intensity, and the utilization of a lower UTT.

Utilizing the NACB = 4 method to time defoliation would have resulted in premature application of harvest aids and reduced lint yields. The NACB benchmark was reached at 417 HU at Wharton County and 472 HU at Burleson County or approximately four days too early for optimum lint yield.

At Wharton County, the effect of delaying defoliation resulted in a gradual reduction or weathering of fiber strength when defoliation was initiated at 472 HU or later. Length was reduced when defoliation was initiated at 528 HU or later. The findings of this phenomenon cannot be explained. Micronaire and uniformity were not affected by the defoliation timings. As defoliation was delayed at Burleson County, micronaire values were increased. Micronaire values were increased when defoliation was delayed until 528 HU. However, other fiber characteristics were not affected by defoliation timings.

Loan values at Wharton County decreased when defoliation timings were delayed until 528 and 583 HU. For Burleson County, HU timings had no impact on loan values. Differences in adjusted gross income values at Wharton County were not affected once 417 HU was reached. Burleson County adjusted gross income peaked in value at 528 HU.

REFERENCES

Arndt, C.H. 1945. Temperature-growth relationship of roots and hypocotyls of cotton seedlings. Plant Physiol. 20:200-220.

Bednarz, C.W., and R.L. Nichols. 2005. Phenological and morphological components of cotton crop maturity. Crop Sci. 45:1497-1503.

Benson, N.R., W.C. Robertson, F.M. Bourland, and E.D. Vories. 2000. On farm validation of COTMAN defoliation rules. Proceedings of the Beltwide Cotton Conference [CD-ROM]. San Antonio, TX. 4-8 Jan. 2000. National Cotton Council of America, Memphis, TN.

Bourland, F.M., D.M. Oosterhuis, and N.P. Tugwell. 1992. Concept for monitoring the growth and development of cotton plants using main-stem node counts. J. Prod. Agric. 5(4):532-537.

Bourland, F.M., D.M. Oosterhuis, N.P. Tugwell, and M.J. Cochran. 1997. Non-computer version of BOLLMAN. Spec. Rep. 179. Arkansas Agric. Exp. Stn., Fayetteville, AR.

Brecke, B.J., J.C. Banks, and J.T. Cothren. 2001. Harvest-aid treatments: Products and application timing. p. 119-142. *In* J.R. Supak and C.E. Snipes (ed.) Cotton Harvest Management: Use and Influence of Harvest Aids. The Cotton Foundation, Memphis, TN.

Brooking, C. 1997. Observations of the Arkansas monitoring system-producer perspective. p. 953-955. Proceedings of the Beltwide Cotton Conference, New Orleans, LA. 6-10 Jan. 1997. National Cotton Council of America, Memphis, TN.

Cochran, M.J., N.P. Tugwell, F.M. Bourland, D.M. Oosterhuis, and D.M. Danforth. 1998. COTMAN™ Expert System 5.0. Arkansas Agric. Exp. Stn., Fayetteville, AR.

Cothren, J.T. 1999. Physiology of the cotton plant. p. 207-268. *In* C.W. Smith and J.T Cothren (ed.) Cotton: Origin, history, technology and production. John Wiley and Sons, New York, NY.

Feller, U., S.J. Crafts-Brandner, and M.E. Salvucci. 1998. Moderately high temperatures inhibit ribulose-1,5-bisphosphate carboxylase/oxygenase (rubisco) activase-mediated activation of rubisco. Plant Physiol. 116:539-546.

Fromme, D.D.1999. Utilizing COTMAN for defoliation timing and the management of micronaire values. Proceedings of the Beltwide Cotton Conference [CD-ROM]. Orlando, FLA. 3-7 Jan. 1999. National Cotton Council of America, Memphis, TN.

Fry, K.E. 1983. Heat-unit calculations in cotton crop and insect models. p. 1-23. USDA, ARS, Adv. in Agric. Tech., AAT-W-23.

Fryxell, P.A. 1986. Ecological adaptations of *Gossypium* species. p. 1-7. *In* J.R. Mauney and J.M. Stewart (ed.) Cotton Physiology. The Cotton Foundation, Memphis, TN.

Gilmore, E.C. Jr., and J.S. Rodgers. 1958. Heat units as a method of measuring maturity in corn. Agron. J. 50:611-615.

Gipson, J.R., and H.E. Joham. 1968. Influence of night temperature on growth and development of cotton (*Gossypium hirsutum* L.). I. Fruiting and boll development. Agron. J. 60:292-295.

Guinn, G. 1979. Hormonal relations in flowering, fruiting ,and cut-out. p. 265-276. *In* J. McD. Stewart (ed.) Cotton Physiology-A treatise, Sect. 1. Part 2. Flowering, fruiting, and cutout. Proceedings of the Beltwide Cotton Production Research Conference, Phoenix, Az. 7-11 Jan.1979. National Cotton Council of America, Memphis, TN.

Guinn, G. 1984. What causes cutout? p. 58. *In* J. Brown (ed.) Proceedings of the Beltwide Cotton Conference. Atlanta, GA. 8-12 Jan. 1984. National Cotton Council of America, Memphis, TN.

Gwathmey, C.O., C.W. Bednarz, D.D. Fromme, E.M. Holman, and D.K. Miller. 2004. Response to defoliation timing based on heat-unit accumulation in diverse field environments [Online]. J. Cotton Sci. 8:142-153. Available at http://www.cotton.org/journal/2004-08/3/ (verified 2 Feb. 2007).

Hesketh, J.D., and A. Low. 1968. Effect of temperature on components of yield and fiber quality of cotton varieties of diverse origin. Cotton Gr. Rev. 45:243-257.

Hodges, T. 1991. Temperature and water stress effects on phenology. p. 7-13. *In* T. Hodges (ed.) Predicting crop phenology. CRC Press, Boca Raton, FL.

Kerby, T.A., J. Supak, J.C. Banks, and C. Snipes. 1992. Timing defoliation using nodes above cracked boll. *In* D.J. Herber and D.A. Richter (ed.) Proceedings of the Beltwide Cotton Conference. Nashville, TN. 6-10 Jan. 1992. National Cotton Council of America, Memphis, TN.

Kerby, T.A. 1985. Upper thresholds required for heat unit calculations for cotton growth in the Far West. p. 366-368. *In* J. M. Brown and T.C. Nelson (ed.) Proceedings of the Beltwide Cotton Conference. New Orleans, LA. 6-11 Jan. 1985. National Cotton Council of America, Memphis, TN.

Kerby, T. 1996. Management considerations in cotton production. Delta and Pine Land Company, Scott, MS.

Larson, J.A., C.O. Gwathmey, and R.M. Hayes. 2002. Cotton defoliation and harvest timing effects on yields, quality, and net revenues [Online]. J. Cotton Sci. 6:13-27. Available at http://www.cotton.org/journal/2002-06/1/ (verified 2 Feb. 2007).

