IMPROVEMENT OF HVI MEASUREMENT PRECISION PART 1 : USE OF HVI FOR BREEDING PROGRAMS : MCI SAMPLING DEVICE EFFECT.

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Summary

The Motion Control 3500 line in our laboratory was fitted successively with a pinch sampler then a universal sampler. The precision of the results obtained with this HVI line fitted with the different samplers was evaluated. Roller-ginned samples required considerably more measurements to obtain the same precision as those that had been saw ginned. A comparison of the within-sample variances showed that the results obtained with the universal sampler were less precise than with the pinch sampler for saw-ginned cottons. The precision of the two systems was identical for roller-ginned samples.

1 - Introduction

To classify all production bales in the USA, HVI (High Volume Instrument) systems were developed to provide an objective measurement of the following technological characteristics of cotton fiber:

- length and uniformity of length,
- resistance and elongation on rupture,
- the maturity/fineness complex, expressed in the form of a micronaire value,
- reflectance and yellow degree,
- an estimation of the waste level in the fiber.

HVIs are also used by the spinning industry to control the quality of its starting material supplies. The industry is thus able to prepare mixes in such a manner to manufacture a product of consistent quality.

Varietal improvement must take at least some account of HVI characteristics as the marketing of the fiber produced is based on this HVI data. This was illustrated by Green and Culp (1988), who noted that the genetic basis of resistance to rupture of a fiber web measured on a Stelometer is different from that measured on a HVI line. Moreover, the HVI lines also increase a laboratory's analytical capacity in comparison with conventional instruments.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1317-1322 (1996)
National Cotton Council, Memphis TN

The sampling and analytical protocol employed has a major impact on the precision of HVI results. According to Sasser (1992), the repeatability of HVI measurements is relatively good, but even more repeatable results are required if problems encountered during marketing are to be avoided.

The solution is provided by module averaging. This consists of averaging the HVI results obtained for the bales of a seed-cotton module and applying this mean result to all the bales in the module. Mayfield (1994) showed that this method enhances the repeatability of the results obtained for the principal parameters in comparison with measurements taken on individual bales (table 1). Obviously, this method cannot be employed in varietal improvement as each individual or line is genetically unique.

According to Green and Culp (1988, 1990), the results obtained on HVI for strength are less powerful than those obtained on a Stelometer. Classification of the lines is therefore less discriminating for HVI strength. The description of the method used is not very precise, but this would seem to be the USDA AMS. This consists of one measuring of micronaire value, and 2 combs per sample on Zellwegger Uster Spinlab (ZUS) systems or 4 pinches per sample on Motion Control Inc (MCI) systems.

Gourlot and Hequet (1994) showed that the Zellwegger Uster HVI 910B measurement line gave precise results. By modifying the operating protocol used by the USDA AMS to classify production bales in the USA, it is possible to reach the tolerance levels presented in table 2.

2 - Aim of the study

The aim was to determine optimal operating conditions to enable the Motion Control 3500 system to produce the tolerance results given in table 2. In particular, we sought to evaluate:

* the influence of ginning type (roller or saw) on within-sample variances. The following are employed in the CIRAD network:

- a 1 yard type roller gin (Nam Chareon Machinery Co, Ltd, Thailand) for small quantities of seed-cotton,

- a saw gin (20 Continental Gin type 90 saws) for larger quantities of seed-cotton.

* the influence of the type of fiber sampler on within-sample variances. We tested two fiber samplers by measuring length and strength: the pinch sampler installed as standard on the machine and a universal sampler installed subsequently by Motion Control Inc. Dallas.

3 - Materials and methods

3.1 - Operation of the Motion Control 3500 machine

The first operation consisted of measuring the micronaire value. The sample was transferred to the Color Trashmeter where it was pressed by a metal plate against a transparent pane of glass. Thus the color of the cotton was characterized and its waste content was established at the same time that a sample of fibers was taken for measurement of length and strength. The fibers in this study were sampled using:

- the pinch sampler

A mechanical arm pressed the pinch into the fiber mass. The pinch then closed to hold the fibers which were then separated from the sample when the mechanical arm withdrew.

- the Universal sampler

A comb removed fibers through perforations in the metal plate. A mechanical arm carrying the pinch pressed this against the fiber mass removed by the comb. The pinch closed to hold the fibers which were then separated from the sample when the mechanical arm withdrew.

