Fiber Property Variability from Bale to Bale

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ABSTRACT

Cotton (Gossypium hirsutum) fiber variability at the bale level is a composite of fiber properties contributed by individual bolls. Environmental conditions, crop management and genotype have an impact on fiber property variability at the boll and seed level. Cotton plants (DPL 51, 1995; NuCOTN 33B, 1996) were grown under rainfed (RF) and centre-pivot irrigated (IR) conditions at Perthshire Farms, Gunnison, MS. Plants were mapped prior to harvest. Fields were spindle picked and grab samples were taken pre and post ginning. Fiber samples from individual bolls and representative samples were analyzed using the Advanced Fiber Information System (AFIS). In 1995 cotton plants (RF, I) showed similar boll distribution patterns with 50% of the bolls located at the first position on fruiting branches. Fiber length and micronaire (micronafis) varied with mainstem node location. Composite fiber properties were similar for rainfed and irrigated cotton (1995). Boll distribution patterns were different for rainfed and irrigated plants in 1996. Composite fiber length properties were similar but micronaire (micronafis) was lower for irrigated cotton (1996). Lint cleaning (one lint cleaner) did not increase short fiber (<12.7 mm) percentages. A main contributor to fiber property variability at the bale level was variability at the boll level rather than ginning procedures.

Introduction

Cotton fiber property variability at the bale level is a composite of fiber properties contributed by individual bolls. Environmental conditions, crop management and genotype are pre-harvest inputs to fiber property variability (Stewart, 1988). Harvesting procedures and ginning methods contribute to post harvest variations in fiber properties (Anthony *et al.*, 1988). Under some field conditions fiber from bolls located close to the main stem (first position on a sympodial branch) was longer and more mature than fiber from bolls located at other positions on the same branch (Kittock *et al.*, 1979; Heitholt, 1997).

On the basis of main stem node location fiber was the longest on first position bolls located below node 10 while micronaire was the highest in bolls located at first position on nodes 13 to 15 (Kerby and Ruppenicker, 1989). When growing conditions were marked by a cool spring and autumn, no statistically significant trends were seen in fiber length values for first position bolls located on nodes 7 to 18 (Bradow *et al.*, 1997). Fiber micronaire (micronafis) varied for first position bolls (Bradow *et al.*, 1997). Environmental fluctuations alter boll retention patterns that impact yield and quality (Pettigrew, 1995; Heitholt, 1997). The objective of this paper is to assess fiber property variability on a per boll basis by main stem node location and position on a sympodial branch in rainfed (RF) and irrigated (IR) cotton and to compare composite fiber properties from spindle picked RF and IR cotton pre and post lint cleaning.

Material and Methods

Field studies were conducted on Robinsonville sandy loam (coarse-loamy, mix, non acidic thermic Typic Udifluvents) near Gunnison, MS during the 1995 and 1996 growing seasons. “Deltapine 51" (DPL 51) was planted on 12 May 1995 and “NUCOTN 33B” was planted 30 April 1996. A pre plant application of 67 kg N/ha and 84 kg N/ha was applied to soil in 1995 and 1996 respectively. Fertilizers, crop protection chemicals, growth regulators and harvest aid chemicals were applied according to recommended rates. Irrigated fields were centre pivot irrigated four times in 1995; 28 July, 30 mm; 7 August, 25 mm; 20 August, 25 mm and 1 September, 25 mm. Irrigation dates for 1996 were 10 July, 25 mm; 13 July, 18 mm; 20 July, 18 mm; and 25 July, 18 mm. Fields were spindle picked 27 September 1995 and 9 October 1996.

Eight areas of 1m^2 each were randomly selected and plant mapped in RF and IR fields prior to spindle picking. For plant mapping purposes node 0 was the cotyledon node. In this study, fruiting branches (sympodia) and vegetative branches (monopodia) were mapped. All bolls on vegetative branches were designated vegetative bolls regardless of position on a branch. Fiber samples were removed from seeds located in the middle of locules (Davidonis *et al.*, 1996). Fiber samples were analyzed on a boll basis using the Zellweger Uster Advanced Fiber Information System (AFIS) equipped with L&D (length and diameter) and F&M (fineness and maturity) modules (Bradow *et al.*, 1997, Calhoun *et al.*, 1997, Davidonis *et al.*, 1996). After commercial saw ginning 2.7 kg of fiber was collected prior to lint cleaning along with about 2.7 kg of fiber collected after passing through one lint cleaner. Samples were analyzed for AFIS fiber properties. Data analysis used the GLM procedure (SAS Institute, 1989).

