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AGRONOMY AND SOILS

Correlation of Defoliation Timing Methods to Optimize Cotton Yield, Quality, and Revenue

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ABSTRACT

The inconsistent nature of timing cotton defoliation indicates the need for ongoing research in an effort to develop a more concrete set of recommendations. Defoliation timing based on mature fruiting (sympodia) branches (MFB) and the correlation between three defoliation timing methods, heat unit (HU) accumulation after 5 nodes above white flower (NAWF5), open boll percentage at defoliation (OBPD), and nodes above cracked boll (NACB), were evaluated to determine which method was the most consistent for maximizing yield, fiber quality, and revenue. Harvest-aids were applied when a physiologically mature first position boll was present at 5, 7, 9, 11, or 13 main stem nodes (MFB) above the first sympodial branch with a harvestable boll. At those times, OBPD, NACB, and accumulated HU beyond NAWF5 were recorded. Heat unit accumulation was significantly correlated to total lint yield and was the best method of determining crop maturity; however, because of the practical limitations of using this method, OBPD, which was significantly correlated to lint yield in three of four studies and was highly correlated to HU accumulation in all studies (r = 0.935), was the preferred method rather than NACB. With a full season cultivar (DP 555 BG/RR), maximum lint yield was obtained by defoliating at 10 MFB (42 to 64 OBPD, NAWF5 + 790 to 906 HU, 4 to 5 NACB). Defoliating an early maturing cultivar (ST 4892 BR) at 8 MFB (17 to 40 OBPD, NAWF5 + 701 to 814 HU, 6 to 7 NACB) did not significantly reduce yield. To maximize lint yield with early defoliation, a second harvest may be necessary. Delaying crop termination until after 75 OBPD had detrimental effects on fiber quality leading to quality-based discounts and reduced gross revenue.

Chemical defoliation is a cultural practice that induces abscission of cotton foliage earlier than normal (Cathey, 1986). The ultimate goal of defoliants is to facilitate mechanical harvest and protect fiber and seed quality by allowing earlier harvest, which reduces field weathering losses and minimizes trash content and lint staining. Numerous factors must be taken into consideration when determining which defoliants to use and when to apply them. These choices play a role in determining the final economic value of a cotton crop.

Proper defoliation timing involves balancing the value of potential yield increases and losses with possible alterations in fiber quality and possible discounts (Faircloth et al., 2004b). Premature defoliation (prior to 60% open bolls) can result in yield losses of 7 to 15% (Snipes and Baskin, 1994), but may be beneficial in reducing micronaire in an effort to avoid discounts on lint quality (Bednarz et al., 2002; Lewis, 1993). Delaying defoliation allows immature bolls to develop, potentially enhancing yield (Snipes and Baskin, 1994) and increasing staple length (UHM, upper half mean) and length uniformity (Laferney et al., 1963). Along with the potential benefits of later defoliation are the risks of adverse weather conditions that may delay or prevent harvest.

There are several accepted techniques for timing cotton defoliation, but they all have limitations, and more than one should be used to help verify or confirm another. The percentage open boll technique specifies that defoliant application occur when 65% to 90% of harvestable bolls on the plant are open, but this technique does not allow for gaps in the fruiting pattern or differences in boll maturity (Brecke et al., 2001). The cut boll technique refers to timing defoliation when the uppermost harvestable boll is mature enough to be opened either naturally or chemically. In this technique, a boll is referred to as "physiologically mature" when a cross section reveals seeds with well defined cotyledons and black seed coats (Cothren, 1999).

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Nodes above cracked boll (NACB) is a technique that is based on the principles of plant monitoring and average HU accumulation to determine when a plant is ready for harvest-aid application. NACB refers to the number of main stem nodes between the uppermost first position cracked boll and the last harvestable boll on the plant. Data from field tests in California, Oklahoma, Texas, and Mississippi concluded that defoliation of cotton at a NACB of equal to or less than 4 resulted in a yield loss of less than 1% and no reduction in fiber quality (Kerby et al., 1992). For the NACB method to be accurately used, the final bloom date for the last effective boll population must be determined.