The fiber specimen was then carded and brushed while still held in the pinch before being characterized for length and subjected to the dynamometer test.

Once a few preliminary tests had been performed, and tests on the Zellweger Uster Spinlab HVI 910 B had been concluded, all the samples were mixed by hand. The samples were prepared for 24 hours in a standard atmosphere (21°C ± 1°C and 65 % relative humidity ± 2%). The measurements were taken under the same atmospheric conditions.

The HVI line was calibrated using ICCS (International Calibration Cotton Standards) to determine micronaire value and with HVICC standards (High Volume Instrument Calibration Cotton) to determine length and strength. These two cotton standards are distributed by the United States Department of Agriculture.

We took 4 micronaire readings and 16 measurements of length and strength for each sample tested. Only the ML length parameter (Mean Length in millimeters), the UHML (Upper Half Mean Length in millimeters), UI% (Uniformity Index in %), Strength (ST: HVI strength in g/tex) and elongation (EL: Elongation in %) were studied. The micronaire value, a variable in the equation used to calculate strength, was analyzed in order to perform the calculation as indicated by Taylor (1986).

3.2 - Samples analyzed

The experiment started with analyses using the pinch sampler (1st part) which was then dismantled and replaced by the universal sampler (2nd part):

- 1st part: samples derived from the varietal improvement programs conducted in the following countries: Brazil, Burkina Faso, Madagascar, Paraguay and Togo; 78 samples were roller ginned and 125 were saw ginned.

- 2nd part: samples derived from varietal improvement programs conducted in the following countries: Benin, Brazil, Madagascar, Paraguay and Togo; 56 samples were roller ginned and 145 were saw ginned.

4 - Results

4.1 - Ginning effect

Ginning induced marked differences in the distribution of within-sample variances for the various characteristics analyzed (figures 1 to 5). Table 3 presents the results of χ^2 tests used to compare these distributions.

4.2 - Fiber sampler effect

The sampler used would seem to introduce bias into the distribution of the within-sample variances. This is confirmed in table 4 which presents the results of tests designed to compare the distributions of the within-sample variances obtained with the two sampling systems.

Figures 1 to 5 and table 4 show that the strength distribution for roller ginning is broader with the universal sampler than with the pinch sampler. After saw ginning, the distribution of the within-sample variances with the universal sampler for ML, UHML, UI% and STR were also broader than with the pinch sampler.

4.3 - Number of measurements

Calculating the confidence interval for a single measurement requires determination of the mean within-sample variance. However, the mean variance can only be calculated if the individual within-sample variances are homogeneous.

Bartlett's method was used to test the null hypothesis that the variances were the same by calculating $\chi^2_{observed}$ to be compared with $\chi^2_{theoretical}$ at n-1 degrees of freedom and for a given risk. For p random, single and independent samples, with an equal number n, the test was performed by calculating the quantity:

$$\chi^2_{obs} = \frac{2.3026\ (n-1)\left[p\ \log\left(\frac{SCE}{p}\right) - \sum_{i=1}^{p} \log(SCE_i)\right]}{1 + \left(\frac{p+1}{3\ p\ (n-1)}\right)}$$

where:

- SCE_i = sum of the squares of the deviations at the mean for sample i,
- SCE = the sum of the SCE_i.

Table 5 presents the $\chi^2_{observed}$ values for both parts of the experiment, and calls for the following comments. When the pinch sampler was used, only the within-sampler variances for Mean Length of roller ginned samples were considered to be homogeneous. When the Universal sampler was used, only the Mean Length and the Uniformity index within-sample variances for roller ginned samples were considered to be homogeneous.

We were therefore unable to calculate a mean variance, so no value for mean confidence interval could be established. Four solutions to calculate confidence intervals are available :

1- note the mean and its standard deviation for each sample,
2- transform the individual data,
3- construct groups showing homogeneous variances,
4- do not take account of the x% with the highest variances and take the maximum of the remaining variances, i.e. (100-x) % as the basis for the calculation of the confidence intervals (figure 6).

