# PRE-HARVEST SPATIAL AND TEMPORAL VARIABILITY IN SHORT FIBER CONTENT IN RELATION TO PROCESSING SUCCESS

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## Abstract

The post-harvest sector of the cotton industry has assigned top priority to minimizing short fiber content [percentage of fiber less than 12.7 mm long] because knowledge of short fiber content is considered indispensable for production of high quality yarns (Rogers, 1997; Wakelyn et al., 1998). However, short fiber content [SFC] is not currently, included in the fiber quality information provided by AMS classing offices for each bale of U.S. cotton. This perceived importance of SFC to processors has led to increased demands for development and approval of a standard SFC measurement for addition to classing office HVI systems and for the inclusion of SFC in the cotton valuation system (Alverson, 1997; Ramey, 1997; Rogers, 1997; Wakelyn et al., 1998). Documentation of post-ginning SFC at the bale level is expected to reduce the cost of textile processing and increase the value of the raw fiber (Behery, 1993; Wakelyn et al., 1998).

However, surprisingly little is known about the levels or sources of pre-harvest short fiber content (Fransen and Verschrage, 1985; Behery, 1993). Based on length measurements of hand-ginned fiber from three genotypes, cotton seeds before harvest are said to account for *ca.* 1.5% of the total SFC in the bale (Fransen and Verschrage, 1985; Alverson, 1997). However, the same literature sources indicate that total SFC in "mechanically ginned" lint ranged from 6.1% to 9% (Fransen and Verschrage, 1985). More recently, the average SFC [by weight] of fiber finger-ginned from normal [full-weight] DPL51 seeds was reported to be 6.2% (Davidonis et al., 1996). Since these Deltapine 51 bolls were hand-harvested, the effects of a spindle-picking, stripper harvesting, mechanical ginning, or lint cleaning were not factors contributing to the higher SFC percentages in the more recent reports (Davidonis et al., 1996; Rogers, 1996).

Examination of SFC data from studies of the effects of growth environment on fiber properties reveal a range in SFC by weight [SFC(w)] from 4.6% for hand-ginned DPL50 greenhouse-grown fibers to 16.1% for spindle-picked, saw-ginned DPL20 fibers field-grown in 1991 in South Carolina (Wartelle, et al., 1995; Bradow et al., 1997a; Bradow et al., 1997b; Bradow et al., 1998a; Johnson et al., 1998). In these studies conducted between 1991 and 1998, fourteen Upland genotypes grown in South Carolina, Mississippi or Louisiana were hand-harvested or spindle-picked. Fibers were separated from seeds by dissection (Wartelle et al., 1995; Bradow et al., 1996; 1997a), roller-ginning (Bradow et al., 1997a; 1997b), or saw-ginning [without lint cleaner] (Bradow and Bauer, 1997; Bradow et al., 1997c; Bradow et al., 1998a; Johnson et al., 1998). Possible discrepancies among instruments designed to measure SFC (Behery, 1993; Ramey, 1997) was minimized by using a single Zellweger AFIS A-2 model calibrated with an Upland standard cotton (Bradow et al., 1996).

Genotype, crop year [weather], and boll position on the plant all had significant effects on SFC. In saw-ginned fiber from eight genotypes grown in South Carolina, [DPL20, DPL50, DPL90, DPL5690, Coker 315, Paymaster 145, and an $F_2$ and $F_3$ crosses between the Coker and Paymaster parents], the 1991maximum SFC(w) of 16.1% was found in DPL20 and the 1991 minimum SFC(w) of 12.6% was found in DPL5690 (Bradow et al., 1997c). In 1992, DPL20 was also the genotype with the maximum SFC(w) of 14.3%; but the genotype with the 1992 minimum SFC(w) of 12.8% was the F3 cross of Coker 315 and Paymaster 145. In a South Carolina plant-mapping study designed to examine the relative effects of drip-irrigation methods (Bradow et al., 1997a; 1997b), the overall SFC(w) treatment means for Pee Dee 3 grown with three irrigation treatments were not significantly different [Alternate-row tube-spacing SFC(w) = 13.8%; rainfed SFC(w) = 13.5%; in-row tube-spacing SFC(w) = 13.5%.] However, those means obscure the range in SFC(w) across fruiting site and irrigation treatment. In the alternate-row treatment, maximum SFC(w) was 25.4% and occurred at fruiting site, 11-2 [fruiting branch 11, branch position 2]. In the in-row treatment, maximum SFC(w) was 26.8% at fruiting site 13-1. The maximum SFC(w) in the rainfed control was 16.1% at fruiting site 8-1(Bradow et al., 1997b; 1997c). The best [lowest] SFC(w) percentages were: alternate-row treatment, 4.8% at fruiting site 14-1; in-row treatment, 4.3% at fruiting site 12-1, and 5.9% at fruiting site 7-1 in the rainfed treatment. Note that the rainfed maxima and minima were found lower on the plant and that SFC(w) maxima and minima frequently appeared on adjacent fruiting branches.

