COMPARISON OF LINT FRACTION AND FIBER QUALITY DATA FROM HAND- VS MACHINE-HARVESTED SAMPLES IN COTTON YIELD TRIALS

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Abstract

In typical small-plot cotton research, sub-samples of seed cotton are collected and ginned on small laboratory gins for determination of lint fraction (used in calculating lint yield) and fiber properties. Literature is scarce on how results from these sub-samples relate to large samples processed through a commercial ginning sequence. The objectives of this study were to: 1) determine if, and by how much, lint fraction and fiber quality results from hand- and machine-harvested sub-samples differ from results obtained from large samples processed through a commercial gin sequence, 2) determine if there is a significant genotype x sample method interaction for lint fraction and important fiber traits, and 3) compare the precision of different sample methods.

Three types of samples were collected from the 1994 Early Maturing Cotton Variety Test at three Mississippi locations. Sample methods were: 1) 100 random bolls hand-harvested prior to mechanical harvest (boll samples, BS), 2) 400 to 600g sample of machine-harvested seed cotton (grab samples, GS), and 3) remainder of seed cotton (25 to 60 lb per plot) (whole plot samples (WP). BS and GS were ginned on a 10-saw laboratory gin; WP were ginned through a commercial ginning sequence on the USDA-ARS 20-saw micro-gin at Stoneville, MS. Lint fraction was determined from each sample method. Fiber samples from each sample method were analyzed on a Motion Control HVI at the Louisiana State University Fiber Testing Laboratory. Data were subjected to analysis of variance, combined over locations with cultivars considered as main plot and sample methods as sub plots.

Averaged across locations and sample methods, cultivars differed for all traits measured. Lint fraction was 5 percentage points lower from WP than from BS or GS. Fiber length from WP was 0.03 in. shorter than GS, and 0.05 in. shorter than BS. Fiber strength was similar for all sample methods. Micronaire from WP was 0.54 units lower than from BS, but only 0.04 units lower than from GS. A significant sample method x cultivar interaction was observed only for lint fraction--relative differences among cultivars were affected by sample method. Both sub-sampling methods introduced bias into data for lint fraction (and thereby for lint yield), when compared to WP and there was no clear indication if GS or BS most closely resembled WP. Precision, measured by coefficient of variation and r-squared, was greatest for WP for most traits. For most traits, BS appeared to give slightly better precision than GS for most traits at one test site, while precision of GS was similar to, or slightly better than, BS at the other two test sites.

There appeared to be no clear advantage of GS over BS for measuring lint fraction. GS more closely resembled WP for micronaire and fiber length, but BS and GS were similar for fiber strength. The lack of sample method x cultivar interaction for fiber traits suggests that BS and GS are similar in distinguishing relative differences among cultivars in a test. Averaged across locations, BS appeared to be slightly more precise than GS, but the difference was small. As long as relative differences among test entries, rather than actual values, are of primary interest, choice of sample method should be governed more by logistical considerations (e.g. labor availability and distribution, cost, and time) rather than concerns about the quality of the data. If actual values are of primary interest, GS would be preferred.

Introduction

In most cotton yield trials, all seed cotton is harvested from plots for direct determination of seed cotton yield. However, only sub-samples are generally collected and ginned on laboratory gins for lint fraction and fiber quality determination. Lint fraction from these sub-samples is used to calculate lint yield indirectly. Accurate lint fraction determination is essential for accurate lint yield determination. Accurate fiber quality determination is needed to correctly assess the relative value of lint produced.

Methods used to collect seed cotton sub-samples fall into two general categories: 1) hand harvest of bolls prior to mechanical harvest (boll sampling), or 2) direct sub-sampling of machine-harvested seed cotton (grab sampling). Both methods have advantages and disadvantages. Collection of grab samples utilizes less total labor, but normally requires one additional person to collect samples during the mechanical harvest operation. Grab samples are likely to be more representative than boll samples, but when processed on laboratory gins, can result in fiber samples with an excessive amount of foreign matter. Boll sampling is more labor-intensive and has the potential of resulting in non-representative samples, but allows determination of boll size, can improve distribution

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of labor requirements and generally results in cleaner fiber samples.

