Chapter 7:

Stepwise Progression Through BOLLMAN with Instructions for Non-Computer Users

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A non-computerized version of BOLLMAN can serve as an excellent teaching tool and can be used by individuals who would like to try the system on a small scale. The user should then be able to gain confidence in the system and an appreciation of the power of the computer-based version. However, this simplified "paper" version should not be considered as a substitute for the computer-based system. Due to voluminous data manipulations, it is not practical to attempt the SQUAREMAN portion of COTMAN™ without a computer. Similarly, as BOLLMAN is conducted on an increasing number of fields, the need for a computer to handle the data greatly increases.

The logic of BOLLMAN is to identify cutout date, i.e., the flowering date of the last population of bolls that is expected to make a profitable contribution to yield, then adjust end-of-season management on the maturation of these bolls. Cutout either coincides with crop maturation (physiological cutout) or is dictated by end-of-season weather (seasonal cutout). BOLLMAN assists with timing of insecticide termination and application of defoliants, as well as with sequencing of fields by their relative maturity.

BOLLMAN requires four steps:

- Sequentially monitor *nodes above white flower* (NAWF) to determine date of physiological cutout.
- Estimate latest possible cutout date from historical local weather data to determine date of seasonal cutout.
- Establish last effective flowering date to determine true cutout date.
- Calculate and accumulate heat units (HU) after true cutout date for each field.

Step 1. NAWF

Initiate NAWF Measurement

Each field should be monitored for the appearance of first flowers. Start collecting NAWF data at first flower and collect once or twice per week until NAWF is less than 5 or until the latest possible cutout date occurs.

NAWF counts should be initiated at first flower because early NAWF counts can be important crop growth indicators (Robertson et al., 1996). Sequential monitoring of NAWF once or twice a week gives information on the progressive maturity of the crop. Timely initiation of NAWF counts also allows the user to distinguish between true cutout (first incidence of NAWF=5) and second growth (or late-flowering plants). Fruit associated with second growth is often costly to protect and contributes little or nothing to yield. Therefore, monitoring NAWF of second growth nullifies the value of BOLLMAN.

NAWF Measurement

Users should make copies of the blank NAWF data collection sheet (Appendix D, page 104). Select at least four sample sites within a field or management unit. For fields larger than approximately 40 acres, add a sample site for each additional 10 acres. It is essential to choose a representative site within each sample site. Find a plant having a first-position white flower, and count the number of main-stem nodes above the branch bearing a first-position white flower. The uppermost node counted is the highest one having an unfurled leaf, i.e., edges not touching (Fig. 1). Find a second plant having a first-position white flower, and count NAWF. Repeat this procedure for 10 plants in each sample site. Do not sample all 10 plants from the same row. Go to the next sample site and repeat the procedure. Deter-

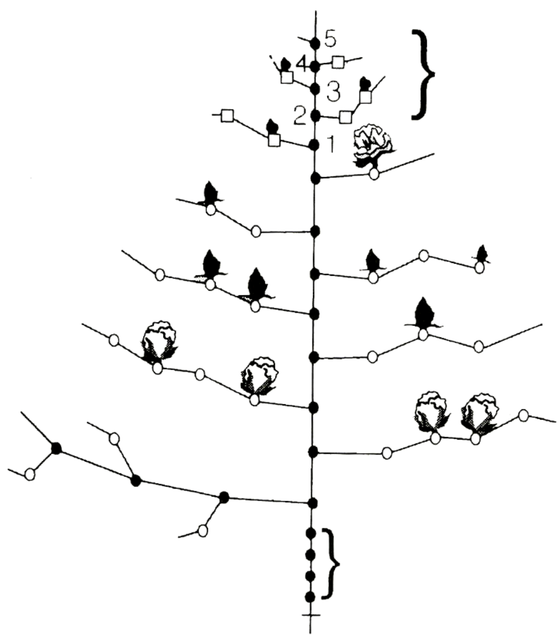

Fig. 1. Plant diagram illustration of NAWF.

mine the mean NAWF for each site (round to nearest 0.1). *Average the site* means to determine a field mean NAWF value (round to nearest 0.1). For each field, NAWF should be determined once or twice per week from first flower until cutout (*See* Physiological Cutout on page 47).

