COTTON

Cotton Fiber Quality is Related to Boll Location and Planting Date

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ABSTRACT

Early cotton (*Gossypium hirsutum* L.) planting in the Texas Coastal Bend has the potential for improved performance through drought avoidance. This 2-yr field study was conducted to compare the effect of boll position on fiber properties across planting dates and to determine how flowering date, boll position, and environmental factors affect fiber quality. Cotton ('Deltapine 5409') was planted early March, late March, and mid-April each year. In 1997, lint yield for the early planting date (731 kg ha^{-1}) was significantly higher than the middle (622 kg ha^{-1}) and late (533 kg ha^{-1}) planting dates. No significant differences in yield were found in 1999. Boll distribution patterns for middle- and late-planted cotton were similar. In 1997, the drier of the 2 yr, fiber length and micronafis values increased at all boll locations with earliness of planting while in 1999, the longest and most mature fiber was associated with a number of boll locations in the middle planting date. High temperatures before and during boll development accompanied by adequate moisture increased fiber maturity.

Early cotton planting in the Texas Coastal Bend takes advantage of favorable environmental conditions before historically low rainfall and high temperatures during flowering and fruit development. The target planting date in the Corpus Christi, TX, area is 15 March with a 20-d window on either side of that date. Cool, wet conditions are prevalent in early March and may lead to poor stand establishment. Morphological and physiological effects of low temperatures during germination, emergence, and early seedling growth can impact lint yields (Kittock et al., 1987; Bauer and Bradow, 1996).

The number of nonfruiting branches produced before the first fruiting branch depends on genotype and environment. The cotyledons are designated as Node 0, and mainstem nodes are defined as places on the mainstem where monopodial or sympodial branches arise. Monopodial branches do not directly bear fruit but can give rise to sympodial branches that produce fruit. The first node position on a sympodial branch is designated as Fruiting Position 1 (FP1) (Jenkins et al., 1990). Boll distribution patterns revealed that Nodes 8 through 13 have the highest boll set and account for the majority of the yield. A change in boll distribution was noted when the growing season was characterized by lower temperature, less solar radiation, and higher precipitation amounts (Jenkins et al., 1990).

During the first week after anthesis, fiber and outer integuments receive the greatest portion of photosynthate. After that, the distribution of photosynthate between the remainder of the seed and fiber is about equal. Fiber elongation begins 2 d after anthesis and continues for an additional 3 to 4 wk. Around 15 d after anthesis, the deposition of a mainly cellulosic secondary wall begins (Stewart, 1986). The degree of secondary-wall deposition determines fiber maturity. Micronaire is a composite measure of maturity and fiber fineness since fiber cells with the same wall width can have different micronaire values (Benedict et al., 1999). Micronafis, a micronaire analog, has been used as a measure of maturity and fineness (Bradow et al., 1997).

Abiotic factors such as rainfall, temperature, and irradiance can alter seed and fiber development (Bradow and Davidonis, 2000). Motes are developmentally arrested seeds in which development was curtailed before or after fertilization and can be categorized by fiber length and weight. Short-fiber motes have fiber shorter than one-half the length of normal fiber in a boll while long-fiber motes have fiber longer than one-half the length of normal fiber in boll, and both types weigh 60 mg or less (Davidonis et al., 1996). As air temperature increased, the number of short-fiber motes increased while the number of long-fiber motes was not altered (Reddy et al., 1999). Irrigation had no effect on short-fiber mote numbers but reduced the number of long-fiber motes (Davidonis et al., 2000).