Published research on the effect sample method may have on test results is scarce. Most references to the effect of sub-sampling are informal asides [e.g. Meredith et al. (1992) reported that using hand-harvested boll samples over estimates gin turnout by about 15%]. Quinby and Stephens (1930) compared large (10 to 30 lb) hand-harvested samples with small (200 g) hand-harvested sub-samples and found only small differences in lint percentage. Meredith et al. (1975) compared selective (i.e. 75 random bolls per plot) vs. non-selective (i.e. all bolls in 0.8m of row) hand-harvested samples. They found that most yield components and fiber quality parameters were significantly higher when determined with selectively harvested samples compared to non-selectively harvested samples. Pinnamaraju et al. (1993) compared lint percentage and fiber properties determined by machine- vs. hand-harvested sub-samples from cotton yield trials. They reported a significant effect of sample method on lint fraction, but no such effect on the fiber properties measured and no sample method x genotype interaction.

Even more important than the comparison between results obtained from hand- vs. machine-harvested sub-samples, is the comparison of results from these methods with results obtained from large, commercially ginned samples. There appears to be no such comparison in the literature. The objectives of this study were to: 1) determine if, and by how much, lint fraction and fiber quality results from hand- and machine-harvested sub-samples differ from results obtained from large samples processed through a commercial-like gin sequence, 2) determine if there is a significant genotype x sample method interaction for lint fraction and important fiber traits, and 3) compare the precision of different sample methods.

Materials and Methods

Seed cotton samples were obtained from the 1994 Early Maturing Cotton Variety Test at Stoneville (Bosket very fine sandy loam), Elizabeth (Sharkey clay) and Starkville (Marietta silt loam), MS. These tests included 24 cultivars in common. Planting and harvest dates and management practices can be found in the Mississippi Agricultural and Forestry Experiment Station bulletin, “1994 Mississippi Cotton Variety Trials” (Calhoun et al., 1995). Two to seven days before mechanical harvest, 100 random bolls were hand-harvested from three replications at each location (referred to in the following as boll samples). Workers collecting bolls were instructed and trained to sample representatively from the top, middle and bottom portion of plants; one worker was assigned to each replication. Plots were mechanically harvested with a John Deere 9900 spindle picker modified for bagging seed cotton harvested from each plot. During mechanical harvest, a seed cotton sub-sample (grab sample) of approximately 400 to 600 g (the same weight range as hand-harvested samples) was collected from the middle portion of bags from the plots that were previously hand-sampled. Remaining seed cotton from all six replications (referred to in the following as whole plot samples) at each location was retained for processing at the USDA-ARS Ginning Laboratory in Stoneville, MS.

Hand-harvested boll samples and machine-harvested grab samples were ginned on a 10-saw Continental Eagle laboratory gin. Seed cotton, seed, and lint weight were determined for each sample.

All remaining seed cotton from plots in replications 1 and 2, 3 and 4, 5 and 6 was combined to give 3 seed cotton samples (ranging in weight from approximately 25 to 60 lb) per cultivar at each location. After conditioning for at least 48 hours in a common environment, seed cotton samples were weighed and processed through a typical commercial ginning sequence on the USDA-ARS micro-gin . The ginning sequence included a tower dryer, cylinder cleaner, stick machine, tower drier, cylinder cleaner, extractor-feeder, gin stand, and 2 lint cleaners. The commercial-type machines were reduced in width to match a 20-saw Continental Eagle 93 gin stand. After processing, lint was weighed and sampled. Results from whole plot samples processed through the commercial-type gin equipment were assumed to closely reflect results that would be obtained in a commercial situation.

Fiber length (upper half mean), strength and micromaire for each sample or sub-sample were determined on a Motion Control high volume instrument (HVI) at the Louisiana State University Fiber Testing Laboratory. Data for fiber properties and lint fraction were subjected to analysis of variance, using a randomized complete block design and split-plot arrangement with culitvars as main plots and sample method as sub-plots, combined across locations. Error terms and calculation of least significant differences (LSD) conformed to procedures outlined by Carmer et al. (1989).