NAWF Variation

Considerable plant-to-plant variation in NAWF within a field is normal. The amount of variation in these values within and across sites can be meaningful. Variation within a site reflects plant-to-plant variation in growth and development. Major contributors to such variation are as follows:

- Differences in stand density,
- Sporadic insect injury, causing loss of fruit or vigor,
- Random physical injury, e.g., hail damage,
- Incidence of non-lethal plant disease, and
- Spot-replanting within an area.

Variation between sites is often related to differences in soil types or water status (excess or deficiency). If sites vary greatly, be sure that the sites properly represent the field. In some cases, you may want to substitute a sample site that better represents the area of the field upon which you wish to base your decisions. Generally, as variation increases, sample sizes and number of samples should be increased to reduce sampling errors.

Chart NAWF

Prior to initiating NAWF counts, make a NAWF chart (Appendix D, page 104) for each field and fill in information relative to field name, planting date, soil type, and cotton variety. The NAWF chart plots "days after planting" (DAP) on the horizontal axis against the NAWF value on the vertical axis. Calendar dates associated with the various DAPs should be determined and entered below each 10-day increment. For example, with a May 1 planting; 50, 60, 70, 80, 90, 100 and 110 DAP would be June 20, 30, July 10, 20, 30, August 9, and 19, respectively. Designating the calendar dates associated with DAPs will greatly facilitate subsequent plotting of data and other information on the chart.

As data are collected, plot the average NAWF against DAP for each sampling date. The chart can also be used to maintain other field management records. For example, it would be useful to indicate inputs such as fertilizer, irrigation (and rainfall), and insecticide applications. Those inputs occurring after 50 DAP can be indicated on the chart by their respective dates of application. Earlier inputs and observations regarding other factors that might influence the plants (damage from disease, hail, herbicide, etc.) may be noted in the margins. At the end of the season, the user may wish to include information regarding yield and quality. Such charts can be maintained as a permanent record and provide valuable insight on both the productivity of the field and the influence of various management inputs on plant growth, yield, and quality.

Observed values generated by sequential, average NAWF can be compared to the right side of the *Target Development Curve* (TDC, Fig. 2). The TDC assumes first flower at 60 DAP, vertical squaring interval of 2.7 days, 25 days from first square to first flower, and NAWF=5 at 80 DAP. Based on these assumptions, NAWF on the TDC at 60 DAP is 9.25, i.e., 25 days from square to flower divided by 2.7-day interval between new main-stem node formation.

The curve generated in the observed NAWF values may be near, below, or above the TDC. Visual observation of the charted line against the TDC provides immediate information on the potential

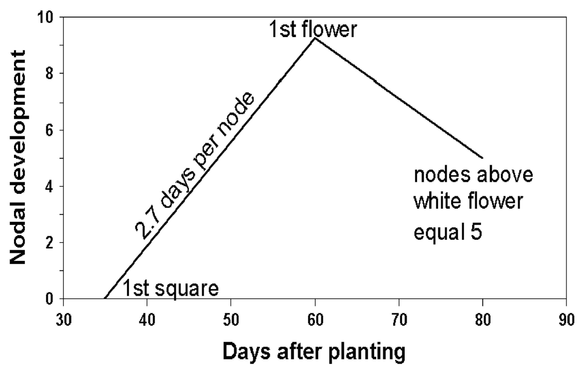

Fig. 2. Target Development Curve.

yield and maturation of the crop. Fields having NAWF that are plotted near the TDC are developing at a pace that should provide the best combination of high yield and early maturation. Stressed growing conditions (e.g., lack of water), are indicated by NAWF values below the TDC (i.e., slope does not parallel and is more steep than TDC). Such conditions can often incite shedding of fruit. If the stressed conditions are alleviated, the plants may initiate second growth and have delayed maturity. Otherwise, plants in these stressed fields reach cutout earlier than desired. Typically, cotton plants are unable to fully recover from severe stress that occurs after flowering. A major reason for using SQUAREMAN in the computer-based COTMAN is to help detect stress early enough that remedial action may be effective.

A NAWF curve above the TDC can be caused by slow early-season growth, which delays plant development and maturity (such a situation could be detected by SQUAREMAN). Of much greater concern is a situation in which NAWF values are not declining over sampling dates. Relatively flat NAWF slopes indicate that plants are not progressing toward maturity in a timely fashion. A high (relative to TDC) and flat-sloped NAWF curve is usually because of lack of fruit development (poor retention/small bolls) in relation to vegetative growth of the plants. Such fields will likely have low yields and delayed maturity. In contrast, relatively flat slopes that have low (relative to TDC) NAWF indicate that vegetative growth is barely sufficient to maintain additional reproductive development. Increased stress on these plants will likely cause premature cutout and low yields. However, if such fields can maintain this precarious vegetative to reproductive balance and experience good late-season conditions, acceptable yields are possible. In these cases, yields will tend to increase as maturity is delayed, with corresponding increases in production costs and risks.