The 1st solution is correct but each sample becomes a single case and it is impossible to determine the confidence intervals for the values obtained. The next two solutions present the advantage of being statistically faultless. However, they present the inconvenience of being impractical for the daily interpretation of results furnished by HVI analysis as it is difficult to determine beforehand the group to which the samples will belong in order to decide which operating procedure to use or establish the confidence interval for the mean observed.

The last solution proposes truncating the distribution; the variances retained for the calculation of the confidence intervals are, for example, the maximum values for 95 % of the samples analyzed. It should nevertheless be noted that this method maximizes the confidence intervals as the value for the variance taken into account (V_{ref}) is markedly higher than the mean of the variances (V_{mean}) observed (table 6 and figure 6).

The confidence intervals for the measurements were determined from these V_{ref} variances and the results obtained are presented in tables 7 to 10.

5 - Discussion:

The very significant results of the tests used to compare the distributions between the two ginning processes were expected as the saw produces better mixing of the fibers than roller ginning thanks to the rotation of the seed-cotton roll in front of the saw. This difference in the homogeneity of the samples was not entirely compensated by the manual mixing of the fibers before analysis.

A comb on the Universal sampler picks up fibers that stick through the holes in a metal plate. This carries them to a site where a pinch takes a sample. This device should have reduced the variability of the results as it takes a far more representative fiber sample than that taken by the pinch sampler. Our results suggest, however, that this is not the case. Several reasons such as the transfer between the comb and the pinch, the number of teeth in the comb, the distance between the comb and the metal plate, or the pressure exerted by the metal plate on the sample may explain this phenomenon. The measuring cells may be sensitive to varying degrees to the quality of the specimen.

However, the technique using the universal sampler is not far removed from that using the fibrosampler. We therefore took the raw data obtained during the development of the operating conditions on the ZUS 910B (Gourlot and Hequet 1994) to compare with the distributions of the within-sample variances. Although the ZUS machine was calibrated with ICCS cottons, it is still possible to compare UHML with SL 2.5 % and Strength HVICC with Strength ICCS multiplied by an average of 1.23 (Hequet 1994). This operation allowed us to compare concisely the data from the following measurement systems and samplers:

- MCI 3500 fitted with a pinch sampler,
- MCI 3500 fitted with a universal sampler,
- ZUS 910 B fitted with a fibrosampler.

Marked differences were noted between the distributions for the fibrosampler and the other two sampling methods, as illustrated in table 11 and figures 7 to 10.

The results show that a broader distribution is obtained for the within-sample variances when using the universal sampler than when using the pinch sampler. Furthermore, the within-sample variances obtained with both samplers are more broadly distributed than when the fibrosampler is used on the ZUS line. The number of values obtained per sample is therefore far higher with the Pinch and Universal Samplers. When cotton has been roller ginned, about 40 measurements are required per sample to reach the precisions given in table 2, and this regardless of the type of MCI sampler used. When cotton has been saw ginned, 20 samples are required using the pinch sampler whereas 40 are required by the universal sampler. As only small quantities of cotton are processed during varietal improvement, the requirement for a large number of measurements is therefore a handicap.

These results suggest that further studies should be conducted on seed-cotton of various origins and ginned using the two methods mentioned to discover the reasons for the differences observed. These results should allow us to gain a better understanding of the sampling mechanisms employed by the different samplers and propose modifications in the MCI sampling technique.

Bibliography:

Dagnélie P. - 1973 - "Théorie et méthodes statistiques" - Les presses agronomiques de Gembloux, A.S.B.L.

Gourlot J.-P. and Hequet E. - 1994 - "Recherche cotonnière : comment utiliser les chaines HVI (High Volume Instrument) en amélioration variétale? "-
Agriculture et Développement n 2 - Mai 1994 - pp. 39-43

Hequet E. - 1994 - "Cotton fiber technology : Agricultural research and development center at Las Torres-Tomejil, Alcala Del Rio Seville" - 9 May - 3rd June 1994.

Green C. C. and Culp T. W. - 1988 - "Utilization of fiber strength measurements in the development of high fiber strength cottons" - Proceeding Beltwide Cotton Conference, pp. 613 - 614.

Green C. C. and Culp T. W. - 1990 "Simultaneous improvement of yield, fiber quality, and yarn strength in Upland cotton" - Crop Sciences 30: pp. 66-69.

Mayfield W. - 1994 - "Module Averaging" - The Cotton and Oil Mill Press, October 1, p. 6.

