Selection Efficiency for Cotton Fiber Quality in Segregating Material by Different Instruments

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ABSTRACT

A breeding programme to develop varieties with a wide range of quality parameters to meet various end uses, requires rapid and accurate fiber quality assessment. This paper examines the potential of instruments to provide data for the selection of fiber quality parameters. Segregating genetic material (F_2) from five intra-specific crosses was tested for fiber length, fineness, maturity and strength with the Fibrograph, Pressley, Fibronaire, High Volume Instrument (HVI) and Advanced Fiber Information System (AFIS). The variability of the coefficient of variation (CV) served as the criterion for testing the reproducibility and the accuracy of the measurements. The results proved that for length parameters the Fibrograph and for strength the Pressley tester were the most appropriate. The AFIS gave better estimations of fineness and maturity. The use of laboratory instruments for most of the fiber properties is suggested on the basis of these results. Nevertheless the choice may depend on other parameters such as the range of characters measured and cost effectiveness.

Introduction

The accuracy of the measurement of quantitative and qualitative parameters is a priority for breeders to increase selection efficiency. This factor, although not a term of the general equation $R=\sigma_P \cdot h^2 \cdot i$, which gives the expected response to direct selection (Falconer, 1981) or any similar equation, is an important element in the efficiency of selection. Instruments that measure parameters accurately help in effective improvement. Non significant differences may prove significant if the accuracy of the instruments is improved. The measurement of the variability of quantitative characteristics in segregating generations is relatively easy. Conversely, the measurement of qualitative characteristics is difficult, depending partly on the accuracy of current technology.

The quality of cotton determines its commercial value. Recently, important progress has been made in developing specific technology for the assessment of fiber quality. High Volume Instruments (HVI) and Advanced Fiber Information Systems (AFIS) have increased the speed of evaluation of basic quality parameters in cotton. The instruments were developed for quality evaluation of commercial production but they are also used in breeding programmes to evaluate fiber parameters in segregating generations. Their main advantage is the high speed of operation but this raises questions as to their accuracy compared to laboratory instruments. If the results are comparable, the new instruments could possibly increase the effectiveness of the selection process. In some characteristics such as strength, results from studies show that the new instruments are not always appropriate for the accurate evaluation in segregating genetic material. Howle *et al.* (1995) reported that the HVI is not reliable for strength measurements in breeding programmes and suggested that breeders continue to rely on the Stelometer until the problem of strength measurement on HVI is resolved. Differences in the measurements of strength with HVI and Stelometer may be resolved by the current development of new high volume instrumentation (Taylor, 1994).

This study compared length, fineness-maturity, and strength measurements on laboratory instruments with high volume instruments to determine their accuracy and reliability when used in segregating genetic material (F_2 generation) of five crosses.

Materials and methods

Cotton samples were taken from F_2 generation of 5 intra-specific crosses (951022 x 821227/695a (CIRAD-CA No 132 x Corina), 951027 x 88422/704a (N703 x Eva), 951030 x 92295/706a (N732 x 88450), 951032 x 94959/708b (N732 x 2PE), 951034 x71042-57/713a (N733 x AcSJ1), in order to be evaluated for their quality parameters. Every F_2 consisted of 192 plants, grown in the same conditions as used during selection.

The samples were taken from the whole plant and after blending, each one was separated in three equal parts, in order to be tested in three different ways. The samples were acclimatized for 24 hours and then the characteristics of 2.5% and 50% span length, uniformity, fineness-maturity and strength were measured. Assessment of length was on a Fibrograph No 530, fineness-maturity on a Fibronaire and strength on a Pressley Fiber Strength Tester No 2041. The HVI-900 Model 109 and AFIS-Version 4.1-396 were used for speed testing of fiber quality.

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The accuracy of measurements performed by any instrument during the evaluation of segregating genetic material was based on the estimation of variation. The comparison of the variations, with F-criteria, gives reliable results, when the measurements use the same scale. In this case however there were different scales and therefore the statistical parameter Coefficient of Variation (CV), expressing variation as a percentage of the mean, solved this problem.