Leffler, H.R. 1976. Development of cotton fruit. I. Accumulation and distribution of dry matter. Agron. J. 68: 855-857.

Mauney, J.R. 1974. Meteorological factors affecting the commercial production of cotton. Unpublished report. National Cotton Council of America, Memphis, TN.

Mauney, J.R. 1986. Vegetative growth and development of fruiting sites. p. 11-28. *In* J.R. Mauney and J.M. Stewart (ed.) Cotton Physiology. The Cotton Foundation, Memphis, TN.

McCarty, W., C. Snipes, and D.B. Reynolds. 2000. Cotton defoliation. IS529. Miss. State Coop. Ext., Miss. State Univ., Starkville.

McIntosh, M.S. 1983. Analysis of combined experiments. Agron. J. 75:153-155.

Oosterhuis, D.M. 1992. Growth and development of a cotton plant. Publ. MP332-4M-9-92R. Ark. Coop. Ext. Serv., Fayetteville.

Oosterhuis, D.M, F.M. Bourland, and N.P. Tugwell. 1992. Basis for the nodes above white flower cotton monitoring system. Arkansas Farm Research. 41(5):3-5.

Oosterhuis, D.M, F.M. Bourland, N.P. Tugwell, and M.J. Cochran. 1996. Terminology and concepts related to the COTMAN crop monitoring system. Ark. Agric. Exp. Stn. Rep. 174, Fayetteville, AR.

Parvin, D.W., Jr. 1990. The importance of harvest initiation date. p. 471-474. *In* J. M Brown and D.A. Richter (ed.) Proceedings of the Beltwide Cotton Production Research Conference. Las Vegas, NV. 9-14 Jan. 1990. National. Cotton Council of America, Memphis, TN.

Patterson, L.L., D.R. Buxton, and R.E. Briggs. 1978. Fruiting in cotton as affected by controlled boll set. Agron. J. 70:118-122.

Perry, S.W., D.R. Krieg, and R.B. Hutmacher. 1983. Photosynthetic rate control in cotton. Plant Physiol. 73:662-665.

Reddy, K.R., H.F. Hodges, and V.R. Reddy. 1992a. Temperature effects on cotton fruit retention. Agron. J. 84:26-30.

Reddy, K.R., V.R. Reddy, and H.F. Hodges. 1992b Temperature effects on early season cotton growth and development. Agron. J. 84:229-237.

Reddy, K.R., H.F. Hodges, and J.M. McKinion. 1995. Carbon dioxide and temperature effects on pima cotton development. Agron. J. 87:820-826.

Reddy, K.R., G.H. Davidonis, A.S. Johnson, and B.T. Vinyard. 1999. Temperature regime and carbon dioxide enrichment alter cotton boll development and fiber properties. Agron. J. 91:851-858.

Reddy, V.R., K.R. Reddy, and D.N. Baker. 1991. Temperature effect on growth and development of cotton during the fruiting period. Agron. J. 83:211-217.

Robertson, W.C., B. Weatherford, and R. Benson. 2003. Defoliation timing based on heat units beyond cutout. Proceedings of the Beltwide Cotton Conference [CD-ROM]. Nashville, TN. 6-10 Jan. 2003. National Cotton Council of America, Memphis, TN.

SAS Institute. 2004. The SAS System for Windows. Release 9.1.3. SAS Inst., Cary, NC.

Sevacharian, V., and K.M. El-Zik. 1983. A slide rule for cotton crop and insect management. Leaflet 21361. Coop. Ext., Univ. California, Berkeley.

Snipes, C.E., and C.C. Baskin. 1994. Influence of early defoliation on cotton yield, seed quality, and fiber properties. Field Crops Res. 37:137-143.

Steel, R.G.D., J.H. Torrie, and D.A. Dickey. 1997. Principles and procedures of statistics – A biometrical approach. 3rd ed. McGraw-Hill Inc., New York.

Unruh, B.L., and J.C. Silvertooth. 1997. Planting and irrigation termination timing effects on the yield of upland and pima cotton. J. Prod. Agric. 10(1):74-79.

USDA-AMS Cotton Program Staff. 2001. The classification of cotton. United States Department of Agriculture-Agricultural Marketing Service. Agric. Handb. 566. U.S Gov. Print. Office, Washington, DC. pp. 1-23.

Waddle, B.A. 1982. Factors affecting fruit and shedding in cotton. Down to Earth 38(2):20-24.

Waddle, B.A. 1984. Crop growing practices. p. 234-263. *In* R.J. Kohel and C.F. Lewis (ed.) Cotton. ASA, CSSA, and SSSA, Madison, WI.

Wang, J.Y. 1960. A critique of the heat unit approach to plant response studies. Ecology. 41:785-790.

Williford, J. R. 1992. Influence of harvest factors on cotton yield and quality. Trans. Amer. Soc. Agric. Eng. 35(4): 1103-1107.

Witten, T.K., and J.T. Cothren. 2002. Heat, maturity, and defoliation. *In* J. McRae and D. Richter (ed.) Proceedings of the Beltwide Cotton Conference [CD-ROM]. Atlanta, GA. 8-12 Jan. 2002. National Cotton Council of America, Memphis, TN.

Yfoulis, A., and A. Fasoulis. 1973. Interactions of genotype and temperature on cotton boll period and their implications in breeding. Exp. Agric. 9:193-201.

Yfoulis, A., and A. Fasoulis. 1978. Role of minimum and maximum environmental temperature on maturation period of cotton boll. Agron. J. 70:421-425.

APPENDIX A

2003 Weather Data-Wharton County, TX

Date	Max.	Min.	DD15s
	°C		Daily
22-Mar	16.39	9.22	0.00
23-Mar	23.83	6.83	0.00
24-Mar	23.83	8.72	0.68
25-Mar	25.89	15.11	4.90
26-Mar	20.39	11.00	0.09
27-Mar	25.00	8.83	1.32
28-Mar	21.44	11.61	0.93
29-Mar	16.67	6.11	0.00
30-Mar	18.39	0.06	0.00
31-Mar	22.83	4.61	0.00
1-Apr	23.67	10.67	1.57
2-Apr	24.17	13.33	3.15
3-Apr	25.28	17.50	5.79
4-Apr	28.00	20.00	8.40
5-Apr	29.17	20.00	8.98
6-Apr	23.56	21.50	6.93
7-Apr	23.78	18.44	5.51
8-Apr	19.83	10.33	0.00
9-Apr	19.83	5.39	0.00
10-Apr	23.17	4.06	0.00
11-Apr	24.11	11.94	2.43
12-Apr	26.78	9.67	2.62
13-Apr	27.78	12.44	4.51
14-Apr	27.28	14.50	5.29
15-Apr	26.83	17.56	6.59
16-Apr	25.61	19.06	6.73
17-Apr	30.22	19.50	9.26
18-Apr	27.22	19.17	7.59
19-Apr	25.22	21.00	7.51
20-Apr	24.44	17.89	5.57
21-Apr	27.17	17.83	6.90
22-Apr	25.61	18.00	6.21
23-Apr	25.61	20.50	7.46
24-Apr	30.22	21.89	10.46
25-Apr	29.83	17.39	8.01
26-Apr	32.00	13.67	7.23
27-Apr	30.00	14.17	6.48
28-Apr	29.06	18.89	8.37