Sasser P. - 1992 -"The repeatability of HVI data" - Proceedings of International Committee on cotton testing methods, Bremen March 10 - 11, appendix 12, pp. 1 - 5.

Taylor, R.A. - 1986 - "Cotton tenacity measurements with High Speed Instruments" -Textile Research Journal n 56-2, pp. 92 - 101.

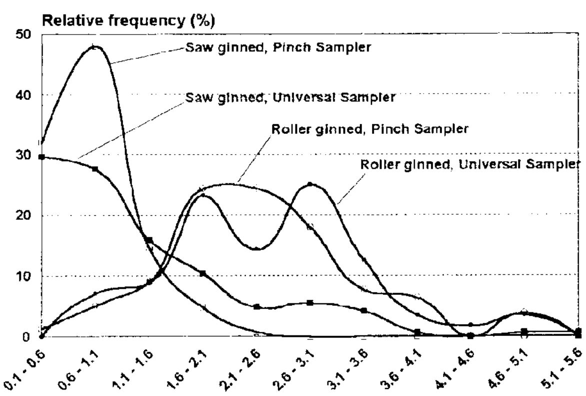

Figure 1: Pinch Sampler vs Universal Sampler, Roller vs Saw ginned samples - Mean Length: distribution of within-sample variances.

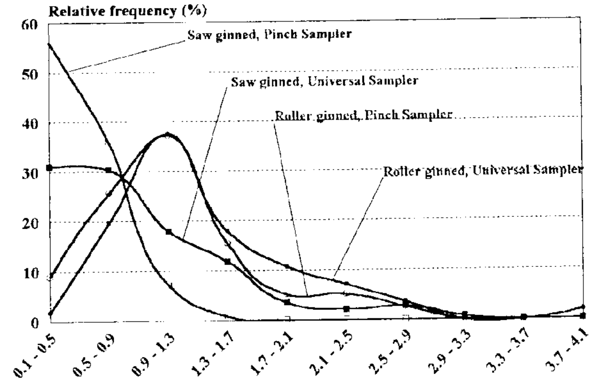

Figure 2: Pinch Sampler vs Universal Sampler, Roller vs Saw ginned samples - Upper Half Mean Length: distribution of within-sample variances.

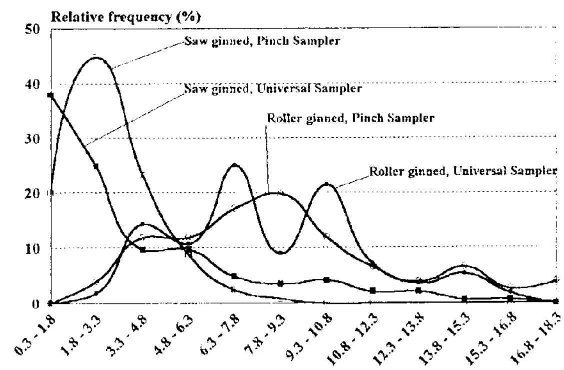

Figure 3: Pinch Sampler vs Universal Sampler, Roller vs Saw ginned samples - Uniformity Index: distribution of within-sample variances.

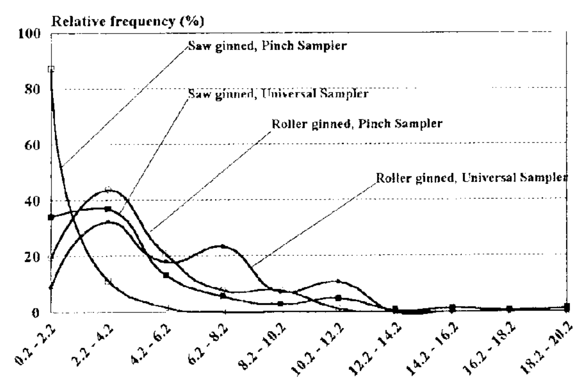

Figure 4: Pinch Sampler vs Universal Sampler, Roller vs Saw ginned samples - Strength: distribution of within-sample variances.