The measurements were performed on three different instruments in five different F_2 generations that were regarded as replications. The CVs were estimated and the variation of coefficients was analyzed and compared with the Least Significant Difference (LSD .05) to determine the best evaluation method of fiber quality in segregating genetic material. Lower coefficient of variation means lower variability in measurements and therefore greater accuracy and ability to detect significant difference.

In addition to test for significance of differences between measurements done in different ways, significant differences were also tested between the five F_2 generations to determine if there were significant group (replication) differences.

Results and discussion

The results show that there were large differences between the mean of the length in all F_2 generations in material under test (Table 1). The F_2 No 3 generation, for example, has a mean for 2.5% length of 31.63 mm, while the F_2 No 4 of 26.33mm (Fibrograph). The variations of the 50% length in the studied genetic material were also large. The F_2 No 4 had a mean of 19.20 mm while the F_2 No 3 was 26.52 (AFIS). Similar results were found in the values of length uniformity with F_2 No 4 giving a mean of 44.32 and F_2 No 3, 56.58 (AFIS).

The results of the analysis of variation of the CV values in these five F_2 generations show significant differences (significance level P 0.01) in the 2.5% and 50% span length and uniformity (Table 2a, b and c). Conversely, in all cases no significant differences were found between groups (F_2 generations). Thus the genetic material did not affect the measurements and the accuracy of each instrument was the same.

Table 3 shows the means of the CV's and their comparison with the LSD 0-05. The means with the same letter do not differ statistically. The CV for 2.5% length values in the segregating F_2 material as measured on the Fibrograph was significantly lower than that of the HVI and the AFIS instruments. The measurements in the same plants and in the same samples on the HVI and AFIS had significantly higher CV values but differences in CVs between these instruments was not significant.

Similar results were obtained in tests on the other length parameters, 50% span length and uniformity (Table 3). The measurements of the 50% length and uniformity of the length with the laboratory Fibrograph, had the lowest CV, meaning that it can reveal smaller differences in the segregating genetic material. The variation between measurements on HVI and AFIS was the similar with no significant differences between means of the CVs (Table 3).

Table 3 shows the values of the five F_2 generations of fineness-maturity and strength show variability of the micronaire value ranging from 3.55 to 4.95 (Table 5a and b). AFIS fineness ranged from 121.20 to 168.40 mTex and maturity from 0.68 to 0.81. Pressley showed a relatively low variation of the F_2 means, ranging from 7.99 to 8.71. HVI strength values ranged from 23.64 to 29.63 gram/Tex.

The results from the analysis of variation of the CV values show significant differences (P=0.01) in the fineness-maturity and strength (Table 5a and b). No significant difference was observed between the groups of five F_2 generations. Thus the genetic material does not affect the measurements and the instrument accuracy is the same. Table 6 shows the comparison of means of the CV values

The Fibronaire and HVI fineness-maturity test showed no significant differences in the coefficients of variation. Thus these instruments have the same accuracy and both can be efficiently used in the selection procedure during the F_2 generation

The two AFIS values are of fineness and maturity respectively. The coefficients of variation show no significant differences, leading to the conclusion that the selection of those two properties in segregating genetic material is equally accurate. There were significant differences between CV values found by the micronaire and AFIS measurements (Table 6). The AFIS measurements give higher accuracy in assessing fineness-maturity with significantly lower CV values. This is important for selection as more accurate measurements increase efficiency.

Fiber strength was assessed on the Pressley Strength Tester and HVI. AFIS has no comparable instrument. Significant differences were found in CVs of these tests. The variability of Pressley Tester was much lower than that of the HVI, indicating that Pressley is more reliable than HVI. Similar results were obtained in studies in which yarn strength was related to fiber strength as measured on the Pressley Strength Tester and HVI (Howle *et al.*, 1995).

The results show that for the 2.5% and 50% span length and uniformity ratio, the Fibronaire No 530 gave more accurate results than the HVI or the AFIS. The AFIS had greater accuracy for fineness-maturity while strength measured with the Pressley Tester had less variability and higher accuracy than the HVI.