Date	Max.	Min.	DD15s
	———°C———		Daily
29-Apr	28.50	18.56	7.93
30-Apr	29.22	19.33	8.68
1-May	30.61	22.50	10.96
2-May	31.06	22.00	10.93
3-May	28.22	22.78	9.90
4-May	28.89	23.44	10.57
5-May	30.50	24.28	11.79
6-May	30.83	24.06	11.84
7-May	33.17	24.22	13.09
8-May	31.56	24.83	12.59
9-May	30.83	22.50	11.07
10-May	31.72	24.06	12.29
11-May	30.28	24.11	11.59
12-May	29.78	22.56	10.57
13-May	31.22	21.89	10.96
14-May	31.06	22.22	11.04
15-May	31.33	22.44	11.29
16-May	32.33	25.06	13.09
17-May	31.56	21.28	10.82
18-May	33.56	17.39	9.87
19-May	33.89	21.28	11.98
20-May	33.39	20.56	11.37
21-May	30.00	18.56	8.68
22-May	30.11	19.22	9.07
23-May	31.83	18.39	9.51
24-May	31.22	17.94	8.98
25-May	32.33	17.78	9.46
26-May	32.28	20.06	10.57
27-May	28.89	22.22	9.96
28-May	30.28	17.56	8.32
29-May	34.00	16.72	9.76
30-May	34.17	21.89	12.43
31-May	32.61	19.33	10.37
1-Jun	32.56	20.33	10.84
2-Jun	34.00	23.33	13.07
3-Jun	35.44	23.17	13.71
4-Jun	30.11	21.39	10.15
5-Jun	31.06	20.44	10.15
6-Jun	31.72	20.67	10.59
7-Jun	32.39	18.67	9.93
8-Jun	32.33	18.83	9.98
9-Jun	33.06	20.44	11.15

Date	Max.	Min.	DD15s
	———°C———		Daily
10-Jun	33.22	23.61	12.82
11-Jun	32.22	25.17	13.09
12-Jun	32.56	25.28	13.32
13-Jun	32.89	20.39	11.04
14-Jun	31.56	20.44	10.40
15-Jun	28.50	19.61	8.46
16-Jun	32.00	21.22	11.01
17-Jun	32.50	20.06	10.68
18-Jun	32.61	20.89	11.15
19-Jun	33.89	21.78	12.23
20-Jun	34.39	21.89	12.54
21-Jun	34.50	22.67	12.98
22-Jun	34.11	22.56	12.73
23-Jun	34.11	23.94	13.43
24-Jun	34.28	24.06	13.57
25-Jun	35.28	24.00	14.04
26-Jun	33.17	22.94	12.46
27-Jun	31.00	23.67	11.73
28-Jun	33.06	23.17	12.51
29-Jun	32.83	22.56	12.09
30-Jun	32.78	22.78	12.18
1-Jul	33.17	22.33	12.15
2-Jul	33.11	22.17	12.04
3-Jul	29.28	23.33	10.71
4-Jul	30.33	22.89	11.01
5-Jul	30.22	21.00	10.01
6-Jul	31.83	23.11	11.87
7-Jul	31.44	23.11	11.68
8-Jul	29.61	22.39	10.40
9-Jul	30.94	23.50	11.62
10-Jul	31.11	23.00	11.46
11-Jul	34.50	21.50	12.40
12-Jul	32.39	20.67	10.93
13-Jul	32.78	22.11	11.84
14-Jul	33.06	22.39	12.12
15-Jul	26.28	23.06	9.07
16-Jul	29.61	22.44	10.43
17-Jul	32.89	23.39	12.54
18-Jul	31.83	22.56	11.59
19-Jul	33.17	22.67	12.32
20-Jul	33.33	23.50	12.82
21-Jul	33.56	22.72	12.54

Date	Max.	Min.	DD15s
	———°C———		Daily
22-Jul	33.17	23.28	12.62
23-Jul	29.67	22.83	10.65
24-Jul	34.67	21.61	12.54
25-Jul	32.89	22.06	11.87
26-Jul	32.89	22.06	11.87
27-Jul	32.28	22.44	11.76
28-Jul	31.83	22.17	11.40
29-Jul	34.06	22.11	12.48
30-Jul	33.78	22.67	12.62
31-Jul	35.06	22.22	13.04
1-Aug	34.17	22.22	12.59
2-Aug	34.44	22.44	12.84
3-Aug	34.11	23.00	12.96
4-Aug	34.44	22.89	13.07
5-Aug	35.06	22.94	13.40
6-Aug	36.00	22.22	13.51
7-Aug	38.33	24.61	15.87
8-Aug	37.78	23.72	15.15
9-Aug	36.22	24.56	14.79
10-Aug	34.72	23.78	13.65
11-Aug	36.17	20.06	12.51
12-Aug	31.44	19.94	10.09
13-Aug	30.78	20.11	9.84
14-Aug	31.00	21.72	10.76
15-Aug	35.56	22.44	13.40
16-Aug	32.56	23.67	12.51
17-Aug	35.06	21.78	12.82
18-Aug	35.61	22.78	13.59
19-Aug	35.06	22.56	13.21
20-Aug	34.94	22.72	13.23
21-Aug	34.89	22.56	13.12
22-Aug	30.33	21.83	10.48
23-Aug	33.94	20.78	11.76
24-Aug	35.44	21.17	12.71
25-Aug	35.06	22.11	12.98
26-Aug	35.39	22.50	13.34
27-Aug	35.33	22.89	13.51
28-Aug	35.00	23.06	13.43
29-Aug	34.33	22.78	12.96
30-Aug	34.11	23.67	13.29
31-Aug	29.72	23.56	11.04
1-Sep	30.61	23.00	11.21

Date	Max.	Min.	DD15s
	———°C———		Daily
2-Sep	31.61	23.72	12.07
3-Sep	31.33	22.78	11.46
4-Sep	32.39	23.50	12.34
5-Sep	31.89	22.11	11.40