Physiological Cutout

Monitoring of NAWF should be stopped when a field has reached cutout, i.e. the flowering date of the last effective boll population (Oosterhuis et al., 1996a). Based on crop development, an average NAWF=5 typically indicates physiological cutout, so monitoring of NAWF should cease when average NAWF<5. Fields that have experienced prolonged stress (particularly water stress) usually have plants that are relatively short with a low NAWF (5 to 6) at first flower. Under such stressed conditions, the relative value of flowers at NAWF=4 increases, but the time between NAWF=5 and NAWF=4 is usually very short. Users may wish to use NAWF=4 as the indicator of cutout in these severe cases.

Do not attempt to identify cutout with one observation of NAWF late in the season. Doing so may result in a false, late indication of cutout if true cutout has previously occurred. In these cases, either plants with second growth (flush of vegetative growth after cutout) or atypically late-maturing plants (where best plants have already ceased flowering) make it impossible to detect true cutout.

The date of physiological cutout in a field can be determined from the NAWF chart by interpolating between sample dates to determine the approximate date that physiological cutout (NAWF=5) is attained.

Step 2. Latest Possible Cutout Date

Determination

If crop maturity is delayed (particularly in northern regions of the Cotton Belt), the crop may not have sufficient HU to mature the late bolls even if they resulted from flowering prior to NAWF=5. Research has indicated that 850 HU (DD60s) are needed for flowers to develop into mature bolls. If physiological cutout occurs after the latest date from which accumulation of 850 HU is likely, cutout is defined by weather rather than plant development. Weather constraints rather than plant development then dictate cutout, and flowers occurring very late in the season are not likely to have adequate time to develop into bolls. The latest possible cutout date is then determined as a function of probable weather estimated from long-term weather patterns.

For estimating the latest possible cutout date based on HU, long-term weather data have been evaluated for several weather stations. Using these data, the latest dates from which 850 HU were attained in 50 and 85% of historical years have been determined. To determine the latest possible cutout date for a field, choose the long-term weather station from Table 1 that is nearest to your farm. Choice of the percentage of years of weather data (risk factor) upon which you wish to base your decisions provides the latest possible cutout date. Indicate the latest possible cutout date on the NAWF chart (Appendix D, page 104) with an asterisk (*) on the NAWF=5 line.

Determination by factors other than heat units

In some regions, weather restrictions other than lack of HU (e.g., high probability of late-season rainfall) may effectively limit the time for crop development and harvest. In these cases, users should establish the latest possible cutout date upon probabilities associated with the factor that limits the length of the effective growing season. These probabilities may be determined by additional analysis of long-term weather data or may be based on practical experience.

Choosing a Risk Factor

Obviously, the latest possible cutout date based on HU occurs later at more southern weather stations. Also, the date can be delayed by assuming higher risks, i.e., basing your decision on a lower percentage of years. Some situations in which it may be advisable to accept higher risks include:

- locations in the more northern regions of the Cotton Belt, since full maturity of the crop (850 HU past physiological cutout) may be difficult to attain,
- locations considerably south of the long-term weather station from which you are obtaining data,
- situations where plant maturity differs widely across the field, and
- fields that have low late-season insect infestations.

Step 3. Last Effective Flowering Date

Depending on which occurs first (i.e., earliest), the last effective flowering date (true cutout) within a field is either the date of physiological cutout (i.e., when NAWF=5) or the date of seasonal cutout (i.e., latest possible cutout date). If the NAWF slope intersects the NAWF=5 line prior to the latest possible cutout date, then the last effective flowering date is the date of physiological cutout. Otherwise, the seasonal cutout date becomes the last effective flowering date.

The last effective flowering date signals the initiation of heat unit accumulation to monitor the development of the last effective population of bolls in a field. Since all other bolls are older and more mature, end-of-season management can be based on the development of bolls arising from the last effective flowering date.

