Gin Machinery[1] Influence on Cotton Quality and Value

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ABSTRACT

Studies involving moisture levels, gin machines and types of cotton were conducted to assess their impact on cotton market value and fiber properties after processing with various gin machinery sequences. Bale values ranged from $357.13 for the standard machine sequence to $404.10 for the extractor-feeder/gin stand only sequence for cultivar DPL 50 cotton. The predominate optimum sequence for the hairy-leaf cottons was stick machine, extractor-feeder/gin stand and two lint cleaners. The smooth-leaf cottons required fewer cleaning machines to maximize monetary returns and also provided higher returns than hairy-leaf cottons. Short fiber content and neps were dramatically lower when fewer machines and less drying was used. Using fewer machines than the currently recommended machine sequence indicated more profits and resulted in other fiber quality factors that were more desirable than the standard machine sequence. Selecting the optimum machine sequences increased monetary values from $12.22 to $20.85 per bale and averaged $16.72 per bale.

Introduction

In addition to its principal function of separating lint from seed, a cotton gin is equipped to remove a large percentage of foreign matter from the cotton that would significantly reduce the value of the ginned lint. As a result of recommendations developed by the U.S. Department of Agriculture, most spindle-harvested cotton in the United States is processed through a standard machinery sequence that includes a dryer, cylinder cleaner, stick machine, dryer, cylinder cleaner, extractor-feeder, gin stand and two lint cleaners (Cotton Ginners Handbook, 1994). This sequence is used regardless of the trash and moisture levels or cleaning difficulty of the cotton. The combination of gin machines that produced a satisfactory compromise of cotton quality and producer monetary returns most of the time was used to establish recommended sequences.

Cotton cleaning machines in gins are generally divided into two categories--seed cotton cleaning and lint cleaning. Seed cotton cleaners are cylinder cleaners, stick machines, and extractor-feeders. The cylinder cleaner consists of 6 or 7 revolving spiked cylinders that rotate at 400 to 5010 r/min. The stick machine removes larger foreign matter such as burs (carpel walls) and sticks from the cotton. Stick machines use the centrifugal force created by saw cylinders rotating at 300 to 400 r/min to sling off foreign material while the seed cotton is retained by the saw. The extractor-feeder located above the gin stand meters seed cotton uniformly to the gin stand at controllable rates, seed cotton cleaning being a secondary function. Cotton enters the gin stand that consists of spaced ribs and saws that pass between the ginning ribs at the ginning point. In the lint cleaner, cotton is held by saws and scrubbed by grid bars.

Processing cotton to minimize fiber damage and maximize returns requires a thorough understanding of the performance characteristics of machinery combinations. Instrument classification of ginned lint has gained acceptance in the world market for upland cotton (*Gossypium hirsutum* L.) and became mandatory for all cotton produced in the USA, being included in the Commodity Credit Corporation loan program after 1990. There is increased emphasis on the impact of cleaning and ginning machinery on the market quality of cotton as determined by High Volume Instrument (HVI) system.

Performance characteristics of individual gin machines have been studied by numerous researchers (Anthony, 1983, 1984a, 1990, 1991, 1994, 1996; Read and Kirk, 1977; Baker, 1978; Wesley and Anthony, 1979; Chen *et al.*, 1980; Anthony, *et al.*, 1982; and Barker and Baker, 1986). Anthony (1984b) developed a computer simulation model to predict the response of 13 physical characteristics of ginned lint. The model was based on linear algorithms and written in BASIC for use with an MS-DOS compatible microcomputer. The computer simulation model allows rapid graphical evaluation of the response of cotton properties to gin machinery. Much of the previous research focuses on the

[1]Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

performance of individual machines and not combinations of machines as they are typically used.

The purpose of this study was to develop the performance characteristics of combinations of cotton gin machinery in terms of fiber quality and value.

Material and Methods

The study evaluated various combinations of moisture and cotton processed with several machinery sequences. The basic procedure for determining the influence of combinations of items of gin equipment on cotton quality and value consisted essentially of ginning with only the extractor-feeder/gin stand as the base and adding the other equipment to that base. Specifically, the following machine treatments were considered:

1) Extractor-feeder/gin stand only
2) Cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand
3) Extractor-feeder/gin stand and one lint cleaner
4) Cylinder cleaner, extractor-feeder/gin stand, and one lint cleaner
5) Cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand, and one lint cleaner
6) Extractor-feeder/gin stand and two lint cleaners
7) Stick machine, extractor-feeder/gin stand and two lint cleaners Recommended or standard (cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand and two lint cleaners)

Samples were taken before seed cotton cleaning (wagon), after seed cotton cleaning (feeder), and after lint cleaning to determine the characteristics of the seed cotton as well as the characteristics of the lint cotton. Fractionation (foreign matter determination of seed cotton), lint foreign matter by the Shirley Analyzer procedure (ASTM, 1981), moisture, and seed-coat fragment content were determined by the cotton testing lab in Stoneville, MS (Shepherd, 1972). Neps were determined by the AFIS-N and fiber length distributions were determined by the Peyer AL-101 at the Stoneville lab. HVI and Smith-Doxey classifications were done by the Agricultural Marketing Service after conditioning for 48 hours (USDA, 1994). Bale values were based on the 1994 Commodity Credit Corporation loan schedule at Greenwood, MS. The study was conducted and analyzed as a completely random design within each moisture level with a factorial arrangement of treatments. Analyses were performed at the 0.05 and 0.01% levels of probability (SAS, 1988).