Another method of timing cotton defoliation is the COTMAN (Tugwell et al., 1998) decision-aid tool, which is based on accumulated HU after NAWF5. Several recent studies have indicated that a first position white flower five nodes below the terminal (NAWF5) indicates the last effective boll population and flowers set above this position contributed little towards total yield (Bourland et al., 1992; Jenkins et al., 1990a; Benson et al., 1999). This method states that defoliation may be initiated once fields accumulate 850 HU beyond NAWF5 (Bourland et al., 1992). In one of three fields tested using Arkansas defoliation timing recommendations according to COTMAN, the suggested defoliation occurred 7 d earlier than the producer standard and resulted in significantly lower yields (Benson et al., 2000). Timing defoliation using the COTMAN system may not be suited for locations outside Arkansas where environmental variations and different cultural practices may require more or fewer HU accumulation before harvest-aid application to maximize yield.

The objectives of this research were to 1) use mature fruiting branches (MFB) to examine defoliation timing effects on cotton lint yield, fiber quality, and gross revenue and 2) analyze correlations between three accepted defoliation timing methods (HU accumulation after NAWF5, NACB, and OBPD) to determine the best method for consistently maximizing revenue in Louisiana cotton.

MATERIALS AND METHODS

Study site and management practices. Field experiments were conducted at the Dean Lee Research Station near Alexandria, Louisiana, during the 2003 and 2004 growing season. The studies were conducted twice each year, once in an area planted to Stoneville 'ST 4892 BR' (Stoneville Pedigreed Seed Co.; Memphis, TN) and again in an area planted to Delta and Pine Land 'DP 555 BG/RR' (Delta Pine and Land Co.; Scott, MS), for a total of four experiments. All experiments were conducted on a non-irrigated Norwood silt loam (fine-silty, mixed, superactive, hyperthermic Fluventic Eutrudepts) soil. Cotton was planted on 22 May 2003 and 24 May 2004. Cultural practices and integrated pest management strategies recommended by the Louisiana Cooperative Extension Service (http://www.lsuagcenter.com/en/crops_livestock/crops/Cotton/) were used to optimize plant development and yield. The experimental design for all trials was a randomized complete block with four replications. Plot size was four, 96.5-cm rows each 12.15 m long. All data were collected from the center two rows of the four-row plot.

Application of defoliants. Ten first position green bolls one to two main stem nodes above the uppermost first position cracked boll were removed from the outside rows of each plot every 3 d. These bolls were cut perpendicular to their vertical axis to reveal seed cross-sections for determining maturity using the cut boll technique (Cothren, 1999). Defoliation treatments were applied when a physiologically mature first position boll based on the cut boll technique occurred 5, 7, 9, 11, or 13 main stem nodes above the first sympodial branch with a harvestable boll, or when 6, 8, 10, 12, or 14 MFB occurred on each plant (for a total of five application timings). Treatments were applied with a tractor mounted CO_2 sprayer calibrated to deliver a carrier volume of 140 liters ha^{-1} at 330 kPa and 5.81 km h^{-1} through a four-row boom equipped with ConeJet (TeeJet Spraying Systems; Wheaton, Il) nozzles. All rows of each plot were treated with a co-application of 56.1 g ai ha^{-1} thidiazuron (Dropp SC, Bayer CropScience, Research Triangle Park, NC) plus 841 g ai ha^{-1} tribufos (DEF 6, Bayer CropScience).

Data collection. Ten cotton plants per plot were monitored twice a week from the third week of bloom until they reached the NAWF5 reproductive stage of development. At NAWF5, HU accumulation was calculated as follows: HU = ([maximum daily temperature + minimum daily temperature]/2) – 60, using a base of 60 °F (15.5 °C) (Landivar and Benedict, 1996). At each application timing, HU accumulation beyond NAWF5 was documented, as well as the OBPD and NACB. Open boll percentage at defoliation (OBPD) was determined by examining bolls on five consecutive plants from each of the center two rows of the four row plot (ten plants total). Bolls on each plant were examined and recorded as open or closed and the data used to calculate mean percentage open bolls [(open bolls / total bolls) * 100]. Nodes above cracked boll (NACB) were recorded as the total number of main stem nodes between the uppermost harvestable boll and the highest first position cracked boll (Kerby et al., 1992) on ten plants per plot (five consecutive plants from each of the center two rows). Two weeks after a defoliation treatment was applied, seedcotton yield was determined in those plots by harvesting the center two rows of each plot with a commercial two-row spindle picker fitted with a weigh cell capable of being tared between plots. All plots were harvested a second time 2 wk after application of the last defoliation treatment. An approximate 0.9-kg sub-sample of seedcotton was retained from each plot and ginned on a 12-saw research gin to determine lint percentage. Fiber properties were measured using the high volume instrumentation (HVI) method (Sasser, 1981) at the LSU AgCenter Fiber Laboratory, Department of Agronomy, Baton Rouge, LA. Revenue was calculated by multiplying total lint yield by the local base loan rate for Rapides Parish, Louisiana, ($1.14 kg lint, color grade 41 strict low middling, leaf content 3) with premiums and discounts applied based on physical fiber properties according to the United States Department of Agriculture Commodity Credit Corporation (USDA CCC) cotton loan schedule (USDA-FSA, 2005).