Step 4. Heat Units

Calculation

Heat units are, to a certain extent, a measure of physiological time and they measure the pace of growth and development of a plant. In cotton, HU are typically measured by DD60s (degree day 60s), which indicate the amount of heat accumulation (daily average temperature over a threshold of 60°F). Calculation and recording of DD60s must be started on the day of the last effective flowering date and continued daily until critical HU associated with various management decisions have been accumulated for each field. Daily high and low temperatures should be obtained from either a maximum/minimum thermometer located in the shade within a relatively close proximity of the field (one thermometer may service several or all your fields) or from a nearby weather station (extension office, television report, etc.). To calculate DD60s for a day, average the high and low temperatures [(high + low) / 2] then subtract 60. If the daily DD60 is a negative value, enter it as zero.

Heat Unit Chart

A simple heat unit chart can be developed (Appendix G, page 107). The chart should have 4 standard columns plus a column for each field that is being monitored. The first column is for “Date.” The first date should coincide with the day that the earliest

Table 1. Latest possible cutout dates for weather stations in several cotton-production areas.[z]

Location	Years analyzed	Harvest completion date[y]	Latest possible cutout date[x] 50% years	Latest possible cutout date[x] 85% years
Alabama				
Andalusia	1959-2007	11/30	08/24	08/17
Huntsville	1959-2007	11/30	08/15	08/06
Lafayette	1968-2007	11/30	08/16	08/07
Mobile	1948-2007	11/30	09/03	08/27
Arkansas				
Bentonville	1944-2007	10/31	08/02	07/26
Jonesboro	1940-2007	10/31	08/13	08/06
Keiser	1960-2007	10/31	08/11	08/02
Little Rock	1948-2007	10/31	0817	08/12
Marianna	1948-2007	10/31	08/14	08/08
Newport	1940-2007	10/31	08/13	08/07
Pine Bluff	1940-2007	10/31	08/19	08/13
Rohwer	1960-2007	11/14	08/19	08/10
Stuttgart	1948-2007	10/31	08/15	08/08
Arizona				
Phoenix	1948-2007	11/18	09/15	09/10
Yuma	1955-2007	11/18	09/13	09/09
California				
Bakersfield	1949-2007	11/18	08/27	08/22
Fresno	1950-2007	11/29	08/19	08/12
Hanford	1948-2007	11/29	08/13	08/07
Los Banos	1949-2007	11/29	08/14	08/09
Sacramento	1949-2007	11/18	08/07	07/30
Florida				
Milton	1949-2007	11/30	08/31	08/27
Plant City	1950-2007	12/30	09/28	09/22
Tallahassee	1954-2007	11/30	09/04	08/29
Georgia				
Albany	1949-2007	11/30	08/30	08/24
Macon	1949-2007	11/30	08/24	08/18
Tifton	1948-2007	11/30	08/28	08/23
Kansas				
Ulysses	1949-2007	10/31	08/01	07/25
Wellington	1949-2007	10/31	08/28	08/23
Louisiana				
Alexandria	1957-2007	10/31	08/25	08/20
Baton Rouge	1948-2007	10/31	08/26	08/21
Lake Providence	1948-2007	10/31	08/22	08/17
Monroe	1948-2007	10/31	08/22	08/16
Shreveport	1948-2007	10/31	08/24	08/19
Winnsboro	1948-2007	10/31	08/23	08/17
Missouri				
Portageville	1952-2007	110/31	08/08	07/31
Mississippi				
Hattiesburg	1960-2007	11/14	08/26	08/20
Meridian	1960-2007	11/14	08/23	08/16
Natchez	1960-2007	10/31	08/23	08/17
Port Gibson	1965-2007	10/31	08/18	08/13
State University	1948-2007	11/14	08/19	08/13
Stoneville	1960-2007	11/14	08/21	08/15
Tupelo	1948-2007	10/31	08/16	08/08

continued

Table 1. Continued.