Significant differences in SFC were found in two locules from the same Pee Dee 3 boll at fruiting site 12-1. The mean length by weight and SFC(w) in locule 3 were 25.7±6.2 mm and 6.2%, respectively; and the corresponding locule-4 values were 25.6±7.3% and 5.9% at that fruiting site. However, the frequency histograms for the length by

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weight data from the two locules are quite different. In locule 3, the maximum length by weight is 28.6 mm, the length of 10.7% of the fibers. The maximum length by weight in locule 4 is 27.0 mm with only 9.0% of the fibers being that length.

The true fiber length distributions within these fiber populations are further disguised by the weight bias inherent in length and SFC by weight measurements. In these within-boll comparisons between locules, the mean length by number for locule 3 was 21.8±9.3 mm, corresponding to a SFC by number of 19.3%. The mean length by number for locule 4 was 21.5±9.3 mm, and the SFC by number was 19.1%. However, these means and standard errors do not reveal that the maximum length by number in locule 3 was 30.2 mm [1.2 inches] attained by 8.4% of the fiber, and the maximum length by number in locule 4 was 26.2 mm [1.0 inches] attained by 14.7% of the fiber. The fiber population in locule 3, based on the typical 10,000-fiber count of an AFIS sample, contains 3460 fibers shorter than the mean of which 1930 fibers are less than half an inch long. The corresponding counts for locule 4 are 4050 fibers shorter than the mean, including 1910 fibers less than half an inch in length. Fiber samples that appeared to have the same mean lengths, based on the length by weight, contained differing numbers of fibers shorter that the mean lengths by weight and would. Presumably, spin differently in equipment set according to the length and SFC bale averages.

Natural within-crop variations in SFC were also modulated by several environmental factors. In an open-top environmental-chamber study in North Carolina (Bradow et al., 1998b), increased ozone concentration when ambient $CO_2$ levels were maintained decreased SFC [by number] percentages by 12.6%, and the ozone effect disappeared when additional $CO_2$ was added to the system. The ozone-related drop in SFC corresponded to an increase in fiber length at the expense of a decreased fiber diameter.

The natural rate of SFC(w) decrease over time was altered by environmental factors that modified fiber maturation (Bradow et al., 1996; 1997c). Higher growth temperatures during the maturation of fibers in bolls that developed from Mississippi-grown DPL5415 August flowers, compared to July flowers, resulted in August fiber elongation rates that were 2.3 times the July fiber elongation rates. The corresponding decrease in SFC(w) of August-bloom fibers was 4.4 times the rate of SFC(w) decrease for July-bloom fibers (Bradow, et al., 1997c).

In a soil spatial-variability study, saw-ginned LA 887 SFC(w) ranged from 6.8% to 11.8% (Bradow et al., 1998a; Johnson et al, 1998). A weak negative correlation was found between SFC and soil phosphorus levels. Yield and SFC were positively correlated, but no significant relationships were found between SFC and fiber bundle strength or elongation. The weak correlations between soil fertility properties and SFC were inadequate for development of recommendations for site-specific fertilizer applications designed to increase fiber length and decrease SFC through improved pre-harvest management of the cotton crop.

Fiber bundle strength and elongation were more closely correlated to fiber properties related to maturity than to length or SFC (Bradow et al., 1997c). When fiber from the eight genotypes grown in 1991 and 1992 in South Carolina was spun into yarn, the correlations between SFC and yarn elongation and breaking strength were not consistent across genotypes or between crop years. When data from the two years were pooled, SFC(w) explained 54.2% of the variation in yarn elongation but only 21.4% of the variation in yarn breaking strength. From similarly pooled data, SFC(n) accounted for 56.1% of the variation in yarn elongation and 28.9% of the variation in yarn breaking strength. In comparison, pooled diameter by number data explained 46.2% of the variation in yarn elongation and 42.0% of the variation in yarn breaking strength.

In summary, in more than 1,000 samples of hand-picked fiber assayed after finger-ginning, roller-ginning, and saw-ginning, the SFC(w) for finger-ginned fiber was 6.2%, for saw-ginned fiber, 10.2%, and for roller-ginned fiber, 11.8%. Variations in growth environment and genotype modulated SFC, and some growing conditions were weakly associated with those SFC changes. However, the few linkages found between SFC and pre-harvest environment and/or crop management were too inconsistent to warrant inclusion of SFC, either by weight or by number, among the fiber properties used to set the bale price paid to the producer. Current crop management technology and the commercial genotypes available do not allow the producer to manage the cotton crop *before harvest* to achieve a SFC range set according to *post-harvest* mill requirements.

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