Results and Discussion

Lint fraction

The analysis of variance for lint fraction is shown in Table 1. Averaged across sample methods, cultivars differed significantly in lint fraction, ranging from 40.62% for Stoneville 474 to 35.87% for Deltapine 50. The main effect of sample method was also significant and accounted for the largest proportion of mean squares. Lint fraction was lowest (35.03%) for whole plot samples (Table 2), as expected since, lint is removed by lint cleaning and unaccounted for. Lint fraction from whole plot samples was approximately 5 percentage points lower than from sub-sample methods. In plots yielding 3000 lb/A of seed cotton, calculated lint yield would be 1051 lb/A for whole plot samples, compared to 1216 lb/A for grab samples (a difference of 16%) and 1190 lb/A for boll samples (a difference of 13%). Meredith's (1992) report of 15% inflation of lint yield due to sub-sampling and laboratory ginning was supported by this study.

Lint fraction from grab samples was slightly higher than that for boll samples. This was unexpected, since machine-harvested seed cotton typically includes burs, green bolls and other foreign material which is included in the seed cotton weight, while boll samples do not. The lint portion of grab samples, after ginning, contains a considerable amount of leaf trash which would be weighed as lint. Another possible explanation is inadvertent selection for well developed bolls (which may have had larger seed and thus lower lint fraction than a truly representative sample) during hand harvest of boll samples. In any case, the difference between boll samples and grab samples, though statistically detectable, was small (0.87%).

The interaction of sample method and cultivar was significant at the 5% probability level (Table 1), indicating that relative differences in lint fraction among cultivars appears to vary depending on which sample method is used. The difference between lint fraction from boll samples and whole plot samples ranged from 1.65 to 7.60 percentage points among cultivars. Between grab samples and whole plot samples, the range was 3.53 to 7.84 percentage points. Between grab samples and boll samples, the differences was -3.04 to 3.38 percentage points. Simple correlation coefficients among sample methods were 0.87 (boll vs. grab samples), 0.89 (boll vs. whole plot samples), and 0.84 (grab vs. whole plot samples)--not particularly high, considering that lint fraction is critical in calculating lint yield.

Lint fraction from whole plot samples, processed through a commercial ginning sequence is assumed to most closely reflect what would happen in a commercial situation. However, collecting and processing whole plots is impractical for most research situations. Between the two sub-sample methods, there does not appear to be any clear advantage in terms of duplicating results from whole plot samples. Results from boll samples had a slightly higher correlation with whole plot samples than did grab samples. However, the range in differences between grab samples and whole plot samples was smaller that the range in differences between boll samples and whole plot samples.

Sample method also interacted significantly with location. However, there were no rank changes among sample methods across locations. Comparing sample methods at each location, boll samples ranged from ranged from 4.07 to 5.39 percentage points higher than whole plot samples, and from 0.83 to 1.60 percentage points higher than grab samples.

Fiber length

Averaged across locations and sample methods, cultivars differed significantly for fiber length (Table 3), with a range of 1.08 for Stoneville 474 to 1.14 in. for Hartz H1215 and H1220. Again, the main effect of sample method accounted for the largest proportion of the mean squares. Fiber length was greatest (1.14 in.) for boll samples, intermediate (1.12 in.) for grab samples, and lowest (1.09 in.) for whole plot samples (Table 2). Shorter upper half mean length in samples processed through a commercial ginning sequence could be accounted for by fiber breakage in processing, particularly during lint cleaning. Longer fiber in boll samples is most likely due to inadvertent selection of larger, better developed bolls, rather than a truly representative sample.

The interaction of sample method with cultivar was not significant. Relative differences among cultivars remained constant regardless of sample method.

The interaction of sample method with location was significant, but no rank changes among locations occurred. Comparing across locations, boll samples had fiber length from 0.01 to 0.04 in longer than grab samples, and 0.05 to 0.08 in. longer than whole plot samples (Table 2).