Statistical analysis. Yield, physical fiber properties, loan premiums/discounts, and revenue data were subjected to analysis of variance where year by treatment interactions were tested for significance using SAS PROC GLM (version 6.0; SAS Institute, Cary, NC). Tables were constructed according to interactions observed and means were separated using Fisher's protected LSD at $P = 0.05$. Significance of correlations between defoliation timing methods and total lint yield were determined using PROC CORR and are ranked using Pearson's correlation coefficients.

RESULTS

Data were combined across years when year by treatment interactions were not significant. All other data are presented by year. Significant year by treatment interactions were attributed to delayed fruiting caused by a 25 cm increase in rainfall from 15 May through 31 August in 2004 (Table 1). In all studies, bolls were set over a 14 to 16 node range on the plant. No significant fruiting gaps were observed.

Correlation of total yield and defoliation timing methods. The only defoliation timing method that significantly correlated with total yield in all four studies was accumulated HU after NAWF5 (Table 2). Previous research has demonstrated the close relationship between temperature and boll development (Hesketh and Low, 1968; Gipson and Ray, 1970), which supports using HU accumulation as the best method of determining crop maturity. This method is not practical in commercial production due to the intensive monitoring required to determine when the majority of plants reach NAWF5. Accurate determination of 'cut-out' requires identification of the point in which rapid decline of the number of main stem nodes above the uppermost first position white flower occurs, usually obtained by plotting NAWF progression over 3 to 4 wk and calculating

Table 1. Minimum and maximum air temperature and precipitation recorded for 2003, 2004, and the 5-year average (2001-2005) recorded at Dean Lee Research Station, Alexandria, LA

Month	2003			2004			5 year average		
	Air temperature (°C)		Precipitation (cm)	Air temperature (°C)		Precipitation (cm)	Air temperature (°C)		Precipitation (cm)
	Min.	Max.		Min.	Max.		Min.	Max.	
May	**13.9**	**35.0**	**2.8**	**8.8**	**32.7**	**24.5**	**9.9**	**34.7**	**8.2**
June	**19.4**	**35.0**	**10.4**	**18.9**	**34.4**	**26.0**	**18.5**	**35.8**	**10.8**
July	**20.0**	**35.0**	**5.5**	**18.9**	**37.2**	**9.8**	**20.1**	**36.7**	**7.8**
August	**20.6**	**36.1**	**3.0**	**13.9**	**36.1**	**2.9**	**18.8**	**37.1**	**2.8**
September	**10.6**	**33.3**	**4.9**	**12.2**	**36.1**	**0.4**	**12.6**	**36.1**	**6.9**
October	**3.3**	**32.7**	**1.8**	**6.7**	**33.3**	**11.5**	**4.3**	**32.2**	**12.2**
Average	**14.6**	**34.5**	**4.7**	**13.2**	**35.0**	**12.5**	**14.0**	**35.4**	**8.1**

HU accumulation from that point. NACB and OBPD measurements are more feasible methods of determining crop maturity. OBPD was significantly correlated to total lint yield in three of four studies and had greater correlation coefficients than the HU accumulation method in all three studies. OBPD was also highly correlated (≥0.935) with HU accumulation in all four studies (Table 2). NACB was significantly correlated to total lint yield only in studies conducted with DP 555 BG/RR, and in most cases correlation coefficients to HU accumulation were numerically less than that of OBPD. This indicates that OBPD is a better indicator of yield potential than NACB.