Results and Discussion

Boll distribution patterns for 1995 were similar for RF and IR cotton. In RF cotton 51, 22, 15 and 12% of the bolls were at first position, second position, and third to fifth position and on monopodia, respectively. Irrigated cotton had a similar boll distribution patter with 50, 21, 19 and 10% of the bolls at first position (FP1), second position (FP2), third to fifth position (FP3-5) and on monopodia, respectively. Boll distribution patterns for 1996 were different for rainfed and irrigated cotton. Rainfed cotton had 59, 20, 8, and 15% of the bolls at first position, second position, third to fifth position and on monopodia, respectively. Irrigated cotton had 75, 14, 3 and 8% of the bolls at first position, second position, third to fifth position and on monopodia, respectively.

In a comparison of fiber lengths of 26 cultivars using AFIS, Calhoun *et al.* (1997) showed that the ranking of cultivars by upper half mean fiber length (UHM) as measured by HVI was similar to the upper quartile length (UQL) measured by AFIS. Correlations with UHM (HVI) were high (r = 0.80) for UQL (AFIS) but lower for length (L(w)) (r = 0.60). Fiber fineness and maturity are expressed in AFIS values for Area (An), micronafis (AFIS equivalent of micronaire) and theta (degree of circularity). Correlation with HVI micronaire were low (r = 0.58) for theta and higher with micronafis (r = 0.79) (Calhoun *et al.*, 1997).

A comparison of fiber properties by boll location revealed that for RF 1995 cotton fiber length by weight (L(w), 23.4 mm) was significantly (P=0.05) shorter in FP1 located at nodes 14 to 18 than at other FP1 locations. Fiber lengths for FP1 bolls nodes 4 to 13 and FP1 monopodial bolls were not significantly different (25.1-25.9 mm). Fiber lengths compared across branches from FP1 to 4 were not significantly different in RF cotton. Fiber length for IR 1995 cotton was significantly shorter (23.9 mm) in first position bolls located at nodes 4 to 7 than in first position bolls located at nodes 8 to 20 and monopodial bolls (25.1 - 25.9 mm). Fiber lengths compared across branches from FP1 to 5 was not significantly different in IR cotton.

Mean fiber lengths (L(w)) do not indicate short fiber content by weight that is the percent of fibers with length less than 12.7 mm. Short fiber content range from 4.2 to 5.3% in first position RF 1995 bolls located at nodes 4 to 18. No significant differences in short-fiber content were found in first position sympodial RF 1995 bolls while first position monopodial bolls had significantly fewer short fibers (3.9%). Short fiber content ranged from 5.1 to 5.4% in first position sympodial IR 1995 bolls located at nodes 4 to 18. No significant differences in short fiber contents were found in first position sympodial IR 1995 bolls. First position monopodial bolls had significantly fewer short fibers (4.4%).

The degree of cell wall thickening, theta, is the cross-sectional area of the fiber wall divided by the area of a circle of the same perimeter. Fiber with thick cell walls have high theta values while immature fibers are defined as having theta values below 0.25. AFIS immature fiber fraction (IFF) is the percent of fibers with theta values below 0.25. For RF cotton, theta values for FP1 bolls were the lowest for nodes 4 to 7 (Table 1a). Micronafis (micronaire) values paralleled theta values (data not shown). IFF values for all boll locations were in the range of 3.6 to 6.6 indicating that dramatic differences in fiber maturity were not associated with any particular boll position (Table 1b). Irrigated cotton showed more fluctuation in theta and IFF values (Table 2ab). Lower theta values and the highest IFF values were found in bolls located on branches 4 to 7. IFF values ranged from 4.1 to 10.6 indicating that irrigation increased variability when examined on a per boll basis.

A boll by boll analysis of fiber properties of RF 1995 cotton showed that fiber properties of FP3 and FP4 bolls were similar to FP1 bolls. Main stem node location of FP1 bolls did not account for the fluctuation in fiber properties often encountered from nodes 7 to 18 (Kerby and Ruppenicker, 1989; Bradow *et al.*, 1997). The boll distribution pattern contributed to greater fiber property uniformity among bolls. An alternative approach to improved fiber quality and uniformity has been the development and selection of cotton with a high percentage of first position bolls. Kerby and Ruppenicker (1989) suggested that columnar plants would have fewer low micronaire bolls from FP2 or greater.