Fiber strength

Cultivars differed significantly in fiber strength, averaged across locations and sample methods (Table 3), with values ranging from 24.42 g/tex for Terra 366 to 29.75 g/tex for Suregrow 404. The main effect of sample method was not significant, due in part to a relatively large sample method x location interaction. The interaction between sample method and cultivar was not significant.

Micronaire

Cultivars differed significantly for micronaire, averaged across locations and sample methods (Table 3), with values ranging from 3.90 for Hartz H1330 to 4.39 for Chembred 830. The main effect of sample method was significant and accounted for the largest proportion of mean squares among treatment variables and interactions involving treatment variables. Micronaire was much higher for boll samples than for grab samples or whole plot samples (Table 2), reflecting again a tendency for inadvertent selection of better developed bolls when hand harvesting. Micronaire from grab samples was statistically higher than from whole plot samples, but the difference was small.

The interaction of sample method with cultivars was not significant (Table 3). Although boll samples gave much higher values than other sample methods, relative differences among cultivars remained nearly constant.

The interaction of sample method with location was significant (Table 3), and some rank changes across locations occurred. Micronaire from boll samples was always higher than from the other sample methods.

Micronaire from grab samples ranged from 0.05 units higher to 0.04 units lower than whole plot samples in various locations.

Precision

Research trials need to utilize methods that are not only accurate (i.e. produce "true" values and/or reflect "true" differences among treatments), but methods that are also precise (i.e. capable of detecting small differences based on relatively small sample size). Precision can be evaluated in several ways. We have used coefficient of variation (CV) and r-squared to compare precision of the tests using different sample methods.

Coefficient of variation values for each trait, by location and sample method, are presented in Table 4. Whole plot samples gave the lowest CV for lint fraction, consistent with the report of Vantine (1934) that larger samples gave more precise measures of lint fraction. Averaged across locations, boll samples gave slightly lower CV's than grab samples. However, at two locations, CV's were lower for grab samples than boll samples.

Whole plot samples also gave lower CV's for fiber length and strength than other sample methods. Averaged across locations, CV's from boll samples were slightly lower than from grab samples, though again, CV's from grab samples were lower than for boll samples at two locations. Whole plot samples and boll samples gave similar CV's for micronaire (4.05 and 4.50%, respectively) and were lower than from grab samples. Averaged across all dependent variables, CV's from whole plot samples were lowest, followed by boll samples, and CV's from grab samples were the highest.

The r-squared values (the proportion of variability accounted for by the analysis of variance model) for each trait, by location and sample method, are presented in Table 5. These values followed a pattern similar to CV. Whole plot samples resulted in the highest r-squared values for most traits, most notably, lint fraction. Averaged across locations, r-squared values were higher for boll samples, compared to grab samples, for lint fraction, fiber length, and micronaire. Grab samples had higher r-squared values for fiber strength, compared to boll samples.

Conclusions

The significant sample method x cultivar interaction for lint fraction should cause concern among scientists conducting cotton yield trials. Neither sub-sampling method was ideal for estimating true lint fraction or for estimating relative differences among cultivars. However, practical considerations will dictate that most yield trials will continue to depend on sub-sampling to estimate lint fraction. There appeared to be no clear advantage of grab samples over boll samples for measuring lint fraction. Grab samples more closely resembled whole plot samples for micronaire and fiber length, but boll samples and grab samples were similar for fiber strength. The lack of sample method x cultivar interaction for fiber traits suggests that boll samples and grab samples are similar in distinguishing relative differences among cultivars in a test. Averaged across locations, boll samples appeared to be slightly more precise than grab samples, but the difference was small. As long as relative differences among test entries, rather than actual values, are of primary interest, choice of sample method should be governed more by logistical considerations (e.g. labor availability and distribution, cost, and time) rather than concerns about the quality of the data. If actual values are of primary interest, grab samples would be preferred.

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Table 1. Analysis of variance for lint fraction in the 1994 Early Maturing Cotton Variety Test grown at Stoneville, Elizabeth and Starkville, MS, and sampled by three methods.