Table 2. Pearson correlation coefficients for defoliation timing methods and total lint yield

	Defoliation timing method[z]			Yield
	OBPD	NACB	HU	
DP 555 BG/RR – 2003				
OBPD	1.000	-0.929*	0.935*	0.610*
NACB	-0.929*	1.000	-0.935*	-0.587*
HU	0.935*	-0.935*	1.000	0.528*
ST 4892 BR – 2003				
OBPD	1.000	-0.896*	0.986*	0.533*
NACB	-0.896*	1.000	-0.900*	-0.463
HU	0.986*	-0.900*	1.000	0.505*
DP 555 BG/RR – 2004				
OBPD	1.000	-0.971*	0.948*	0.741*
NACB	-0.971*	1.000	-0.962*	-0.685*
HU	0.948*	-0.962*	1.000	0.734*
ST 4892 BR – 2004				
OBPD	1.000	-0.954*	0.958*	0.391
NACB	-0.954*	1.000	-0.911*	-0.380
HU	0.958*	-0.910*	1.000	0.469*

[z] OBPD = open boll percentage at defoliation; NACB = nodes above cracked boll; HU = cumulative heat units, base 15.5 °C (60 °F), after NAWF = 5 until treatment. Pearson's correlation coefficients followed by * are significant at $P = 0.05$.

Delta and Pine Land DP 555 BG/RR. Maximum lint yields in 2003 were obtained with defoliant application at 12 MFB (1,575.4 kg ha^{-1}), which corresponded to NAWF5 + 906 HU, 62 OBPD, and 5 NACB (Table 3). Significant reductions in total lint yield occurred with defoliant applications both prior to and after this stage. A second harvest was necessary to obtain the total yield at the 12 MFB defoliation timing. Lint yields at first harvest were not significantly different between defoliant applications at 12 or 14 MFB (1250.3 and 1273.7 kg ha^{-1}, respectively), but the first harvest proportion significantly increased from 79.3 to 91.7% when defoliation was delayed from 12 to 14 MFB (Table 3). In 2004, the greatest total lint yields were achieved by defoliation at ≥10 MFB (NAWF5 + ≥790 HU, ≥64% OBPD, and ≤4 NACB) (Table 3). By delaying defoliant application to 12 or 14 MFB, the first harvest accounted for at least 94.3% of the total yield and was significantly greater than 86.6% first harvest proportion of the 10 MFB timing (Table 3).

Defoliation timing did not influence micronaire or staple length (UHM) of DP 555 BG/RR in either year or uniformity in 2003 (Table 4). In 2003, a significant reduction in fiber strength was observed when defoliation was delayed to 14 MFB. Defoliation timings required to maximize yield in 2004 (≥10 MFB) resulted in significant reductions in both fiber strength and uniformity when compared with earlier treatments (Table 4).

Although differences in fiber properties existed, none were detrimental with respect to adjusted loan value (Table 5). Defoliation at 6 and 8 MFB brought a 0.41¢ fiber strength premium in 2003, but defoliation at 14 MFB did not bring any premium. Higher uniformity with defoliation treatments at 6 or 8 MFB provided greater premiums than the other timings. No significant differences among defoliation timing treatments were observed with respect to total difference from the base price in either year (Table 5). The highest gross revenue was achieved by defoliating at 12 MFB in 2003 and 2004, $1868 and $2110 ha^{-1}, respectively (Table 5). Significant reductions in revenue occurred with all other defoliation treatments in 2003. Revenue from defoliation at 10 or more MFB was not significantly different in 2004 (Table 5).

Stoneville ST 4892 BR. In 2003, the greatest total lint yields were obtained with defoliation at 10 and 12 MFB (1444.7 and 1603.9 kg ha^{-1}, respectively), which occurred at NAWF5 + 814 to 906 HU, 40 to 60 OBPD, and 6 to 4 NACB (Table 6). Although the greatest first harvest lint proportion occurred with defoliation at 14 MFB (88.3%), first harvest lint yields were not significantly different for defoliation timings ≥10 MFB (Table 6). In 2004, total lint yield was not different among defoliation timings. The first harvest proportion was at least 80% for all defoliation timing treatments except 10 MFB (75.3%), which received 10.2 cm of rain 3 d before harvest and suffered severe weathering losses. The lack of a defoliation timing effect on total lint yield is attributed to environmental conditions during 2004 which were conducive for fruit set over a short period of time. Excessive rainfall in early June delayed fruiting and five consecutive days with nighttime temperatures below 15.5 °C (60 °F) (61.5 HU, 12 Aug to 16 Aug 2004) lead to premature arrival of the last effective bloom date, which historically occurs around 20 August in central Louisiana (Anonymous, 2004).