Location	Years analyzed	Harvest completion date[y]	Latest possible cutout date[x] 50% years	85% years
North Carolina				
Fayetteville	1952-2007	11/14	08/13	08/20
Greensboro	1948-2007	10/31	08/01	07/26
Greenville	1949-2007	11/14	08/13	08/07
Jackson	1952-2007	11/14	08/08	07/31
Raleigh	1948-2007	11/14	08/07	07/31
New Mexico				
Artesia	1948-2007	11/18	08/10	07/30
Portales	1949-2007	11/18	08/02	07/27
Tucumcari	1948-2007	11/18	08/06	07/30
Oklahoma				
Altus	1948-2007	10/31	08/20	08/13
Ardmore	1948-2007	11/14	08/26	08/20
Newkirk	1948-2007	10/31	08/14	08/05
South Carolina				
Columbia	1948-2007	10/31	08/10	08/03
Orangeburg	1960-2007	11/30	08/23	0/14
Tennessee				
Covington	1948-2007	10/31	08/10	08/03
Dyersburg	1949-2007	10/31	08/11	08/04
Jackson	1948-2007	10/31	08/09	08/02
Memphis	1948-2007	10/31	08/18	08/12
Texas				
Abilene	1960-2007	11/14	08/24	08/19
Bay City	1960-2007	10/31	08/31	08/28
Childress	1960-2007	10/31	08/17	08/10
College Station	1960-2007	11/14	09/03	08/30
Corpus Christi	1960-2007	09/29	08/12	08/11
Dumas	1964-2007	11/14	08/03	07/26
El Paso	1948-2007	12/30	08/21	08/15
Harlingen	1960-2007	11/30	09/21	09/16
Hereford	1960-2007	10/31	07/28	07/23
Lamesa	1954-2007	10/31	08/13	08/07
Lubbock	1960-2007	10/31	08/09	08/03
San Angelo	1960-2007	11/14	08/24	08/20
San Antonio	160-2007	11/14	09/05	08/31
Virginia				
Farmville	1960-2007	10/31	07/28	07/22
Suffolk	1960-2007	10/31	08/07	07/31

[z] Data for new locations are being added periodically. Contact the Texas A&M University for the most recent up-dates (361) 265-9203).

[y] Target dates for completion of harvest at the Arkansas and Stoneville, Miss., locations were based on day length and probability of dry weather. Dates for all other locations were estimated by cotton extension specialists or researchers in the respectively states.

[x] The latest date from which 850 HU were accumulated in 50 and 85% of years. Calculations assumed 14 days from defoliation of latests fields to harvest completion

maturing field reaches last effective flowering date. The second and third columns are for the high and low temperatures associated with that date. The fourth column is the calculated DD60s for that date.

Beginning in the fifth column, enter "Field Name" at the top of the column on the day that last effective flowering date is attained for the field. Place an asterisk (*) in the field column on the date it reaches cutout. DD60 accumulation commences on the day after the last effective flowering date. As fields are added, they will be arranged from earliest (fifth column) to latest (extreme right column) maturity. Add the daily DD60 to the accumulative DD60 values in each field column. Users may wish to use a simple spreadsheet to facilitate these calculations.

Critical Heat Units for Insecticide Termination

Since the last effective boll population represents the youngest bolls that should be protected, insecticide termination can be sequenced with the development of these bolls (Oosterhuis et al., 1996b). For example, research has indicated that developing bolls resist damage by tarnished plant bugs, bollworms, and boll weevils at about 350 DD60s after white flower (*See* Chapter 4). Therefore, when a field has accumulated 350 DD60s past the last effective flowering date (determined in the heat unit chart), control of these insects can be terminated. In cases in which there is considerable variation (*See* NAWF Variation on page 46), consider extending control to 450 DD60s. After attaining 350 DD60s past the last effective flowering date, fields should still be monitored for the presence of defoliating pests, such as loopers and armyworms. These insects should not be allowed to prematurely defoliate the crop until it is safe to be chemically defoliated.

Critical Heat Units for Defoliation

Defoliation can also be timed by the maturity of the last effective boll population. To achieve near maximum yield and revenue, 850 DD60s should be accumulated after the last effective flowering date prior to defoliation. Some have suggested that 650 to 750 DD60s may be appropriate for defoliation when plants set fruit in a short period so that 60 to 70% of crop is open. Other situations in which early defoliation might be advisable include:

- fields located in northern extreme of Cotton Belt in which full maturity may not occur,
- fields in which picker capacity is limited and harvest should be initiated earlier in some fields, and
- fields for which adverse weather forecasts indicate a need for early harvest.

Heat Unit Chart Example (Table 2)

Average high and low temperatures from historical weather data for July 29 through Oct. 31 at Marianna, Ark., are charted and daily DD60s are calculated in this example chart. This provides an indication of the maximum/minimum temperatures and daily HU that can be expected in the central Delta region of Arkansas. Obviously, actual temperatures within a specific year will fluctuate much more than these average temperatures.