Temperature fluctuations before anthesis and during fiber development have been implicated in changes in fiber quality. While increasing heat unit accumulation in the first 50 d after planting had a negative effect on micronafis values, increasing heat accumulations in the time period from 100 to 150 d after planting had a positive effect on micronafis values (Bradow and Bauer, 1997). Under adequate moisture conditions and increasing temperatures, fiber length decreased and fiber micronafis values increased (Reddy et al., 1999). As temperatures decreased during the 7-wk period from anthesis to boll opening, fiber length and micronaire decreased (Jones and Wells, 1998). Stewart (1986) reported that environmental conditions from 3 to 25 d postanthesis impacted fiber elongation and conditions from 15 to

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Abbreviations: AFIS, Advanced Fiber Information System; DD 15.5, degree days 15.5°C; FP1, Fruiting Position 1; FP2, Fruiting Position 2; FP3, Fruiting Position 3 and above.

45 d postanthesis impacted secondary-wall deposition. Micronaire was linearly related to the amount of canopy photosynthesis that occurred from 15 to 45 d after flowering (Bauer et al., 2000).

When normal-planting-date cotton was compared with late-planting-date cotton, micronaire declined while fiber length decreased, remained unchanged, or increased in late-planted cotton (Bilbro and Ray, 1973; Porter et al., 1996; Bauer et al., 1998). Fiber lengths from FP1 bolls from the first week of flowering were longer than fiber from bolls from the fourth week of flowering in 1 yr of a 2-yr study (Bauer et al., 2000). Bauer et al. (2000) also reported that fiber from FP1 bolls from the first week of flowering had higher micronaire values than fiber from bolls from the fourth week of flowering in both normal- and late-planted cotton.

Early planting can potentially increase cotton yield and improve fiber quality by avoiding the effects of drought and high temperatures. The objective of this study was to compare the effect of boll position on boll and fiber properties across planting dates and to determine how flowering date, boll position, and environmental factors affect fiber quality.

MATERIALS AND METHODS

The experiment was conducted on Victoria clay soil (fine montmorillonitic, hyperthermic Typic Pellustert) at the Texas Cooperative Agricultural Research and Extension Center, Corpus Christi, TX. Cotton production recommendations from the Texas Cooperative Extension Service were followed (Ashlock and Metzer, 1979). Cotton (Deltapine 5409) was planted at a rate of 16 seeds m^{-1}. Plots were six 11-m-long rows in 1997 and six 12-m-long rows in 1999. Row spacing was 1 m. Daily maximum and minimum temperatures and precipitation data were collected by the Texas A&M University Agricultural Research and Extension Center weather station. Heat units were calculated as (maximum daily temperature + minimum daily temperature)/2 − 15.5 and designated as DD 15.5 (degree days 15.5°C). Phenology information was obtained by using the Crop Stages Simulation Program at http://cwp.tamu.edu (verified 18 Sept. 2003). Harvest aids included thidiazuron (*N*-phenyl-*N′*-1,2,3-thiadiazol-5-ylurea) and ethephon [(2-chloroethyl)phosphonic acid] and were applied at 60% open bolls on 2 Aug. 1997 and 9 Aug. 1999.

A split-plot design was used with four replications. Main unit treatments were planting dates, and the main-plot design was a randomized complete block. Node and position classifications were the sub-unit treatment. Early planting date was 1 March in both years. Middle planting dates were 24 Mar. and 22 Mar. in 1997 and 1999, respectively. Late planting date was 11 Apr. and 12 Apr. in 1997 and 1999, respectively. First-position flowers (FP1) were tagged on the day of anthesis with color-coded plastic tags placed on the peduncles. Tagging dates in 1997 were 2 June and 17 June, respectively. Tagging dates in 1999 were 20 May, 2 June, 11 June, and 17 June. Two rows were tagged in each plot.

A 1-m section from one tagged row was removed from each plot, and bolls were mapped by node and fruiting position. The cotlyedonary node was designated as Node 0. The first sympodial position closest to the mainstem was designated FP1, and successive boll positions were designated FP2 (Fruiting Position 2) and FP3 (Fruiting Position 3). Bolls with position numbers greater than three were classified as FP3. Bolls on monopodial branches were mapped. The remaining tagged bolls in the plot were harvested. Two nontagged rows of each plot were hand-harvested for yield determination.