APPENDIX B

2004 Weather Data-Wharton County, TX

Date	Max.	Min.	DD15s
	———°C———		Daily
29-Mar	21.17	11.56	0.76
30-Mar	29.11	8.28	3.09
31-Mar	29.28	10.39	4.23
1-Apr	29.39	10.00	4.09
2-Apr	26.28	15.06	5.07
3-Apr	26.94	14.83	5.29
4-Apr	25.94	15.61	5.18
5-Apr	24.50	17.61	5.46
6-Apr	22.11	15.11	3.01
7-Apr	28.72	13.94	5.73
8-Apr	25.67	15.50	4.98
9-Apr	28.11	14.83	5.87
10-Apr	29.11	15.94	6.93
11-Apr	16.72	10.11	0.00
12-Apr	15.67	8.78	0.00
13-Apr	18.50	6.94	0.00
14-Apr	22.39	7.11	0.00
15-Apr	23.83	9.44	1.04
16-Apr	26.00	13.28	4.04
17-Apr	27.50	15.72	6.01
18-Apr	27.17	15.28	5.62
19-Apr	27.50	17.89	7.09
20-Apr	26.89	17.67	6.68
21-Apr	27.78	20.06	8.32
22-Apr	28.78	20.72	9.15
23-Apr	28.72	22.11	9.82
24-Apr	25.06	17.72	5.79
25-Apr	24.89	19.33	6.51
26-Apr	26.22	17.94	6.48
27-Apr	27.28	14.78	5.43
28-Apr	24.50	13.50	3.40
29-Apr	28.06	16.89	6.87
30-Apr	28.56	21.17	9.26
1-May	24.72	13.67	3.59
2-May	21.50	10.83	0.57
3-May	27.17	10.33	3.15
4-May	27.11	13.89	4.90
5-May	27.17	14.17	5.07

Date	Max.	Min.	DD15s
	——°C——		Daily
6-May	27.94	14.56	5.65
7-May	28.17	17.50	7.23
8-May	25.67	20.17	7.32
9-May	26.11	19.39	7.15
10-May	28.00	19.00	7.90
11-May	24.83	18.61	6.12
12-May	27.89	23.11	9.90
13-May	26.89	17.67	6.68
14-May	25.00	17.50	5.65
15-May	27.00	15.78	5.79
16-May	28.78	17.39	7.48
17-May	28.94	19.06	8.40
18-May	29.89	21.17	9.93
19-May	30.33	20.06	9.59
20-May	30.33	21.28	10.21
21-May	29.61	21.17	9.79
22-May	30.17	21.28	10.12
23-May	30.22	20.17	9.59
24-May	30.89	20.22	9.96
25-May	31.11	20.72	10.32
26-May	30.56	20.22	9.79
27-May	31.22	21.50	10.76
28-May	31.00	22.33	11.07
29-May	30.56	23.11	11.23
30-May	31.83	26.00	13.32
31-May	34.11	25.22	14.07
1-Jun	33.11	24.39	13.15
2-Jun	33.17	24.33	13.15
3-Jun	32.39	18.89	10.04
4-Jun	33.39	22.17	12.18
5-Jun	33.33	20.83	11.48
6-Jun	31.83	23.72	12.18
7-Jun	31.33	20.89	10.51
8-Jun	28.61	21.28	9.34
9-Jun	29.78	25.06	11.82
10-Jun	30.28	24.28	11.68
11-Jun	30.67	24.94	12.21
12-Jun	31.06	23.61	11.73
13-Jun	31.67	22.56	11.51
14-Jun	32.44	21.28	11.26
15-Jun	29.00	20.61	9.21
16-Jun	24.67	20.67	7.07

Date	Max.	Min.	DD15s
	——°C——		Daily
17-Jun	31.50	22.50	11.40
18-Jun	32.22	22.06	11.54
19-Jun	33.56	21.61	11.98
20-Jun	35.06	22.11	12.98
21-Jun	32.33	22.39	11.76
22-Jun	29.17	21.89	9.93
23-Jun	28.72	21.89	9.71
24-Jun	26.83	22.11	8.87
25-Jun	25.11	21.61	7.76
26-Jun	27.50	20.94	8.62
27-Jun	31.22	22.39	11.21
28-Jun	30.89	23.33	11.51
29-Jun	28.89	21.28	9.48
30-Jun	27.28	22.39	9.23
1-Jul	31.28	23.83	11.96
2-Jul	31.89	22.22	11.46
3-Jul	32.22	22.56	11.79
4-Jul	32.56	22.39	11.87
5-Jul	32.83	22.39	12.01
6-Jul	33.56	22.56	12.46
7-Jul	34.00	22.67	12.73
8-Jul	33.50	23.56	12.93
9-Jul	31.28	21.83	10.96
10-Jul	33.39	19.61	10.90
11-Jul	32.11	21.06	10.98
12-Jul	33.89	19.94	11.32
13-Jul	35.00	19.78	11.79
14-Jul	36.22	21.33	13.18
15-Jul	35.39	22.00	13.09
16-Jul	34.67	21.61	12.54
17-Jul	35.00	22.11	12.96
18-Jul	32.89	22.44	12.07
19-Jul	34.83	20.89	12.26
20-Jul	33.89	22.39	12.54
21-Jul	32.94	21.56	11.65
22-Jul	33.28	22.94	12.51
23-Jul	35.06	22.06	12.96
24-Jul	35.22	20.94	12.48
25-Jul	35.67	22.83	13.65
26-Jul	32.28	21.89	11.48
27-Jul	33.89	21.06	11.87
28-Jul	33.78	23.00	12.79

Date	Max.	Min.	DD15s
	——°C——		Daily
29-Jul	35.00	23.33	13.57
30-Jul	36.61	23.61	14.51
31-Jul	36.83	23.11	14.37
1-Aug	36.61	23.33	14.37
2-Aug	35.56	23.50	13.93
3-Aug	35.94	23.94	14.34
4-Aug	36.00	23.28	14.04
5-Aug	37.00	23.11	14.46
6-Aug	34.61	25.00	14.21
7-Aug	33.33	21.83	11.98
8-Aug	33.83	20.00	11.32
9-Aug	35.28	20.11	12.09
10-Aug	34.33	22.78	12.96
11-Aug	35.22	21.44	12.73
12-Aug	30.06	18.11	8.48
13-Aug	30.89	16.06	7.87
14-Aug	30.94	18.39	9.07
15-Aug	31.00	16.67	8.23
16-Aug	32.28	16.39	8.73
17-Aug	32.89	16.61	9.15
18-Aug	33.39	20.00	11.09
19-Aug	32.50	23.44	12.37
20-Aug	35.00	24.22	14.01
21-Aug	31.06	22.11	10.98
22-Aug	31.39	23.94	12.07
23-Aug	33.06	24.56	13.21
24-Aug	34.61	22.78	13.09
25-Aug	35.28	23.56	13.82
26-Aug	35.56	24.22	14.29
27-Aug	35.56	22.17	13.26
28-Aug	33.11	22.22	12.07
29-Aug	30.11	21.56	10.23
30-Aug	33.94	21.72	12.23
31-Aug	32.39	22.33	11.76
1-Sep	31.56	19.83	10.09
2-Sep	29.61	21.28	9.84
3-Sep	28.39	21.72	9.46
4-Sep	31.72	21.89	11.21
5-Sep	34.00	22.06	12.43
6-Sep	34.06	22.17	12.51