It would be easy to decide on the most suitable instruments to evaluate qualitative characteristics of

fiber in segregating generations if accuracy were the only criterion. However, the speed of the measurements and therefore the cost plays an important role in these decisions. Furthermore, the new instruments are capable of measuring additional quality parameters at the same time, making the quality evaluation more complete. Taking all this into account the breeder may have to choose between accuracy and speed or cost.

References

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Table 1. Mean of 2.5% and 50% fiber length and uniformity of F_2 generations.

Genetic material	Fiber length 2.5%			Fiber length 50%			Uniformity		
	F. 530*	HVI**	AFIS***	F. 530	HVI	AFIS	F. 530	HVI	AFIS
F_2 No 1	31.53	33.09	41.00	15.50	16.41	20.23	47.68	48.86	50.23
F_2 No 2	30.90	33.14	40.20	16.10	17.51	23.32	50.33	51.12	55.26
F_2 No 3	31.63	33.23	41.34	16.20	18.05	26.52	51.45	52.29	56.58
F_2 No 4	26.33	27.65	35.36	15.12	15.40	19.20	47.55	44.80	44.32
F_2 No 5	28.56	29.33	37.56	14.41	16.04	22.24	48.96	49.63	51.57

* F.530, Fibrograph No 530
** HVI, High Volume Instrument 900 Model 109
*** AFIS, Advanced Fiber Information System Version 4.1 - 396

Table 2. Analysis of variation of fiber length 2,5% and 50% and uniformity of F_2 generations.

a. Fiber length 2.5%

Source of Variation	df	MS	F-experimental	F-critical	
Type of measurements	2	2.11	7.59	4.45	**
Groups (F_2 generations)	4	0.04	0.13	3.83	Ns
Error	8	0.276			

b. Fiber length 50%

Source of Variation	df	MS	F-experimental	F-critical	
Type of measurements	2	18.69	39.62	4.46	**
Groups (F_2 generations)	4	0.62	1.32	3.83	Ns
Error	8	0.471			

c. Uniformity

Source of Variation	df	MS	F-experimental	F-critical	
Type of measurements	2	19.91	35.21	4.45	**
Groups (F_2 generations)	4	1.04	1.83	3.83	Ns
Error	8	0.565			

Table 3. Mean values of fibrograph, HVI and AFIS coefficient of variation (CV) in fiber length 2,5%, 50% and uniformity, in segregating generations.

Instrument	Fiber length 2.5%	Fiber length 50%	Uniformity
Fibrograph	1,28 a	5,35 a	5,84 a
HVI	2,31 b	8,41 b	9,24 b
AFIS	2,48 b	9,03 b	10,01 b
LSD_{05}	0,767	1,001	1,096

Table 4. Mean values of fineness, maturity and strength of F_2 generations.

Genetic Material	Fibronaire	HVI	Fineness[1]	Maturity[2]	Index	gms/tex
F_2 No 1	3,55	3,60	121,20	0,76	8,16	26,40

F_2 No 2	4,16	4,18	160,20	0,81	8,34	24,15
F_2 No 3	4,21	4,30	167,50	0,78	8,71	27,25
F_2 No 4	4,95	4,85	168,40	0,74	8,01	29,63
F_2 No 5	3,92	3,90	154,80	0,68	7,99	23,64

1 Militex
2 Maturity Ratio

Table 5. Analysis of variation of fineness-maturity and strength of F_2 generations.

a. Fineness - maturity					
Source of Variation	df	MS	F-experimental	F-critical	
Type of measurements	3	99,72	31,61	3,49	**
Groups (F_2 generations)	4	0,61	0,19	3,25	ns
Error	12	3,155			
b. Strength					
Source of Variation	df	MS	F-experimental	F-critical	
Type of measurements	1	14,54	39,63	7,71	**
Groups (F_2 generations)	4	0,28	0,76	6,39	ns
Error	4	0,367			

Table 6. Mean values of coefficient of variation (CV) in fiber fineness-maturity and strength, in segregating generations, with laboratory Fibronaire, HVI and AFIS.

Instrument	Fineness-maturity	Strength
Laboratory	14,94 a	4,51 a
HVI	17,80 a	6,92 b
AFIS (Fineness)	10,29 b	
AFIS (Maturity)	7,91 b	
LSD 05	2,448	1,064

Means, followed by the same letter were not different.