Boll weight refers to the mass of seed and fiber. Short-fiber motes were defined as having fibers less than half the length of fibers from normal seeds within the same carpel. Long-fiber motes had fiber longer than one-half the length of fiber on normal seeds and weighed less than 60 mg (Davidonis et al., 1996). The number of seeds, short-fiber motes, and long-fiber motes per boll were recorded. Fiber samples were composed of fiber from seeds located in the middle of a boll, two seeds per carpel. Fiber from eight seeds in the case of a four-carpel boll and fiber from 10 seeds in the case of a five-carpel boll were used for fiber analysis. Some bolls contained large numbers of long-fiber motes. Fiber from long-fiber motes was added in the proportion that it occurred within the boll. If 25% of a four-carpel boll was composed of long-fiber motes, then the fiber sample contained fiber from two long-fiber motes and six seeds. If a boll weighed 1.4 g or less, all fiber from the boll was used for fiber analysis. Fiber samples ranged from 200 to 700 mg. Fiber properties were analyzed on a per-boll basis using the Advanced Fiber Information System (AFIS-A2, Zellweger-Uster, Knoxville, TN).

The AFIS length and diameter module measures single fibers, and a length distribution is obtained. Mean fiber length and short-fiber content (percentage of fibers less than 12.7 mm in length) can be used to characterize a fiber length distribution. Fiber maturity is defined as the degree of cell wall thickening relative to the diameter of the fiber. A measure of fiber maturity that is independent of fiber perimeter is theta. Theta is the ratio of the cross-sectional area of fiber wall to the area of a circle having the same perimeter. After boll opening, fibers dry out and collapse, and the degree of collapse from the original circular shape depends on the thickness of the cell wall (Bradow et al., 1997). Theta and cross-sectional areas were quantified by the AFIS fineness and maturity module. Perimeter was calculated from cross-sectional area and theta. The AFIS fineness and maturity module calculated a micronaire analog, micronafis (Bradow et al., 1997). Analysis of variance was conducted using PROC MIXED in SAS (SAS Inst., 1997). PROC MIXED will correctly analyze any data set that PROC GLM will. However, the reverse is not true. In this case, PROC MIXED was necessary because the data did not contain the same number of bolls in each position-node group category, and due to the split-plot design structure, PROC MIXED gives better estimates of treatment effects and associated errors.

RESULTS AND DISCUSSION

From 1986 through 1996, the average Corpus Christi, TX, rainfall for May, June, and July was 63, 95, and 25 mm, respectively. The rainfall amounts in 1997 for May, June, and July were 91, 34, and 11 mm, respectively, while in 1999, the rainfall amounts for May, June, and July were 49, 62, and 92, respectively. Due to the difference in rainfall patterns between 1997 and 1999, each year was analyzed separately. When the growing seasons were broken down into three sections for each planting date, 1997 precipitation during the first 50 d after planting was higher than the 51- to 100-d sections (Table 1). The precipitation pattern showed the opposite trend in 1999 (Table 1). Heat unit accumulation (DD 15.5) within the first 50 d after planting increased with lateness of planting in both years while 1999 was characterized as the hotter year when total heat accumulation from planting date to 100 d after planting was

Table 1. Rainfall and heat unit accumulations [degree days 15.5°C (DD 15.5)] partitioned into 50-d increments after day of planting (DOP).

Planting date	DOP–50 d	51–100 d	101 d–harvest
		Rainfall, mm	
1 Mar. 1997	191	112	17
24 Mar. 1997	138	90	12
11 Apr. 1997	102	34	12
1 Mar. 1999	53	78	155
22 Mar. 1999	81	111	84
12 Apr. 1999	78	150	0
		DD 15.5	
1 Mar. 1997	218	441	559
24 Mar. 1997	288	553	540
11 Apr. 1997	375	608	307
1 Mar. 1999	317	539	584
22 Mar. 1999	417	586	300
12 Apr. 1999	496	608	193

considered (Table 1). Seasonal heat unit accumulations (DD 15.5) from March through August were 1717 in 1997 and 1838 in 1999. In 1997, lint yields were 731, 622, and 553 kg ha^{-1} (LSD = 105 kg ha^{-1}) for the early, middle, and late planting dates, respectively. The yield for the early planting date was higher ($p \leq 0.05$) than middle and late planting dates. In 1999, yields were 1053, 1287, and 1211 kg ha^{-1} (LSD = 228 kg ha^{-1}), respectively, for the early through late planting dates and were not significantly different.