Table 3. Heat unit (HU) accumulation, open boll percentage at defoliation (OBPD), nodes above cracked boll (NACB), and lint yield for defoliation timing treatments for DP 555 BG/RR

Timing (MFB)[y]	Criteria for timing defoliation[z]						Lint yield (kg ha^{-1})					
	HU		OBPD (%)		NACB		Total		1st harvest		1st harvest (%)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
6	694	580	11	20	10	9	1189.1	1179.8	681.4	802.8	57.6	68.0
8	776	680	31	39	9	7	1231.5	1529.0	801.2	1210.8	65.2	79.3
10	814	790	42	64	7	4	1400.5	1721.0	944.2	1486.4	67.5	86.6
12	906	1011	62	86	5	2	1575.4	1780.0	1250.3	1726.1	79.3	96.9
14	1060	1089	74	91	2	1	1389.6	1759.3	1273.7	1659.8	91.7	94.3
LSD (P = 0.05)	-	-	-	-	-	-	160.9	217.7	148.7	211.6	6.5	6.1

[y] Number of main stem nodes above the first sympodial branch on which a physiologically mature first position boll occurred at defoliation application or the number of mature fruiting branches present on the plant (MFB).

[z] OBPD = open boll percentage at defoliation; NACB = nodes above cracked boll; HU = cumulative heat units, base 15.5 °C (60 °F), after NAWF = 5 until treatment.

Table 4. Effect of defoliation timing on cotton fiber micronaire, strength, length (UHM), and uniformity for DP 555 BG/RR

Timing MFB[y]	Micronaire[z]	Strength (cN tex^{-1})		Length (cm)[z]	Uniformity (%)	
		2003	2004		2003	2004
6	4.6	29.1	29.7	2.95	82.4	83.6
8	4.6	29.2	31.7	2.92	82.6	83.5
10	4.6	28.6	29.3	2.90	82.9	82.2
12	4.6	28.8	27.9	2.90	82.1	82.4
14	4.6	27.6	29.0	2.90	82.5	82.3
LSD (P = 0.05)	NS	1.1	1.6	NS	NS	0.8

[y] Number of main stem nodes above the first sympodial branch on which a physiologically mature first position boll occurred at harvest-aid application or the number of mature fruiting branches present on the plant (MFB).

[z] Data averaged across experiments conducted in 2003 and 2004.

Table 5. Effect of defoliation timing on lint price differences using 2005 USDA Commodity Credit Corporation cotton loan information applied to fiber data from DP 555 BG/RR cotton

Timing MFB[y]	Price difference (¢ kg^{-1})[z]										Gross revenue ($ ha^{-1})	
	Micronaire		Strength		Length (UHM)		Uniformity		Total difference			
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
6	0.00	0.00	0.41	0.74	4.29	4.29	0.33	0.66	5.03	5.69	1417	1415
8	0.00	0.00	0.41	1.05	3.99	4.29	0.33	0.72	4.73	6.05	1464	1838
10	0.00	0.00	0.14	0.63	4.29	4.29	0.47	0.28	4.90	5.20	1667	2054
12	0.00	0.14	0.28	0.14	3.99	3.99	0.14	0.14	4.40	4.40	1868	2110
14	0.00	0.00	0.00	0.39	3.99	4.29	0.41	0.14	4.40	4.81	1646	2092
LSD (P = 0.05)	NS	NS	0.30	NS	NS	NS	NS	0.35	NS	NS	183	265

[y] Number of main stem nodes above the first sympodial branch on which a physiologically mature first position boll occurred at harvest-aid application or the number of mature fruiting branches present on the plant (MFB).

[z] Price difference from the base price of $1.14 kg^{-1}.

Micronaire, fiber strength, and length were not influenced by defoliation timing in 2003. In 2004, micronaire progressively increased with later defoliation timings and a decline in fiber strength occurred with defoliation timings after 8 MFB (Table 7). Length declined with later defoliation timings in 2004, and uniformity averaged across both years was significantly lower when defoliation was delayed until 12 or 14 MFB, demonstrating deterioration in fiber quality over time (Table 7).