Source	df	Mean squares Lint fraction
Total	647	
Block (B)	2	0.696
Location (L)	2	175.369
B in L	6	4.362
Cultivar (C)	23	62.681**
C by L	46	3.215**
Pooled error	144	1.015
Sample method (S)	2	1888.565**
S by L	4	11.123**
S by C	46	1.804*
S by C by L	92	1.109NS
Residual	280	0.598

Table 2. Main effect of sample method on lint fraction and selected fiber properties in the 1994 Early Maturing Cotton Variety Test, averaged across 3 Mississippi locations (n=72).

	Sample method			
Parameter	Boll sample	Grab sample	Whole plot	LSD (0.05)
Lint fraction	39.66	40.53	35.03	0.11
Length (UHM)	1.14	1.12	1.09	0.001
Strength (HVI)	27.59	26.06	26.85	NS
Micronaire	4.48	3.97	3.94	0.001

Table 3. Analysis of variance for fiber properties from the 1994 Early Maturing Cotton Variety Test grown at Stoneville, Elizabeth and Starkville, MS, and sampled by three methods.

		Mean squares		
Source	df	Length	Strength	Micronaire
Total	647			
Block (B)	2	61.529	0.182	1.262
Location (L)	2	1055.761	113.591	74.119
B in L	6	43.990	1.864	0.580
Cultivar (C)	23	54.902**	61.045**	0.583**
C by L	46	18.458NS	3.041**	0.092 NS
Pooled error	144	7.806	1.845	0.070
Sample method (S)	2	1711.650**	126.350 NS	19.573**
S by L	4	75.890**	33.517**	0.112**
S by C	46	3.274NS	2.407 NS	0.041NS
S by C by L	92	5.534**	1.745 NS	0.041NS
Residual	280	3.068	1.548	0.012

Table 4. Coefficient of variation (%) from analysis of variance of factors measured by 3 sample methods in the 1994 Early Maturing Cotton Variety Test at 3 Mississippi locations.

Location	Boll sample	Grab sample	Whole-plot sample
		Lint fraction	
Stoneville	2.99	1.89	1.38
Elizabeth	2.20	2.09	1.20
Starkville	1.32	3.15	1.02
Mean	2.17	2.38	1.20
		Fiber length	
Stoneville	2.48	1.87	1.71
Elizabeth	2.59	2.07	2.50
Starkville	1.26	2.47	1.32
Mean	2.11	2.14	1.84
		Fiber strength	
Stoneville	7.09	4.18	2.45
Elizabeth	5.52	5.08	6.02
Starkville	3.96	6.45	2.55
Mean	5.52	5.24	3.67
		Micronaire	
Stoneville	3.39	4.18	3.27
Elizabeth	3.94	4.28	6.00
Starkville	4.83	8.40	4.22
Mean	4.05	5.62	4.50
		All variables	
Over all mean	3.46	3.85	2.80

Table 5. R-squared values from analysis of variance of factors measured by 3 sample methods in the 1994 Early Maturing Cotton Variety Test at 3 Mississippi locations.

Location	Boll sample	Grab sample	Whole-plot sample
		Lint fraction	
Stoneville	0.76	0.89	0.93
Elizabeth	0.86	0.86	0.95
Starkville	0.95	0.61	0.96
Mean	0.86	0.79	0.95
		Fiber length	
Stoneville	0.54	0.65	0.76
Elizabeth	0.54	0.60	0.53
Starkville	0.85	0.48	0.71
Mean	0.64	0.58	0.67
		Fiber strength	
Stoneville	0.61	0.82	0.88
Elizabeth	0.73	0.79	0.54
Starkville	0.74	0.60	0.86
Mean	0.69	0.74	0.76
		Micronaire	
Stoneville	0.75	0.73	0.78
Elizabeth	0.63	0.71	0.49
Starkville	0.78	0.52	0.77
Mean	0.72	0.65	0.68
		All variables	
Over all mean	0.73	0.69	0.77