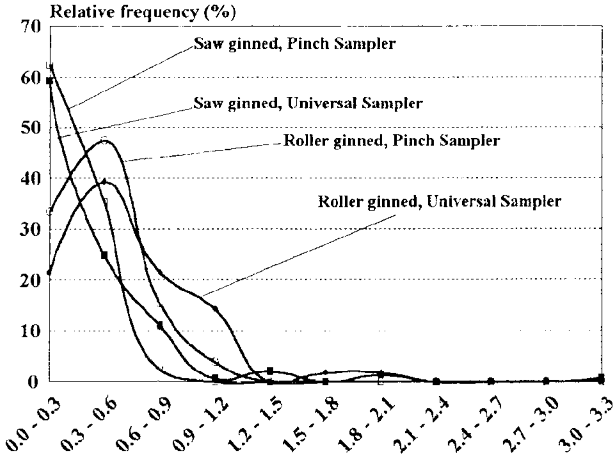

Figure 5: Pinch Sampler vs Universal Sampler, Roller vs Saw ginned samples - Elongation: distribution of within-sample variances.

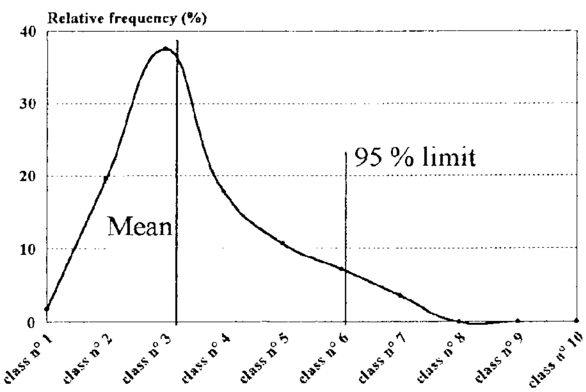

Figure 6: Choice of a variance limit on a within-sample variance chart: Mean or 95 % limit.

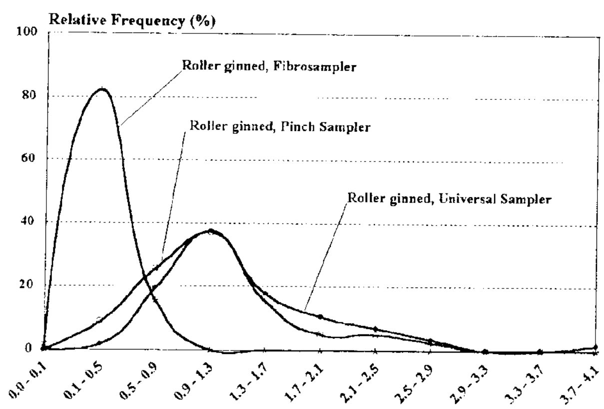

Figure 7: Pinch Sampler vs Universal Sampler vs Fibrosampler - Roller ginned samples - UHML: distribution of within-sample variances.

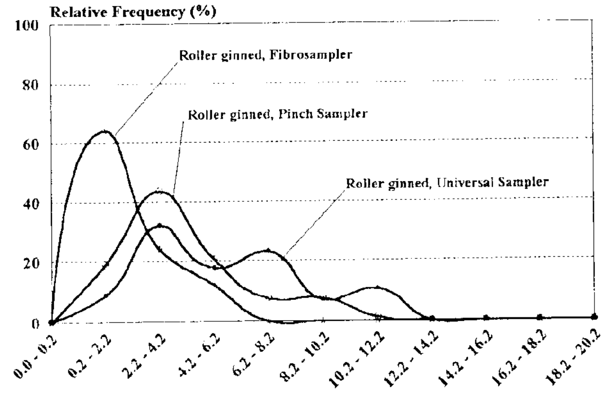

Figure 8: Pinch Sampler vs Universal Sampler vs Fibrosampler - Roller ginned samples - Strength: distribution of within-sample variances.

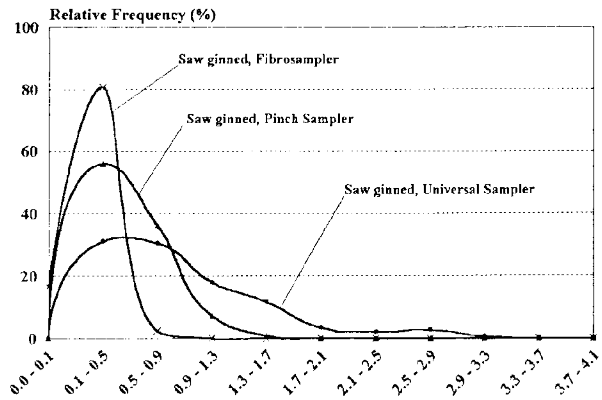

Figure 9: Pinch Sampler vs Universal Sampler vs Fibrosampler - Saw ginned samples - UHML: distribution of within-sample variances.