Although no significant differences in micronaire existed with respect to defoliation timing, all values in 2003 were high enough to reduce the base loan price at least 1.68¢ kg^{-1} (Table 8). Fiber strength premiums associated with defoliation at 6 to 10 in 2003 or 6 and 8 MFB in 2004 increased cotton base loan price at least 0.66 and 1.02¢ kg^{-1}, respectively. Uniformity premiums were significantly lower when defoliation was delayed until 14 MFB than all other treatments in 2003, and premiums were at least 0.20¢ kg^{-1} lower when defoliation occurred at 12 and 14 MFB in 2004 (Table 8). Because of high micronaire values, all defoliation timings except 6 and 10 MFB had negative total differences from the cotton loan base price in 2003. In 2004, total premiums above the loan base price were significantly greater for defoliation at 6 and 8 MFB with at least a 5.94¢ kg^{-1} increase. Defoliation timing did not influence gross revenue in 2004. In 2003, the greatest gross revenue ($1787 ha^{-1}) was obtained by defoliating at 12 MFB, which did not significantly differ from defoliation at 10 or 14 MFB, but was at least $88 ha^{-1} greater than all other treatments (Table 8).

Table 6. Heat unit (HU) accumulation, open boll percentage at defoliation (OBPD), nodes above cracked boll (NACB), and lint yield for defoliation timing treatments for ST 4892 BR

Timing MFB^y	Criteria for timing defoliation^z						Lint yield (kg ha^{-1})					
	HU		OBPD (%)		NACB		Total		1st harvest		1st harvest (%)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
6	694	586	21	11	7	7	1246.8	1070.6	859.9	859.2	68.8	80.2
8	776	701	36	17	7	7	1395.6	1260.8	924.1	1102.9	70.3	87.4
10	814	808	40	50	6	5	1444.7	1145.5	1097.0	860.7	76.0	75.3
12	906	908	60	78	4	2	1603.9	1105.3	1237.8	971.7	80.6	88.1
14	1023	1020	78	92	2	1	1418.9	1263.6	1186.8	1154.1	88.3	91.4
LSD (P = 0.05)	-	-	-	-	-	-	184.7	NS	197.8	185.7	6.8	8.7

^{y} Number of main stem nodes above the first sympodial branch on which a physiologically mature first position boll occurred at harvest-aid application or the number of mature fruiting branches present on the plant (MFB).

^{z} OBPD = open boll percentage at defoliation; NACB = nodes above cracked boll; HU = cumulative heat units, base 15.5 °C (60 °F), after NAWF = 5 until treatment.

Table 7. Effect of defoliation timing on cotton fiber micronaire, strength, length (UHM), and uniformity for ST 4892 BR

Timing MFB^y	Micronaire		Strength (cN tex^{-1})		Length (cm)		Uniformity (%)^z
	2003	2004	2003	2004	2003	2004	
6	5.0	4.0	29.8	32.0	2.82	2.95	83.8
8	5.2	4.4	30.4	31.5	2.84	2.90	83.4
10	5.0	4.5	30.0	28.9	2.87	2.87	83.5
12	5.1	4.6	29.3	28.9	2.82	2.84	82.7
14	5.1	4.7	29.3	29.0	2.82	2.87	82.4
LSD (P = 0.05)	NS	0.3	NS	1.1	NS	0.05	0.5

^{y} Number of main stem nodes above the first sympodial branch on which a physiologically mature first position boll occurred at harvest-aid application or the number of mature fruiting branches present on the plant (MFB).

^{z} Data averaged across experiments conducted in 2003 and 2004.