The number of bolls at a particular node and branch position location and the fiber properties of those bolls contribute to the composite fiber properties of a field. The composite fiber properties for DP51 (1995) of L(w), short fiber content (w), micronafis and theta under RF and IR conditions were similar (Table 3). Some of the values differ from individual boll values and may be due to fiber property alterations due to mechanical harvesting and ginning. In both RF and IR cotton in 1995 and 1996, the use of one lint cleaner did not change fiber property values. Excessive lint cleaning increased short fiber content (Anthony *et al.*, 1995). Differences between short fiber content in fiber that was not cleaned and fiber that passed through one lint cleaner were significant (Anthony *et al.*, 1988). It may be that low micronaire (3.5 to 4.3) cottons are more susceptible to breakage during the lint cleaning process.

Interpretative Summary

Fiber uniformity is a main concern of textile mills. Pre-harvest inputs into fiber property variability include environmental conditions, crop management practices, and genetics. Post harvest contributors include harvesting and ginning procedures. Fiber property uniformity was analyzed on a per boll level and on the bale level. At the boll level, fiber uniformity was related to the location of the boll on the plant. A boll distribution pattern in which more than 50% of the bolls were not located close to the main stem was associated with more uniform fiber. Lint cleaning (one lint cleaner) did not increase short fiber (<12.7 mm) percentages. The main contributor to fiber property variability at the bale level was variability at the boll level rather than ginning procedures.

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Table 1. Theta values for 1995 DP51 cotton.

Rainfed	Boll Position			
Node Number	FP4	FP3	FP2	FP1
14-18				0.64a†
11-13		0.61 ab	0.60 ab	0.62 a
8-10	0.61 ab	0.64 a	0.60 ab	0.60 b
4-7		0.57 b	0.60 ab	0.58 b
Monopodia				0.a
Irrigated				
14-20			0.63 ab	0.60 ab†
11-13		0.62 ab	0.59 ab	0.62 a
8-10	0.62 ab	0.58 ab	0.60 ab	0.58 bc
4-7	0.61 ab	0.53 cd	0.58 bc	0.53 d
Monopodia				0.57 bc

†Means followed by the same letter are not significantly different at the 0.05 probability level.

Table 2. Immature fiber fraction percentages for 1995 DP51 cotton.

Rainfed	Boll Position			
Node Number	FP4	FP3	FP2	FP1
14-18				3.6 b†
11-13		5.5 ab	5.9 ab	5.0 ab
8-10	6.2 ab	4.1 b	5.7 ab	5.4 ab
4-7		6.6 a	4.9 ab	6.3 a
Monopodia				4.2 b
Irrigated				
14-20			4.1 b	5.7 b†
11-13		4.8 b	5.2 b	4.9 b
8-10	4.4 b	6.2 b	5.0 b	6.4 b
4-7	6.2 ab	10.6 a	6.0 b	9.0 a
Monopodia				6.6 b

†Means followed by the same letter are not significantly different at the 0.05 probability level.

Table 3. AFIS fiber properties and lint cleaning.

1995 DPL51	Rainfed		Irrigated	
Fiber property	No lint cleaning	One lint cleaning	No lint cleaning	One lint cleaning
L(w)	21.8 ± 0.3	21.6 ± 0.1	22.0 ± 0.2	21.6 ± 0.2
SFC (w)	12.3 ± 0.6	12.6 ± 0.6	11.1 ± 0.3	11.7 ± 0.4
Theta	0.53 ± 0.01	0.53 ± 0.01	0.54 ± 0.01	0.53 ± 0.01
Micronafis	4.9 ± 0.2	4.9 ± 0.01	5.1 ± 0.1	5.0 ± 0.1
1996 NuCotn 33B				
L(w)	22.3 ± 0.2	22.6 ± 0	22.7 ± 0.4	23.0 ± 0.2
SFC (w)	8.4 ± 0.3	8.0 ± 0.1	8.7 ± 0.4	8.0 ± 0.3
Theta	0.50 ± 0.01	0.51 ± 0.01	0.48 ± 0	0.50 ± 0.02
Micronafis	4.7 ± 0.1	4.8 ± 0.1	4.3 ± 0	4.5 ± 0.1