The number of bolls present at each location was expressed as a percentage of the total number of bolls within a planting date. Boll location patterns across planting dates showed some differences (Table 2). Early planted cotton in 1997 was characterized by a low percentage of first-position (FP1) bolls at or below Node 7 but a higher percentage of FP1 bolls at Node 14 and above compared with middle- and late-planted cotton. In 1999, differences were found in the percentages of second-position and monopodial bolls. When both years were combined and boll and fiber properties were analyzed, there was a highly significant ($P \leq 0.01$) interaction of year × planting date and a significant ($P \leq 0.05$) interaction of year × boll position for all boll and fiber properties except short-fiber mote percentages and fiber cross-sectional area. Due to these interactions, each year was analyzed separately. Planting date, boll position, and interactions modified boll weight in 1997 but not in 1999 (Table 3).

Planting date and boll position effects were evident

Table 2. Boll distribution by node location.

Position and node†	Planting date: Early	Middle	Late
		% of bolls	
a. 1997			
FP1, 5–7	8.0b‡	25.8a	35.1a
FP1, 8–10	30.7a	33.5a	37.7a
FP1, 11–13	16.0a	23.1a	11.0a
FP1, 14 and above	8.0a	2.2b	0.6b
FP2	20.7a	10.4a	9.7a
FP3	5.3a	0.6a	0a
Monopodial bolls	11.3a	4.4a	5.8a
b. 1999			
FP1, 5–7	29.4a	18.0a	28.4a
FP1, 8–10	36.1a	28.4a	29.2a
FP1, 11–13	18.6a	19.0a	15.7a
FP1, 14 and above	3.6a	4.7a	5.1a
FP2	8.8b	17.5a	17.0a
FP3	1.6a	1.0a	3.4a
Monopodial bolls	2.1b	11.4a	1.3b

† FP1, Fruiting Position 1; FP2, Fruiting Position 2; FP3, Fruiting Position 3 and above.
‡ Values in each row followed by the same letter are not significantly different according to LSD test at the 0.05 probability level.

for long-fiber mote percentages (Tables 3 and 4). Long-fiber mote percentages increased under water deficit conditions (Davidonis et al., 2000). In 1997, when monthly rainfall amounts decreased from May through July, long-fiber mote percentages increased in middle- and late-planted cotton. In 1999, when monthly rainfall amounts increased from May through July, long-fiber mote percentages decreased in middle- and late-planted cotton (Table 4). Competition among bolls has been implicated in boll weight and fiber property differences among bolls (Stewart, 1986; Jenkins et al., 1990). The competition for photosynthate may be accentuated during moisture stress so that seed development and fiber quality are affected. Differences in long-fiber motes were found in both years for FP1 bolls at Nodes 11 to 13 and FP2 bolls across planting dates. Although boll position effects were not evident for short-fiber motes, a planting date × boll position interaction was found (Table 3).

The consequences of staggered planting dates on fiber quality can be used to assess the effects of different environmental inputs on similar boll locations. The dates of first flower were obtained using the Crop Stages Simulation Program. Heat unit accumulations were obtained for the time period from first flower to 30 d after first flower. Over the 2-yr period, heat unit accumulations

Table 3. Analysis of variance of boll and fiber properties using SAS PROC MIXED.