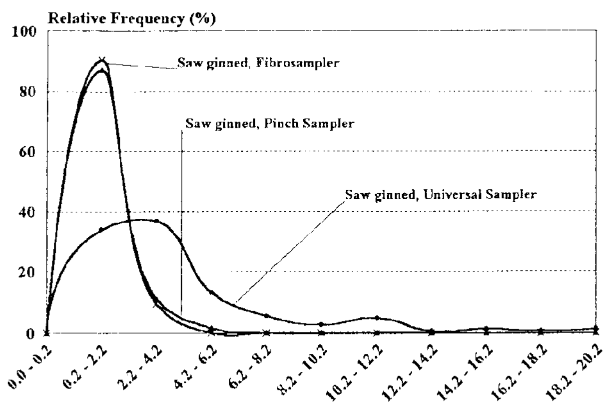

Figure 10: Pinch Sampler vs Universal Sampler vs Fibrosampler - Saw ginned samples - Strength: distribution of within-sample variances.

Table 1: repeatability of HVI results according to W. Mayfield: bale per bale (BB) versus module averaging (MA).

HVI measurement	Tolerance	BB	MA
Length	± 0.015 inch ± 0.38 mm	74 %	86 %
Length Uniformity	± 1.0 %	80 %	90 %
Strength	± 1.5 g/tex	69 %	79 %

Table 2: Tolerances set for varietal improvement.

HVI measurement	Tolerance
Lengths	± 0.02 inch ± 0.51 mm
Uniformity Index	± 1.5 %
Strength	± 1.0 g/tex

Table 3: Results of χ^2 comparison tests on the distribution of within-sample variances: effect of the ginning method.

A : Observed χ^2,
B : theorical χ^2,
C : Signification.
** = significant at α=0.01,
*** = significant at α=0.001.

	Pinch: Roller vs Saw			Universal: Roller vs Saw		
	A	B	C	A	B	C
ML	138.4	16.9	***	61.2	18.3	***
UHML	84.6	12.6	***	34.5	16.9	***
UI%	124.3	19.7	***	73.6	18.3	***
ST	97.8	11.1	***	27.8	15.5	**
EL	25.5	7.81	***	38.8	12.6	***

Table 4: χ^2 tests to compare the distributions between the pinch and universal samplers.

A : Observed χ^2,
B : probability at the 5% level,
C : Signification.
NS = Non significant,
* = significant at α =0.05,
** = significant at α=0.01,
*** = significant at α=0.001.

	Roller ginned samples			Saw ginned samples		
	A	B	C	A	B	C
ML	6.0	0.7346	NS	28.7	0.0014	**
UHML	6.5	0.6859	NS	39.7	0.0000	***
UI%	8.4	0.5859	NS	38.2	0.0000	***
ST	14.6	0.0117	*	81.3	0.0000	***
EL	9.9	0.1294	NS	15.7	0.0000	***

Table 5: Values for χ^2 observed.

NS = Non significant,
* = significant at α =0.05,
** = significant at α=0.01,
*** = significant at α=0.001.

Sampling device		Pinch Sampler		Universal Sampler	
Ginning process		Roller	Saw	Roller	Saw
Degrees of freedom		77	124	55	144
ML	χ^2	78.4	194.6	63.6	563.5
	Probability	0.4330	0.0000	0.1999	0.0000
	Significance	NS	***	NS	***
UHML	χ^2	118.7	197.14	75.6	440.0
	Probability	0.0016	0.0000	0.0340	0.0000
	Significance	***	***	*	***
UI%	χ^2	116.4	197.6	69.9	715.6
	Probability	0.025	0.0000	0.0855	0.0000
	Significance	***	***	NS	***
ST	χ^2	169.0	243.6	113.5	616.1
	Probability	0.0000	0.0000	0.0000	0.0000
	Significance	***	***	***	***
EL	χ^2	155.0	238.3	159.0	569.5
	Probability	0.0000	0.0000	0.0000	0.0000
	Significance	***	***	***	***

Table 6: mean and maximum variances observed for distributions truncated at 95 %.