APPENDIX C

2005 Weather Data-Wharton County, TX

Date	Max.	Min.	DD15s
	°C		Daily
2-Apr	24.17	6.50	0.00
3-Apr	24.06	6.67	0.00
4-Apr	25.17	14.39	4.18
5-Apr	25.33	19.33	6.73
6-Apr	27.33	17.22	6.68
7-Apr	27.67	12.61	4.54
8-Apr	27.78	11.89	4.23
9-Apr	27.11	13.44	4.68
10-Apr	24.72	18.89	6.21
11-Apr	28.61	14.83	6.12
12-Apr	27.28	10.83	3.46
13-Apr	30.50	13.56	6.43
14-Apr	26.22	11.06	3.04
15-Apr	25.39	13.61	3.90
16-Apr	27.28	11.56	3.82
17-Apr	25.89	14.50	4.59
18-Apr	25.56	17.89	6.12
19-Apr	25.83	17.78	6.21
20-Apr	27.22	18.28	7.15
21-Apr	29.00	20.06	8.93
22-Apr	29.78	18.56	8.57
23-Apr	24.06	11.67	2.26
24-Apr	24.00	8.56	0.68
25-Apr	19.17	15.39	1.68
26-Apr	24.78	12.89	3.23
27-Apr	28.67	11.22	4.34
28-Apr	28.72	17.17	7.34
29-Apr	28.56	21.56	9.46
30-Apr	23.06	12.56	2.21
1-May	24.39	9.17	1.18
2-May	25.94	11.06	2.90
3-May	25.89	12.83	3.76
4-May	25.33	14.50	4.32
5-May	27.56	12.06	4.21
6-May	28.17	13.61	5.29
7-May	26.44	16.00	5.62
8-May	24.33	16.28	4.71
9-May	29.44	16.83	7.54

Date	Max.	Min.	DD15s
	———°C———		Daily
10-May	28.78	20.56	9.07
11-May	28.56	20.28	8.82
12-May	27.89	21.00	8.84
13-May	28.56	18.17	7.76
14-May	30.89	18.11	8.90
15-May	30.72	18.78	9.15
16-May	26.72	17.17	6.34
17-May	27.17	16.11	6.04
18-May	28.67	17.94	7.71
19-May	30.83	18.11	8.87
20-May	33.56	19.33	10.84
21-May	34.17	20.83	11.90
22-May	34.06	21.28	12.07
23-May	32.50	21.00	11.15
24-May	31.83	17.61	9.12
25-May	33.83	20.39	11.51
26-May	31.50	21.39	10.84
27-May	31.56	20.39	10.37
28-May	29.89	20.89	9.79
29-May	29.39	18.89	8.54
30-May	29.11	19.61	8.76
31-May	31.94	20.61	10.68
1-Jun	28.94	18.72	8.23
2-Jun	30.94	19.00	9.37
3-Jun	30.78	19.72	9.65
4-Jun	30.67	23.39	11.43
5-Jun	32.11	23.44	12.18
6-Jun	32.00	23.33	12.07
7-Jun	31.78	24.50	12.54
8-Jun	31.50	23.61	11.96
9-Jun	31.11	24.17	12.04
10-Jun	31.39	22.00	11.09
11-Jun	32.83	22.11	11.87
12-Jun	31.67	20.94	10.71
13-Jun	32.33	22.61	11.87
14-Jun	34.78	21.72	12.65
15-Jun	35.33	22.61	13.37
16-Jun	33.78	21.78	12.18
17-Jun	33.78	22.17	12.37
18-Jun	34.11	21.78	12.34
19-Jun	35.33	22.78	13.46
20-Jun	34.50	21.50	12.40

Date	Max.	Min.	DD15s
	———°C———		Daily
21-Jun	34.28	19.44	11.26
22-Jun	34.67	19.83	11.65
23-Jun	34.50	20.89	12.09
24-Jun	34.28	20.56	11.82
25-Jun	34.11	20.94	11.93
26-Jun	34.17	21.61	12.29
27-Jun	32.94	21.33	11.54
28-Jun	33.89	20.67	11.68
29-Jun	34.17	21.50	12.23
30-Jun	35.33	22.78	13.46
1-Jul	36.94	22.83	14.29
2-Jul	36.83	22.39	14.01
3-Jul	35.28	23.72	13.90
4-Jul	35.00	23.89	13.84
5-Jul	36.44	22.61	13.93
6-Jul	38.33	23.94	15.54
7-Jul	36.11	21.00	12.96
8-Jul	34.33	21.06	12.09
9-Jul	31.56	22.33	11.34
10-Jul	35.78	21.83	13.21
11-Jul	34.11	22.72	12.82
12-Jul	33.72	22.44	12.48
13-Jul	33.33	23.11	12.62
14-Jul	34.72	21.89	12.71
15-Jul	26.00	21.50	8.15
16-Jul	29.39	22.39	10.29
17-Jul	33.39	23.44	12.82
18-Jul	33.06	23.72	12.79
19-Jul	31.78	22.94	11.76
20-Jul	32.11	23.94	12.43
21-Jul	31.11	23.89	11.90
22-Jul	34.44	22.72	12.98
23-Jul	33.50	22.39	12.34
24-Jul	33.67	23.17	12.82
25-Jul	33.72	22.72	12.62
26-Jul	33.50	21.39	11.84
27-Jul	34.78	21.56	12.57
28-Jul	34.89	23.44	13.57
29-Jul	34.61	21.67	12.54
30-Jul	34.61	22.39	12.90
31-Jul	34.33	22.22	12.68
1-Aug	36.28	23.17	14.12

Date	Max.	Min.	DD15s
	————°C————		Daily
2-Aug	34.17	23.28	13.12
3-Aug	33.89	23.00	12.84
4-Aug	33.78	23.17	12.87
5-Aug	33.17	22.28	12.12
6-Aug	34.67	22.11	12.79
7-Aug	33.89	22.72	12.71
8-Aug	34.72	21.61	12.57
9-Aug	34.78	22.78	13.18
10-Aug	34.61	23.78	13.59
11-Aug	34.17	22.44	12.71
12-Aug	34.17	23.33	13.15
13-Aug	34.72	22.83	13.18
14-Aug	33.78	24.28	13.43
15-Aug	34.89	23.44	13.57
16-Aug	33.11	24.22	13.07
17-Aug	34.17	22.67	12.82
18-Aug	35.22	22.67	13.34
19-Aug	34.33	23.33	13.23
20-Aug	36.39	23.44	14.32
21-Aug	36.56	22.33	13.84
22-Aug	35.44	23.61	13.93
23-Aug	36.89	23.44	14.57
24-Aug	35.61	23.44	13.93