Source of variation	Boll weight	Percentage long-fiber motes	Percentage short-fiber motes	Fiber length	Percentage short-fiber fibers	Theta	Cross-sectional area	Micronafis	Perimeter
a. 1997									
Planting date (PD)	***	***	ns†	***	***	**	ns	*	ns
Boll position (P)	***	***	ns	***	***	**	*	**	ns
PD × P	**	ns	***	ns	ns	ns	ns	ns	**
b. 1999									
PD	**	**	**	***	**	**	**	**	***
P	***	***	ns	***	***	***	**	***	***
PD × P	ns	ns	*	***	***	*	**	*	***

* Significant at the p = 0.05 level.
** Significant at the p = 0.01 level.
*** Significant at the p = 0.001 level.
† ns = nonsignificant.

Table 4. Effect of planting date on long-fiber mote percentages by boll location.

Position and node†	Planting date: Early	Middle	Late
	long-fiber motes, %		
a. 1997			
FP1, 5–7	5.1a‡	16.0a	19.2a
FP1, 8–10	4.1b	24.5a	26.2a
FP1, 11–13	15.5b	42.9a	44.2a
FP2	20.0b	51.8a	60.8a
b. 1999			
FP1, 5–7	8.9a	3.4a	4.8a
FP1, 8–10	11.0a	3.2a	5.3a
FP1, 11–13	27.0a	4.4b	10.6b
FP2	35.3a	14.0b	18.0b

† FP1, Fruiting Position 1; FP2, Fruiting Position 2.
‡ Values in each row followed by the same letter are not significantly different according to LSD test at the 0.05 probability level.

Table 5. Effect of planting date on mean cotton fiber length by boll location.

Position and node†	Planting date: Early	Middle	Late
	mm		
a. 1997			
FP1, 5–7	27.2a‡	26.4a	25.1b
FP1, 8–10	27.4a	25.1b	23.1c
FP1, 11–13	26.2a	22.3b	21.8b
FP2	26.2a	23.9b	22.6b
b. 1999			
FP1, 5–7	24.7b	25.3b	27.7a
FP1, 8–10	24.3b	25.9a	26.2a
FP1, 11–13	23.1c	26.9a	25.4b
FP2	23.4b	25.0a	25.6a

† FP1, Fruiting Position 1; FP2, Fruiting Position 2.
‡ Values in each row followed by the same letter are not significantly different according to LSD test at the 0.05 probability level.

for that 30-d period ranged from 349 to 376. Therefore, during the period of boll development for first of the season bolls, heat unit accumulations were similar across planting dates and years. Under water deficit conditions in 1997, middle- and late-planted cotton fiber lengths were reduced while in 1999, deficit conditions mainly affected early planted cotton (Table 5). Competition among bolls is a factor to consider when comparing fiber properties. First-position bolls at Nodes 5 to 7 would be less subject to within-plant competition than other locations. Mean fiber length was similar for early and middle-planted cotton at FP1 Nodes 5 to 7 (Table 5). At other boll positions, differences were found between fiber lengths in early and middle-planted cotton. Although planting date and boll position affected fiber length and percentage short fibers in both years, it was only in 1999 that the planting date × boll position interaction was significant (Table 3). Mean fiber length in 1997 was longer for early planted cotton than late-planted cotton at all boll locations (Table 5a). Conversely, fiber length in 1999 was longer for late-planted than early planted cotton at all boll locations (Table 5b). In both years, the percentage short fibers in bolls from FP1 Nodes 5 to 7 did not differ across planting dates (data not shown) although differences in mean fiber length were found (Table 5).