In the example, seven hypothetical fields that used the same weather station are listed in the order they attained cutout. Field A1 and B2 reached physiological cutout long before the latest possible cutout date and are easily able to accumulate 850 HU after cutout. Both fields C3 and D4 reached physiological cutout on Aug. 8, the latest possible cutout date based on 85% of years at Marianna. Note multiple fields having identical cutout dates will accumulate HU at the same rate, provided the fields are using the same weather station. Field E5 reached physiological cutout on Aug. 14, the latest possible cutout date based on 50% of years. For all fields reaching cutout after the latest possible cutout date (Aug. 8 or Aug. 14, e.g., Field F6), heat accumulation for end-of-season management would begin at the latest possible cutout date.

This example illustrates the importance of attaining timely cutout. Since heat unit accumulation was relatively constant throughout August, variation among fields for days to cutout was similar to the variation in number of days required to accumulate 350 HU after cutout. However, as physiological cutout was delayed, the time required to attain maturity (NAWF=5 + 850 HU) was greatly prolonged. The 8-day delay in cutout between Fields B2 and C3 caused only a 13-day difference in time to 850 HU, whereas the 6-day delay between C3 an E5 resulted in a 25-day delay to 850 HU. Field G7 further illustrates the ineffectiveness of accumulating late-season HU. Attaining cutout only one day later than Field E5, Field G7 never reached 850 HU.

Final Remarks

Hopefully, this "by hand" version of BOLLMAN will be helpful to producers or consultants in making some critical end-of-season management decisions. As experience with this paper version of BOLLMAN is gained, we encourage users to obtain information on the whole COTMAN system. The full value of plant monitoring can be achieved only when the entire growth pattern with COTMAN components SQUAREMAN and BOLLMAN is evaluated.

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Fig. 4. Heat Unit Chart Example.

	Temperature[1]		Daily	Accum. DD_{60}'s by fields, listed sequentially as cutout is reached					
Date	High	Low	DD60's[2]	A1	B2	C3/D4	E5	F6	G7
7/28	92	71	21.5	21.5					
7/29	92	71	21.5	43.0					
7/30	92	71	21.5	64.5					
7/31	92	71	21.5	86.0					
8/1	92	71	21.5	107.5	21.5				
8/2	92	70	21.0	128.5	42.5				
8/3	92	70	21.0	149.5	63.5				
8/4	92	70	21.0	170.5	84.5				
8/5	92	70	21.0	191.5	105.5				
8/6	92	70	21.0	212.5	126.5				
8/7	92	70	21.0	233.5	147.5				
8/8	91	69	20.0	253.5	167.5	20.0			
8/9	91	69	20.0	273.5	187.5	40.0			
8/10	91	69	20.0	293.5	207.5	60.0			
8/11	91	69	20.0	313.5	227.5	80.0			
8/12	91	69	20.0	333.5	247.5	100.0			
8/13	91	69	20.0	353.5	267.5	120.0			
8/14	91	69	20.0	373.5	287.5	140.0	20.0		
8/15	91	68	19.5	393.0	307.0	159.5	39.5	19.5	
8/16	91	68	19.5	412.5	326.5	179.0	59.0	39.0	
8/17	91	68	19.5	432.0	346.0	198.5	78.5	58.5	
8/18	91	68	19.5	451.5	365.5	218.0	98.0	78.0	98.0
8/19	91	68	19.5	471.0	385.0	237.5	117.5	97.5	117.5
8/20	91	68	19.5	490.5	404.5	257.0	137.0	117.0	137.0
8/21	91	68	19.5	510.0	424.0	276.5	156.5	136.5	156.5
8/22	91	68	19.5	529.5	443.5	296.0	176.0	156.0	176.0
8/23	91	68	19.5	549.0	463.0	315.5	195.5	175.5	195.5
8/24	91	68	19.5	568.5	482.5	335.0	215.0	195.0	215.0
8/25	91	68	19.5	588.0	502.0	354.5	234.5	214.5	234.5
8/26	91	68	19.5	607.5	521.5	374.0	254.0	234.0	254.0
8/27	91	68	19.5	627.0	541.0	393.5	273.5	253.5	273.5
8/28	91	68	19.5	646.5	560.5	413.0	293.0	273.0	293.0
8/29	90	68	19.0	665.5	579.5	432.0	312.0	292.0	312.0
8/30	90	67	18.5	684.0	598.0	450.5	330.5	310.5	330.5
8/31	90	67	18.5	702.5	616.5	469.0	349.0	329.0	349.0
9/1	90	67	18.5	721.0	635.0	487.5	367.5	347.5	367.5
9/2	89	66	17.5	738.5	652.5	505.0	385.0	365.0	385.0
9/3	89	66	17.5	756.0	670.0	522.5	402.5	382.5	402.5
9/4	89	65	17.0	773.0	687.0	539.5	419.5	399.5	419.5
9/5	89	65	17.0	790.0	704.0	556.5	436.5	416.5	436.5
9/6	89	64	16.5	806.5	720.5	573.0	453.0	433.0	453.0
9/7	88	64	16.0	822.5	736.5	589.0	469.0	449.0	469.0
9/8	88	64	16.0	838.5	752.5	605.0	485.0	465.0	485.0
9/9	87	64	15.5	854.0	768.0	620.5	500.5	480.5	500.5
9/10	87	63	15.0		783.0	635.5	515.5	495.5	515.5
9/11	86	63	14.5		797.5	650.0	530.0	510.0	530.0
9/12	86	63	14.5		812.0	664.5	544.5	524.5	544.5
9/13	86	63	14.5		826.5	679.0	559.0	539.0	559.0
9/14	86	62	14.0		840.5	693.0	573.0	553.0	573.0
9/15	86	62	14.0		854.5	707.0	587.0	567.0	587.0