Sampling device		Pinch Sampler		Universal Sampler	
Ginning process		Roller	Saw	Roller	Saw
ML	95 % variance	3.9	1.6	3.9	3.4
	Averaged var.	2.4	0.8	2.4	1.3
UHML	95 % variance	2.2	1.0	2.1	2.1
	Averaged var.	1.1	0.5	1.4	0.3
UI %	95 % variance	16.9	6.9	13.8	10.9
	Averaged var.	9.0	3.0	8.3	3.8
ST	95 % variance	8.9	2.7	11.4	11.1
	Averaged var.	4.1	1.4	5.7	4.1
EL	95 % variance	0.9	0.5	1.1	0.9
	Averaged var.	0.4	0.3	0.6	0.4

Table 7: Pinch sampler - Confidence intervals calculated from maximum variances observed on distributions truncated at 95% - Roller ginning - α risk = 5 %.
(* = calculation with averaged variances).

Numb.of readings		4	12	20	28	40
ML (*)	mm	± 1.5	± 0.9	± 0.9	± 0.7	± 0.6
UHML	mm	± 1.5	± 0.8	± 0.7	± 0.6	± 0.5
UI %	%	± 4.0	± 2.3	± 1.8	± 1.5	± 1.3
ST	g/tex	± 2.9	± 1.7	± 1.3	± 1.1	± 0.9
EL	%	± 0.9	± 0.5	± 0.4	± 0.3	± 0.3

Table 8: Pinch sampler - Confidence intervals calculated from maximum variances observed on distributions truncated at 95% - Saw ginning - α risk = 5 %.

Numb.of readings		4	12	20	28	40
ML	mm	± 1.2	± 0.7	± 0.6	± 0.5	± 0.4
UHML	mm	± 1.0	± 0.6	± 0.4	± 0.4	± 0.3
UI %	%	± 2.6	± 1.5	± 1.2	± 1.0	± 0.8
ST	g/tex	± 1.6	± 0.9	± 0.7	± 0.6	± 0.5
EL	%	± 0.7	± 0.4	± 0.3	± 0.3	± 0.2

Table 9: Universal sampler - Confidence intervals calculated from maximum variances observed on distributions truncated at 95% - Roller ginning - α risk = 5 %.
(* = calculation with averaged variances).

Numb.of readings		4	12	20	28	40
ML (*)	mm	± 1.5	± 0.9	± 0.8	± 0.7	± 0.6
UHML	mm	± 1.5	± 0.8	± 0.6	± 0.5	± 0.5
UI % (*)	%	± 2.8	± 1.6	± 1.3	± 1.1	± 0.8
ST	g/tex	± 3.3	± 1.9	± 1.5	± 1.3	± 1.1
EL	%	± 1.0	± 0.6	± 0.5	± 0.4	± 0.3

Table 10: Universal sampler - Confidence intervals calculated from maximum variances observed on distributions truncated at 95% - Saw ginning - α risk = 5 %.

Numb.of readings	4	12	20	28	40
ML	± 1.8	± 1.0	± 0.8	± 0.7	± 0.6
UHML	± 1.4	± 0.8	± 0.6	± 0.5	± 0.5
UI %	± 3.2	± 1.9	± 1.4	± 1.2	± 1.0
ST	± 3.3	± 1.9	± 1.5	± 1.2	± 1.0
EL	± 0.9	± 0.5	± 0.4	± 0.4	± 0.3

Table 11: χ^2 tests to compare the distributions.

A : Observed χ^2,
B : probability at the 5% level,
C : Signification.
NS = Non significant,
* = significant at α =0.05,
** = significant at α=0.01,
*** = significant at α=0.001.

	Roller ginned			Saw ginned		
	A	B	C	A	B	C
Pinch Sampler vs Fibrosampler						
UHML	42.4	0.0000	***	25.5	0.0000	***
ST	29.5	0.0000	***	0.79	0.6737	NS
Universal Sampler vs Fibrosampler						
UHML	46.8	0.0000	***	36.6	0.0000	***
ST	44.7	0.0000	***	42.3	0.0000	***