APPENDIX D

2003 Weather Data-Burleson County, TX

Date	Max.	Min.	DD15s
	°C		Daily
12-May	24.50	19.30	6.30
13-May	32.60	17.40	9.40
14-May	32.80	22.40	12.00
15-May	32.80	22.50	12.05
16-May	35.40	22.30	13.25
17-May	30.90	17.90	8.80
18-May	33.80	15.40	9.00
19-May	35.10	19.70	11.80
20-May	31.00	18.10	8.95
21-May	27.70	17.80	7.15
22-May	30.10	17.90	8.40
23-May	32.10	15.80	8.35
24-May	32.40	19.90	10.55
25-May	31.10	17.90	8.90
26-May	31.30	21.30	10.70
27-May	29.50	20.80	9.55
28-May	31.20	13.50	6.75
29-May	35.60	13.20	8.80
30-May	37.20	18.80	12.40
31-May	36.30	20.70	12.90
1-Jun	35.10	20.00	11.95
2-Jun	33.50	22.40	12.35
3-Jun	35.70	21.00	12.75
4-Jun	29.30	20.40	9.25
5-Jun	26.10	19.60	7.25
6-Jun	28.70	20.10	8.80
7-Jun	32.10	16.70	8.80
8-Jun	31.90	18.50	9.60
9-Jun	33.80	18.60	10.60
10-Jun	32.60	24.60	13.00
11-Jun	35.00	25.10	14.45
12-Jun	33.70	19.50	11.00
13-Jun	33.80	20.00	11.30
14-Jun	33.90	19.10	10.90
15-Jun	28.50	19.00	8.15
16-Jun	31.90	21.40	11.05
17-Jun	31.20	20.90	10.45
18-Jun	32.50	20.90	11.10

Date	Max.	Min.	DD15s
	°C		Daily
19-Jun	35.10	21.10	12.50
20-Jun	34.70	21.70	12.60
21-Jun	34.50	22.60	12.95
22-Jun	35.10	23.20	13.55
23-Jun	34.60	24.60	14.00
24-Jun	33.50	24.00	13.15
25-Jun	35.10	24.00	13.95
26-Jun	35.00	23.60	13.70
27-Jun	32.80	22.80	12.20
28-Jun	33.60	21.70	12.05
29-Jun	32.70	21.70	11.60
30-Jun	33.20	23.10	12.55
1-Jul	34.70	22.70	13.10
2-Jul	34.70	21.10	12.30
3-Jul	33.70	22.10	12.30
4-Jul	30.60	22.30	10.85
5-Jul	31.10	23.40	11.65
6-Jul	33.10	24.70	13.30
7-Jul	32.10	23.40	12.15
8-Jul	32.30	21.90	11.50
9-Jul	32.40	22.10	11.65
10-Jul	33.40	22.80	12.50
11-Jul	30.60	22.30	10.85
12-Jul	31.10	23.40	11.65
13-Jul	33.10	24.70	13.30
14-Jul	32.10	23.40	12.15
15-Jul	32.30	21.90	11.50
16-Jul	32.40	22.10	11.65
17-Jul	33.40	22.80	12.50
18-Jul	35.50	24.00	14.15
19-Jul	33.80	23.10	12.85
20-Jul	35.00	21.70	12.75
21-Jul	36.40	24.40	14.80
22-Jul	36.00	24.90	14.85
23-Jul	31.60	21.90	11.15
24-Jul	33.50	22.90	12.60
25-Jul	34.80	24.70	14.15
26-Jul	35.00	21.90	12.85
27-Jul	34.40	22.10	12.65
28-Jul	35.70	22.00	13.25
29-Jul	36.50	21.10	13.20
30-Jul	36.30	26.70	15.90

Date	Max.	Min.	DD15s
	———°C———		Daily
31-Jul	36.50	23.00	14.15
1-Aug	36.80	22.40	14.00
2-Aug	36.60	22.50	13.95
3-Aug	35.30	24.10	14.10
4-Aug	37.10	22.40	14.15
5-Aug	37.20	23.30	14.65
6-Aug	38.60	24.40	15.90
7-Aug	40.50	22.80	16.05
8-Aug	40.60	24.00	16.70
9-Aug	35.90	23.00	13.85
10-Aug	38.10	23.30	15.10
11-Aug	34.70	21.60	12.55
12-Aug	30.70	19.10	9.30
13-Aug	31.40	19.50	9.85
14-Aug	32.20	22.00	11.50
15-Aug	35.40	20.60	12.40
16-Aug	36.00	23.50	14.15
17-Aug	37.50	22.10	14.20
18-Aug	36.60	24.10	14.75
19-Aug	36.00	22.70	13.75
20-Aug	36.20	22.40	13.70
21-Aug	37.50	21.50	13.90
22-Aug	31.60	21.60	11.00
23-Aug	34.00	22.30	12.55
24-Aug	35.40	22.50	13.35
25-Aug	35.50	22.90	13.60
26-Aug	35.60	23.00	13.70
27-Aug	36.00	23.30	14.05
28-Aug	35.70	24.30	14.40
29-Aug	35.40	23.30	13.75
30-Aug	34.30	23.20	13.15
31-Aug	25.70	23.80	9.15
1-Sep	31.50	23.70	12.00
2-Sep	31.30	23.10	11.60
3-Sep	30.90	23.10	11.40
4-Sep	34.60	22.90	13.15
5-Sep	32.10	21.40	11.15
6-Sep	31.70	17.70	9.10
7-Sep	30.90	14.50	7.10
8-Sep	30.20	16.30	7.65
9-Sep	32.70	17.70	9.60
10-Sep	33.30	22.50	12.30

Date	Max.	Min.	DD15s
	———°C———		Daily
11-Sep	32.70	20.20	10.85
12-Sep	28.30	19.40	8.25
13-Sep	32.10	18.30	9.60
14-Sep	29.60	19.50	8.95
15-Sep	30.70	17.20	8.35
16-Sep	31.50	19.60	9.95
17-Sep	30.80	17.70	8.65
18-Sep	26.90	21.30	8.50
19-Sep	28.40	19.80	8.50
20-Sep	27.60	18.50	7.45
21-Sep	22.40	19.90	5.55
22-Sep	29.90	19.00	8.85
23-Sep	30.00	16.00	7.40
24-Sep	29.30	19.60	8.85

APPENDIX E

2004 Weather Data-Burleson County, TX

Date	Max.	Min.	DD15s
	°C		Daily
8-Apr	26.90	12.00	3.85
9-Apr	28.60	12.60	5.00
10-Apr	26.90	13.50	4.60
11-Apr	13.50	9.90	0.00
12-Apr	13.40	7.50	0.00
13-Apr	18.70	5.80	0.00
14-Apr	23.10	4.80	0.00
15-Apr	24.60	7.80	0.60
16-Apr	26.50	13.00	4.15
17-Apr	27.50	14.70	5.50
18-Apr	26.70	16.30	5.90
19-Apr	27.80	17.50	7.05
20-Apr	26.50	17.30	6.30
21-Apr	27.90	18.20	7.45
22-Apr	29.90	21.40	10.05
23-Apr	29.70	22.40	10.45
24-Apr	23.60	17.40	4.90
25-Apr	21.60	18.50	4.45
26-Apr	27.00	15.90	5.85
27-Apr	29.00	13.60	5.70
28-Apr	24.80	14.10	3.85
29-Apr	28.90	18.10	7.90
30-Apr	28.90	21.30	9.50
1-May	23.00	13.00	2.40
2-May	23.80	8.60	0.60
3-May	28.30	9.40	3.25
4-May	28.00	14.10	5.45
5-May	27.60	13.20	4.80
6-May	28.20	14.10	5.55
7-May	28.80	16.10	6.85
8-May	27.00	19.40	7.60
9-May	27.40	18.70	7.45
10-May	29.40	17.80	8.00
11-May	26.60	19.30	7.35
12-May	29.30	20.80	9.45
13-May	24.90	17.60	5.65
14-May	22.70	16.00	3.75
15-May	26.90	15.90	5.80