Any environmental factor that affects photosynthesis and cellulose synthesis has the potential to alter fiber maturity (Bradow and Davidonis, 2000). Fiber maturity has been defined as the degree of cell wall thickening relative to the diameter of the fiber. After boll opening, fibers dry out and collapse, and the degree of collapse from circular depends on the thickness of the cell wall (Bradow et al., 1997). Planting date and boll position affected fiber circularity (theta) and micronafis in each year. Planting date × boll position interactions were present in 1999 but not in 1997 (Table 3). In this study, fiber from early planted cotton had the highest theta values at all boll locations in 1997 while middle-planted cotton had the highest theta values at all first-position boll locations in 1999 (Table 6a and 6b). Fiber micronafis values declined in middle- and late-planted cotton in 1997 (Table 7a). No decline in micronafis values occurred when early planted cotton was compared with late-planted cotton in 1999 (Table 7b). Since heat unit accumulations during the period of boll development for first of the season bolls were similar, differences in theta and micronafis values for fibers from FP1 bolls at Nodes 5 to 7 may be related to other factors. As rainfall accumulation during the flower and boll development period of 20 d before flowering to 30 d after flowering increased, micronafis values increased (Fig. 1).

Large numbers of long-fiber motes per boll reduced the extent of secondary-wall deposition in fiber from

Table 6. Effect of planting date on cotton fiber theta values by boll location.

Position and node†	Planting date: Early	Middle	Late
	degree of circularity, theta		
a. 1997			
FP1, 5–7	0.534a‡	0.497b	0.501b
FP1, 8–10	0.538a	0.495b	0.504b
FP1, 11–13	0.533a	0.490b	0.493b
FP2	0.520a	0.468b	0.469b
b. 1999			
FP1, 5–7	0.505b	0.572a	0.527b
FP1, 8–10	0.506b	0.573a	0.524b
FP1, 11–13	0.521b	0.564a	0.520b
FP2	0.501ab	0.545a	0.498b

† FP1, Fruiting Position 1; FP2, Fruiting Position 2.
‡ Values in each row followed by the same letter are not significantly different according to LSD test at the 0.05 probability level.

Table 7. Effect of planting date on cotton micronafis values by boll location.

Position and node†	Planting date: Early	Middle	Late
	micronafis units		
a. 1997			
FP1, 5–7	4.80a‡	4.17b	4.16b
FP1, 8–10	4.83a	4.13b	4.29b
FP1, 11–13	4.63a	4.15b	4.15ab
FP2	4.45a	3.79b	3.79b
b. 1999			
FP1, 5–7	4.54b	5.58a	4.68b
FP1, 8–10	4.57b	5.46a	4.70b
FP1, 11–13	4.86a	5.16a	4.62a
FP2	4.47ab	5.02a	4.25b

† FP1, Fruiting Position 1; FP2, Fruiting Position 2.
‡ Values in each row followed by the same letter are not significantly different according to LSD test at the 0.05 probability level.