Table 8. Effect of defoliation timing on cotton lint price differences using 2005 USDA Commodity Credit Corporation cotton loan information applied to fiber data for ST 4892 BR

Timing MFB[y]	Price difference (¢ kg^{-1})[z]										Gross revenue ($ ha^{-1})	
	Micronaire		Strength		Length (UHM)		Uniformity		Total difference			
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
6	-3.36	0.28	0.66	1.02	2.61	4.29	0.66	0.88	0.58	6.46	1433	1291
8	-7.18	0.14	0.88	1.05	3.38	3.99	0.61	0.77	-2.31	5.94	1554	1513
10	-1.68	0.00	0.88	0.41	3.69	3.69	0.66	0.72	3.55	4.81	1699	1363
12	-6.71	0.00	0.55	0.28	3.08	3.38	0.41	0.41	-2.50	4.07	1787	1308
14	-5.50	0.00	0.55	0.39	2.31	3.69	0.14	0.28	-2.67	4.35	1596	1497
LSD (P = 0.05)	NS	NS	0.26	0.41	NS	NS	0.28	0.35	4.47	1.30	228	NS

[y] Number of main stem nodes above the first sympodial branch on which a physiologically mature first position boll occurred at harvest-aid application or the number of mature fruiting branches present on the plant (MFB).

[z] Price difference from the base price of $1.14 kg^{-1}.

DISCUSSION

The results of this study support the use of defoliation timing based on accumulated HU after NAWF5. In large operations where time is a critical factor in determining crop maturity, the percentage of open bolls can be used rather than NACB. This contrasts with the findings of Faircloth et al. (2004b) who stated NACB was more effective than OBPD for timing defoliation in North Carolina. Different results may be due to the variability between environmental conditions in Louisiana and North Carolina.

These studies demonstrate that defoliation should be initiated at 60 OBPD to maintain fiber quality and maximize harvest efficiency by removing the majority of seedcotton in one harvest operation. This supports current recommendations in both Louisiana (Stewart et al., 2003) and Mississippi (Snipes and Baskin, 1994). Under some circumstances, such as when the majority of fruit are set in a relatively short range on the plant, defoliation may occur as early as 40 OBPD (NAWF5 + 700 HU, 7 NACB) without sacrificing yield or gross revenue. Faircloth et al. (2004a) reported data from North Carolina that suggested the possibility of defoliating before the recommended 60% open bolls without negatively impacting yield, but a second harvest may be necessary to realize maximum yield with early defoliation timings. Defoliant combinations including ethephon (Snipes and Cathey, 1992) or ethephon plus a synergist (Stewart et al., 2000) could be used to increase the rate of boll dehiscence, which may alleviate this problem. Yield losses with premature harvest-aid application were consistent with findings of Snipes and Baskin (1994), and the degradation of fiber properties with delayed crop termination was similar to those documented by Bednarz et al. (2002).

These results indicate that defoliation timing based on a range of MFB should be further investigated. Gross revenue was not significantly reduced when defoliation occurred at 10 MFB in both years with two different cultivars. Defoliation timing methods presently used (NACB, OBPD, and the cut boll technique) all present the same challenge of identifying the uppermost harvestable boll on the plant. Delaying crop termination to wait on "phantom" bolls (bolls that will not accumulate enough heat units to reach physiological maturity) can have negative effects on lint yield and fiber quality. Defoliation timing based on MFB removes the factor of identifying the uppermost harvestable boll and focuses on fruit set on the bottom of the plant. Jenkins et al. (1990a) reported that in studies conducted for two years with eight cultivars, nodes 9 to 14 (which correspond to the third to eight sympodial branches) were the largest contributors to yield. In those studies, harvestable bolls were set on 16 to 18 sympodial branches. Greater than 80% of the total harvestable lint was set on the lower 10 sympodial branches, and up to 93% of harvestable lint on the lower 14 sympodial branches. Jenkins et al. (1990b) showed that first position bolls tended to increase in size from sympodial branches 3 to 9 and then began decreasing after that point. It is also documented that boll size generally decreases as the season progresses (Meredith and Bridge, 1973). Bolls set above the 14th sympodial branch and on monopodial branches contributed less than 2 and 10% of total lint, respectively (Jenkins et al., 1990a). Bernhardt et al. (1986) and Bernhardt and Phillips (1986) findings support this concept, indicating that flowers developing into harvestable bolls after a field average of four nodes above white flower have been shown to contribute less than 2% to overall yield. This suggests yield gained by delaying defoliation to harvest the uppermost bolls will not offset discounts due to fiber deterioration and supports the practice of timing defoliation to protect fiber quality on the greatest proportion of harvestable lint.

Defoliation timing is best determined on a field by field basis. These results should be used as a guideline along with appropriate considerations made for cultivar (Kerby et al., 1990), growing conditions throughout the season, and upcoming weather forecast.

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