Date	Max.	Min.	DD15s
	———°C———		Daily
16-May	30.10	16.30	7.60
17-May	29.50	20.40	9.35
18-May	31.20	22.90	11.45
19-May	31.10	21.30	10.60
20-May	31.10	21.60	10.75
21-May	30.50	20.80	10.05
22-May	31.00	22.30	11.05
23-May	31.30	20.60	10.35
24-May	31.50	21.00	10.65
25-May	32.10	22.30	11.60
26-May	32.00	21.10	10.95
27-May	32.50	22.00	11.65
28-May	32.90	23.80	12.75
29-May	32.20	23.30	12.15
30-May	31.30	26.30	13.20
31-May	34.90	22.70	13.20
1-Jun	34.90	20.00	11.85
2-Jun	33.90	22.50	12.60
3-Jun	31.70	19.10	9.80
4-Jun	34.30	21.10	12.10
5-Jun	29.60	21.10	9.75
6-Jun	32.20	22.20	11.60
7-Jun	30.90	20.60	10.15
8-Jun	25.10	20.70	7.30
9-Jun	30.80	22.60	11.10
10-Jun	31.60	24.50	12.45
11-Jun	31.20	23.80	11.90
12-Jun	32.10	24.30	12.60
13-Jun	33.60	21.40	11.90
14-Jun	31.40	20.50	10.35
15-Jun	25.60	19.10	6.75
16-Jun	29.70	19.10	8.80
17-Jun	32.00	21.90	11.35
18-Jun	34.10	22.60	12.75
19-Jun	33.80	22.80	12.70
20-Jun	34.00	22.90	12.85
21-Jun	32.80	22.90	12.25
22-Jun	30.70	21.60	10.55
23-Jun	30.20	22.80	10.90
24-Jun	25.40	22.50	8.35
25-Jun	30.60	21.90	10.65
26-Jun	29.60	22.10	10.25

Date	Max.	Min.	DD15s
	———°C———		Daily
27-Jun	29.60	20.90	9.65
28-Jun	32.50	22.10	11.70
29-Jun	28.50	22.00	9.65
30-Jun	28.50	22.40	9.85
1-Jul	32.90	22.60	12.15
2-Jul	33.30	25.60	13.85
3-Jul	32.60	24.70	13.05
4-Jul	32.80	23.70	12.65
5-Jul	34.20	23.40	13.20
6-Jul	34.70	22.20	12.85
7-Jul	34.10	22.40	12.65
8-Jul	34.30	24.10	13.60
9-Jul	31.60	21.80	11.10
10-Jul	33.30	20.60	11.35
11-Jul	33.00	21.60	11.70
12-Jul	33.00	20.70	11.25
13-Jul	34.60	20.00	11.70
14-Jul	35.90	22.10	13.40
15-Jul	35.30	21.90	13.00
16-Jul	33.70	23.00	12.75
17-Jul	34.50	23.30	13.30
18-Jul	33.40	21.90	12.05
19-Jul	33.70	19.60	11.05
20-Jul	33.70	20.50	11.50
21-Jul	34.00	20.10	11.45
22-Jul	33.00	21.70	11.75
23-Jul	35.30	21.60	12.85
24-Jul	35.00	22.40	13.10
25-Jul	34.80	22.60	13.10
26-Jul	30.90	20.10	9.90
27-Jul	32.00	19.90	10.35
28-Jul	32.80	21.60	11.60
29-Jul	34.10	23.30	13.10
30-Jul	34.60	22.80	13.10
31-Jul	35.10	23.50	13.70
1-Aug	35.40	23.60	13.90
2-Aug	35.60	22.90	13.65
3-Aug	36.70	23.10	14.30
4-Aug	38.40	22.70	14.95
5-Aug	38.50	22.60	14.95
6-Aug	32.50	23.20	12.25
7-Aug	32.00	20.40	10.60

Date	Max.	Min.	DD15s
	———°C———		Daily
8-Aug	33.10	19.40	10.65
9-Aug	35.40	21.10	12.65
10-Aug	33.00	22.30	12.05
11-Aug	35.60	20.90	12.65
12-Aug	30.50	17.50	8.40
13-Aug	30.70	14.90	7.20
14-Aug	30.60	17.30	8.35
15-Aug	30.40	16.60	7.90
16-Aug	31.90	15.20	7.95
17-Aug	32.90	16.00	8.85
18-Aug	33.70	17.20	9.85
19-Aug	33.30	22.00	12.05
20-Aug	35.30	21.80	12.95
21-Aug	32.90	21.20	11.45
22-Aug	33.60	22.10	12.25
23-Aug	32.30	24.00	12.55
24-Aug	34.60	24.40	13.90
25-Aug	34.90	24.40	14.05
26-Aug	35.50	25.10	14.70
27-Aug	35.10	24.50	14.20
28-Aug	33.30	22.20	12.15
29-Aug	33.10	20.80	11.35
30-Aug	34.20	19.90	11.45
31-Aug	32.30	18.10	9.60
1-Sep	31.10	15.70	7.80
2-Sep	30.30	19.70	9.40
3-Sep	28.00	19.60	8.20
4-Sep	32.70	20.90	11.20
5-Sep	33.70	21.10	11.80
6-Sep	33.00	22.00	11.90
7-Sep	25.20	18.80	6.40
8-Sep	31.70	17.60	9.05
9-Sep	32.60	14.60	8.00
10-Sep	33.60	16.50	9.45
11-Sep	34.40	21.00	12.10
12-Sep	34.10	20.00	11.45
13-Sep	33.40	18.90	10.55
14-Sep	31.10	21.80	10.85
15-Sep	34.60	21.90	12.65
16-Sep	37.30	20.40	13.25
17-Sep	36.30	20.20	12.65
18-Sep	35.00	20.90	12.35

Date	Max.	Min.	DD15s
	———°C———		Daily
19-Sep	34.80	19.10	11.35
20-Sep	33.00	17.30	9.55
21-Sep	31.90	18.10	9.40