Table 2. Continued.

9/16	85	62	13.5			720.5	600.5	580.5	600.5
9/17	85	62	13.5			734.0	614.0	594.0	614.0
9/18	85	62	13.5			747.5	627.5	607.5	627.5
9/19	85	62	13.5			761.0	641.0	621.0	641.0
9/20	85	61	13.0			774.0	654.0	634.0	654.0
9/21	85	61	13.0			787.0	667.0	647.0	667.0
9/22	84	59	11.5			798.5	678.5	658.5	678.5
9/23	83	59	11.0			809.5	689.5	669.5	689.5
9/24	82	57	9.5			819.0	699.0	679.0	699.0
9/25	82	57	9.5			828.5	708.5	688.5	708.5
9/26	82	57	9.5			838.0	718.0	698.0	718.0
9/27	81	57	9.0			847.0	727.0	707.0	727.0
9/28	81	56	8.5			855.5	735.5	715.5	735.5
9/29	81	55	8.0				743.5	723.5	743.5
9/30	81	55	8.0				751.5	731.5	751.5
10/1	81	55	8.0				759.5	739.5	759.5
10/2	81	55	8.0				767.5	747.5	767.5
10/3	81	55	8.0				775.5	755.5	775.5
10/4	80	55	7.5				783.0	763.0	783.0
10/5	80	54	7.0				790.0	770.0	790.0
10/6	79	53	6.0				796.0	776.0	796.0
10/7	78	52	5.0				801.0	781.0	801.0
10/8	78	52	5.0				806.0	786.0	806.0
10/9	78	52	5.0				811.0	791.0	811.0
10/10	78	52	5.0				816.0	796.0	816.0
10/11	78	52	5.0				821.0	801.0	821.0
10/12	78	52	5.0				826.0	806.0	826.0
10/13	78	51	4.5				830.5	810.5	830.5
10/14	77	51	4.0				834.5	814.5	834.5
10/15	77	50	3.5				838.0	818.0	838.0
10/16	77	51	4.0				842.0	822.0	842.0
10/17	76	50	3.0				845.0	825.0	845.0
10/18	75	48	1.5				846.5	826.5	846.5
10/19	75	48	0.0				846.5	826.5	846.5
10/20	74	47	0.0				846.5	826.5	846.5
10/21	74	48	1.0				847.5	827.5	847.5
10/22	74	49	1.5				849.0	829.0	849.0
10/23	74	48	1.0				850.0	830.0	850.0
10/24	73	47	0.0					830.0	
10/25	72	46	0.0					830.0	
10/26	72	46	0.0					830.0	
10/27	72	46	0.0					830.0	
10/28	72	46	0.0					830.0	
10/29	71	46	0.0					830.0	
10/30	71	46	0.0					830.0	
10/31	71	46	0.0	(target harvest completion date)				830.0	

[1] Based on historical high:low temperatures at Marianna, AR

[2] DD_{60} = [(High + Low) - 60