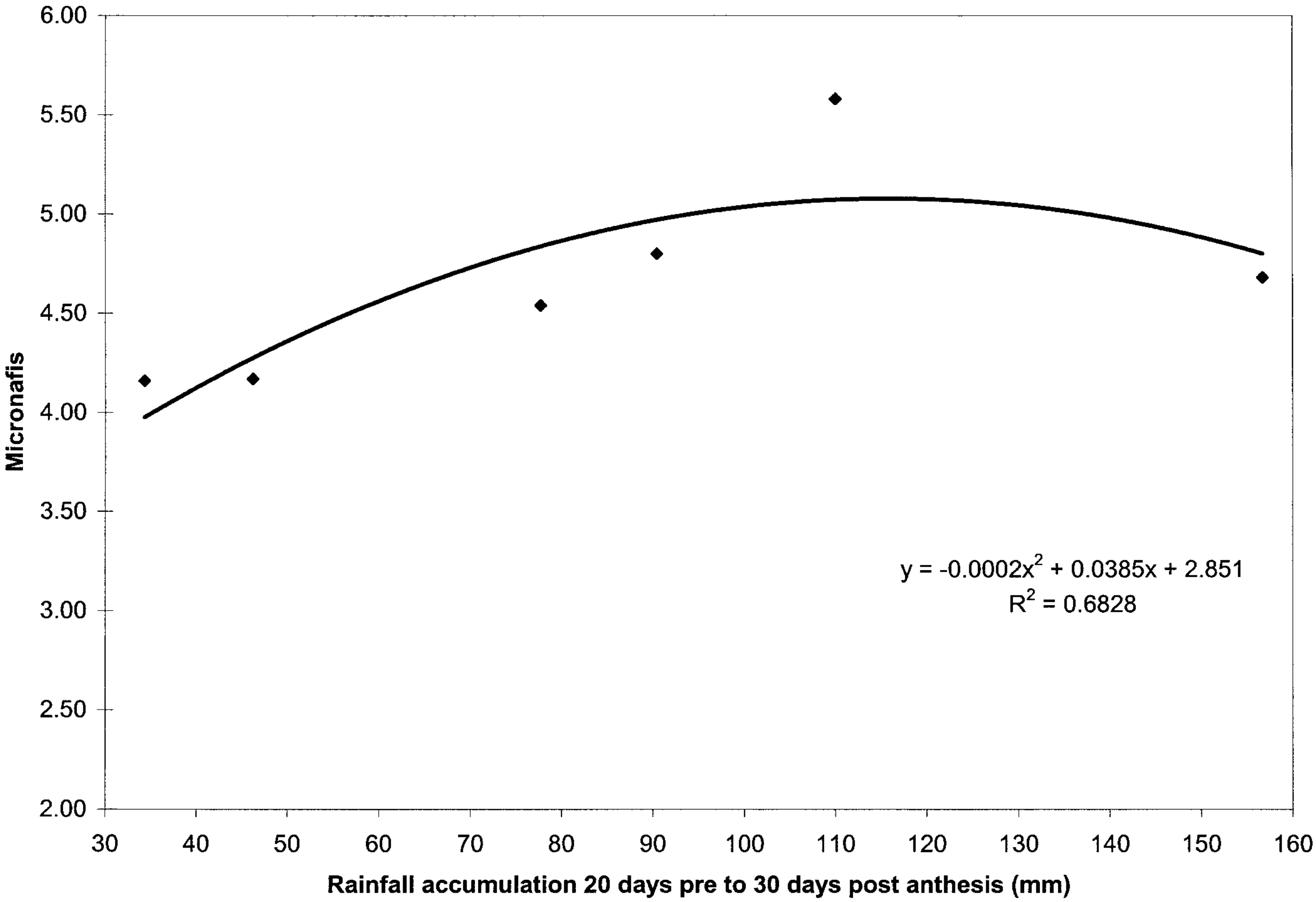

Fig. 1. Relationship between micronafis values for fiber from Fruiting Position 1 bolls at Nodes 5 to 7 and rainfall accumulation 20 d before and 30 d postanthesis in 1997 and 1999.

normal seeds within the same boll (Davidonis et al., 1996). Long-fiber motes have more immature fibers than normal seeds (Davidonis et al., 1999). Therefore, an increase in long-fiber mote percentages would be expected to have a detrimental effect on fiber maturity. The contribution of fibers from long-fiber motes to fiber maturity was obscured since significant differences in long-fiber mote percentages at some boll positions were not associated with reduced fiber maturity (Tables 4, 6, and 7).

When bolls at similar locations are compared, differences due to environmental conditions can be addressed. Bolls tagged at similar locations on different tagging dates were compared. In 1997, fiber from early planted cotton (Tagging Date 1) Nodes 8 to 10 was compared with fiber from late-planted cotton (Tagging Date 2) Nodes 6 to 10. Fiber lengths and micronafis values were similar (Table 8a), and heat unit accumulations during the period from flowering to 39 d postanthesis differed by 27 units. In 1999, fiber from early planted cotton (Tagging Date 1) Nodes 8 to 11 was compared with fiber from late-planted cotton (Tagging Date 4) Nodes 9 to 11. Fiber length was shorter and micronafis values lower in fiber from early planted cotton (Table 8b). Fiber from middle-planted cotton (Tagging Date 2) Nodes 6 to 10 was compared with fiber from late-planted cotton (Tagging Date 3) Nodes 6 to 9. Fiber length was shorter and micronafis values higher in fiber from middle-planted cotton than in late-planted cotton (Table 8b).