APPENDIX F

2005 Weather Data-Burleson County, TX

Date	Max.	Min.	DD15s
	°C		Daily
12-Apr	27.40	9.60	2.90
13-Apr	28.30	12.10	4.60
14-Apr	25.60	11.10	2.75
15-Apr	24.40	11.80	2.50
16-Apr	26.40	10.40	2.80
17-Apr	25.80	12.20	3.40
18-Apr	25.70	17.60	6.05
19-Apr	25.50	17.50	5.90
20-Apr	28.40	18.00	7.60
21-Apr	28.80	18.00	7.80
22-Apr	30.80	17.20	8.40
23-Apr	22.90	9.50	0.60
24-Apr	22.60	5.30	0.00
25-Apr	20.30	12.90	1.00
26-Apr	25.50	11.20	2.75
27-Apr	29.90	9.40	4.05
28-Apr	31.40	15.90	8.05
29-Apr	29.50	17.30	7.80
30-Apr	21.50	10.10	0.20
1-May	24.20	7.20	0.10
2-May	26.00	9.90	2.35
3-May	23.20	14.10	3.05
4-May	23.70	13.90	3.20
5-May	27.00	10.90	3.35
6-May	28.50	14.00	5.65
7-May	27.50	15.10	5.70
8-May	21.80	15.30	2.95
9-May	27.80	13.50	5.05
10-May	30.00	20.20	9.50
11-May	29.50	20.10	9.20
12-May	29.00	20.40	9.10
13-May	29.20	18.80	8.40
14-May	30.20	18.70	8.85
15-May	29.30	17.10	7.60
16-May	23.90	17.20	4.95
17-May	29.40	14.20	6.20
18-May	30.80	19.00	9.30
19-May	30.80	19.10	9.35

Date	Max.	Min.	DD15s
	———°C———		Daily
20-May	33.10	21.20	11.55
21-May	36.50	19.40	12.35
22-May	35.50	20.40	12.35
23-May	32.80	21.20	11.40
24-May	32.50	19.60	10.45
25-May	34.40	19.50	11.35
26-May	26.50	19.10	7.20
27-May	31.60	18.10	9.25
28-May	30.90	21.50	10.60
29-May	32.50	19.70	10.50
30-May	30.40	19.80	9.50
31-May	33.50	19.50	10.90
1-Jun	30.10	18.70	8.80
2-Jun	33.30	17.90	10.00
3-Jun	32.50	20.80	11.05
4-Jun	33.30	23.60	12.85
5-Jun	33.80	23.60	13.10
6-Jun	34.00	22.00	12.40
7-Jun	34.60	23.90	13.65
8-Jun	34.10	24.40	13.65
9-Jun	33.70	23.90	13.20
10-Jun	34.50	22.80	13.05
11-Jun	34.70	21.80	12.65
12-Jun	34.10	22.10	12.50
13-Jun	33.30	21.90	12.00
14-Jun	36.60	22.50	13.95
15-Jun	36.70	21.80	13.65
16-Jun	35.80	21.90	13.25
17-Jun	35.20	21.70	12.85
18-Jun	35.50	22.30	13.30
19-Jun	35.90	23.40	14.05
20-Jun	34.00	20.60	11.70
21-Jun	35.10	17.90	10.90
22-Jun	35.90	20.10	12.40
23-Jun	34.90	21.30	12.50
24-Jun	34.80	20.00	11.80
25-Jun	35.10	18.80	11.35
26-Jun	37.00	21.40	13.60
27-Jun	35.30	20.50	12.30
28-Jun	35.50	20.30	12.30
29-Jun	36.10	21.50	13.20
30-Jun	36.90	21.60	13.65

Date	Max.	Min.	DD15s
	———°C———		Daily
1-Jul	38.40	25.10	16.15
2-Jul	38.30	25.10	16.10
3-Jul	37.40	24.20	15.20
4-Jul	37.20	25.00	15.50
5-Jul	36.10	22.40	13.65
6-Jul	39.80	22.80	15.70
7-Jul	37.90	20.60	13.65
8-Jul	34.60	20.50	11.95
9-Jul	34.80	21.50	12.55
10-Jul	37.00	22.10	13.95
11-Jul	37.20	22.90	14.45
12-Jul	37.00	22.50	14.15
13-Jul	36.80	23.40	14.50
14-Jul	35.40	22.00	13.10
15-Jul	32.00	21.40	11.10
16-Jul	29.80	22.40	10.50
17-Jul	30.90	23.40	11.55
18-Jul	33.60	23.60	13.00
19-Jul	34.30	22.30	12.70
20-Jul	33.40	24.80	13.50
21-Jul	33.50	23.70	13.00
22-Jul	36.10	23.00	13.95
23-Jul	34.60	23.30	13.35
24-Jul	34.30	22.30	12.70
25-Jul	35.10	22.40	13.15
26-Jul	33.80	21.30	11.95
27-Jul	35.60	20.90	12.65
28-Jul	36.20	21.40	13.20
29-Jul	35.80	22.60	13.60
30-Jul	35.70	20.90	12.70
31-Jul	36.10	17.70	11.30
1-Aug	35.50	21.70	13.00
2-Aug	35.80	21.80	13.20
3-Aug	34.90	22.70	13.20
4-Aug	34.20	22.50	12.75
5-Aug	34.50	21.80	12.55
6-Aug	36.70	20.40	12.95
7-Aug	35.30	21.30	12.70
8-Aug	34.30	22.20	12.65
9-Aug	29.70	22.30	10.40
10-Aug	28.10	22.50	9.70
11-Aug	34.00	21.80	12.30

Date	Max.	Min.	DD15s
	———°C———		Daily
12-Aug	34.20	22.30	12.65
13-Aug	34.10	22.70	12.80
14-Aug	32.30	24.20	12.65
15-Aug	34.40	23.10	13.15
16-Aug	33.70	22.30	12.40
17-Aug	34.80	21.80	12.70
18-Aug	35.20	22.90	13.45
19-Aug	34.20	22.80	12.90
20-Aug	35.40	22.60	13.40
21-Aug	36.50	21.90	13.60
22-Aug	37.90	22.20	14.45
23-Aug	36.60	22.90	14.15
24-Aug	36.60	23.30	14.35
25-Aug	35.40	22.50	13.35
26-Aug	36.80	22.10	13.85
27-Aug	37.90	23.60	15.15
28-Aug	36.40	22.60	13.90
29-Aug	36.80	23.00	14.30
30-Aug	37.90	20.80	13.75
31-Aug	38.30	20.90	14.00
1-Sep	38.60	20.40	13.90
2-Sep	35.50	21.20	12.75

VITA

Daniel D. Fromme received his Bachelor of Science degree in Crops from Texas Tech University at Lubbock in 1979. In 1992, he received his Masters of Education degree from Southwest Texas State University at San Marcos and a PhD in Agronomy from Texas A&M University at College Station in 2007. For the past twenty-three years, he has been employed by Texas Cooperative Extension. He currently serves as the Extension Agronomist for the Rio Grande Valley and Winter Garden regions of Texas.

Dr. Fromme may be reached at the Texas A&M Research and Extension Center, 1619 Garner Field Road, Uvalde, TX 78801. His email address is d-fromme@tamu.edu.