A complicating factor in assessing the effect of environmental conditions on micronafis is fiber length. If fiber elongation is limited, then during secondary-wall deposition, the same quantity of carbohydrate will be deposited over a shorter length of fiber. This is the situation when fiber from middle-planted cotton (Tagging Date 2) Nodes 6 to 10, 23.9 mm in length, was compared with fiber from late-planted cotton (Tagging Date 3) Nodes 6 to 9, 27.7 mm in length (Table 8b). With smaller differences in length, and similar heat unit accumulations during the 39-d postanthesis period, fiber from late-planted cotton (Tagging Date 4) had higher theta, cross-sectional area, and micronafis values than fiber from early planted cotton. Increased rainfall during the pre- and postbloom period was a determining factor in fiber micronafis values (Table 8b).

In late-planted cotton, low micronaire values were reported for the Texas High Plains and South Carolina (Bilbro and Ray, 1973; Porter et al., 1996; Bauer et al., 1998). The decline in micronaire values was linked to flowering and boll development at lower temperatures (Bauer et al., 1998). The harvest dates in Coastal Texas were in early August when daily heat unit accumulations were not declining. It is hypothesized that under adequate water conditions, temperature regulates second-

Table 8. Environmental parameters and fiber properties for bolls tagged in early, middle-, and late-planted cotton.

Environmental parameters and fiber properties	Date			
	Planting date			
a. 1997	Early	Late		
	Tagging date			
	1	2		
Rainfall 20 d preanthesis to 30 d postanthesis, mm	90	34		
DD 15.5† 35 d preanthesis	317	378		
DD 15.5 anthesis to 39 d postanthesis	482	509		
Node location	8–10	6–10		
Length, mm	25.6a‡	25.6a		
Short fiber, %	3.0a	2.7b		
Perimeter, µm	54.4a	51.7b		
Theta	0.511b	0.535a		
Cross-sectional area, µm²	120.2a	114.2b		
Micronafis	4.62b	4.65b		
	Planting date			
b. 1999	Early	Middle		Late
	Tagging date			
	1	2	3	4
Rainfall 20 d preanthesis to 30 d postanthesis, mm	64	100	129	134
DD 15.5, 35 d preanthesis	329	383	400	417
DD 15.5 anthesis to 39 d postanthesis	476	490	486	485
Node location	8–11	6–10	6–9	9–11
Length, mm	23.1c	23.9b	27.7a	24.4b
Short fiber, %	4.1a	4.5a	3.2b	4.3a
Perimeter, µm	54.4b	54.6a	52.5c	53.9b
Theta	0.502b	0.538a	0.530a	0.534a
Cross-sectional area, µm²	118.3c	127.1a	116.6c	123.6b
Micronafis	4.50c	5.11a	4.71b	4.96a

† DD 15.5, degree days 15.5°C.
‡ Values in each row followed by the same letter are not significantly different according to LSD test at the 0.05 probability level.

ary-wall deposition while under water deficit conditions with adequate daily heat units, water input regulates secondary-wall deposition. Therefore, under adequate moisture, the higher the heat unit input, the greater the degree of secondary-wall deposition.

In summary, early planting of cotton did not result in lower yields than normal (middle)-planted cotton. Planting date had a greater impact on boll distribution patterns in 1997 than in 1999. Long-fiber mote percentages increased under water deficit conditions at most boll locations. In 1997, fiber length and micronafis values decreased in late-planted cotton compared with early planted cotton at most boll locations. In 1999, most fiber length and micronafis value differences were between early and middle-planted cotton. In years with low or above-average July rainfall accumulations, early planting was not detrimental to fiber micronafis values. Early planting could avoid high micronafis/micronaire values since the acceptable micronaire range is 3.5 to 4.9 and any fiber outside that range is subject to a price penalty.

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