In addition to the eight machine treatments, three moisture levels and six cottons (some smooth-leaf and hairy-leaf varieties) were used in the study and all were replicated three times. The varieties of cotton used were DES 119 (cottons 1, 2, and 3, a hairy-leaf variety) and DPL 50 (cotton 4, 5, and 6, a smooth-leaf variety). The three moisture levels were achieved by using no drying for the high level, two dryers at 49-60^{o}C (120^{o}-140^{o}F) for the medium level and using two dryers at 107^{o}C-121^{o}C (225^{o}-250^{o}F) for the low level. These temperatures were measured at the second shelf of the tower dryer. No heat was applied prior to entry into the dryer. The cotton was conditioned for 48 hours on racks at 55% relative humidity and 21^{o}C (70^{o}F) before the study began.

Results and Discussion

Analyses of variance for the dependent variables are given in tables 1, 3, 5, and 7; the respective means are presented in tables 2, 4, 6, and 8.

Moisture

Wagon moisture averaged 8.5% overall and was 9.5, 8.2, and 7.7%, respectively, for the high, medium and low moisture levels (Table 2). Lint moisture averaged 5% overall and was 6.6, 5.0 and 3.4%, respectively, for high, medium and low levels.

Seed Cotton Foreign Matter

Wagon fractionation averaged 4.1% and was significantly different only for cotton. Feeder fractionation total averaged 2.7% and was 3.0, 2.7, and 2.5%, respectively, for the high, medium and low moisture levels. The feeder fractionation was significantly different for machine, moisture, cotton and the interaction between moisture and cotton. Feeder fractionation ranged from a high of 3.3% where no precleaning was used to a low of 2.2% when the standard cylinder cleaner, stick machine and cylinder cleaner were used as precleaners.

Lint Turnout

Lint turnout was significantly different for machine, moisture, cotton and the interactions machine x cotton and moisture x cotton (Table 5). From an overall standpoint, turnout ranged from 34.74% for the standard treatment to 37.25% for the extractor-feeder/gin stand only (Table 6). From a turnout change standpoint with extractor-feeder/gin stand only as the base, the standard precleaning sequence reduced turnout by 0.74%, one lint cleaner reduced turnout by 1.77% and two lint cleaners reduced turnout by 2.28%, while the standard sequence reduced turnout by 2.51%. For the sequences used in this study, this would be 4.87 kg (10.83 lb) to 17.36 kg (38.57 lb) of material (cotton and trash) based on a 680 kg (1,500-lb) initial weight of seed cotton.

Manual Classification

Manual classification of lint grading was considered as color grade and leaf grade. The color grade was converted to the USDA grade index which uses 94 as the index for color grade 41 and 100 as the index for color grade 31 and scales other color grades in a similar fashion. Machine, moisture, cotton, and the machine x cotton, cotton x moisture interactions were all significant for color grade index (Table 5). The color

grade index ranged from a high of 99.8 for the standard treatment to a low of 92.1 for the extractor-feeder/gin stand treatment (Table 6). One lint cleaner increased the color grade index from 92.1 up to 97.8. The addition of the second lint cleaner increased the color grade index to 99.3.

Leaf grade by the cotton classer was significantly influenced by machine, moisture, cotton and the interaction between machine and cotton. Leaf grade ranged from a high of 5.0 for the extractor-feeder/gin stand treatment to a low of 2.5 for the standard treatment. With the exception of the cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand, and one lint cleaner treatment and the extractor-feeder/gin stand and two lint cleaner treatment, each treatment was significantly different from the others. Manual leaf grade was significantly affected by moisture content; leaf grade was 3.8, 3.5 and 2.9, respectively, for high, medium and low moisture contents.

High Volume Instrument Classification

The color grade index based on HVI determinations was significantly affected by machine, moisture, cotton, machine x cotton, moisture x cotton, and machine x cotton x moisture (Table 3). Reflectance (Rd) was significantly different for machine, moisture, cotton, machine x cotton, and moisture x cotton. Means ranged from 75.2 for the standard treatment to 70.3 for the extractor-feeder/gin stand only treatment (Table 4). For yellowness (plus b), machine, moisture, cotton, and the cotton x moisture and machine x cotton interactions all significantly influenced plus b. Plus b ranged 8.6 for standard machine sequence to 8.0 for the extractor-feeder/gin stand alone.

For trash as measured by HVI, all primary variables as well as the two-way interactions significantly influenced HVI trash. High volume instrument trash was 0.79, 0.60, and 0.43 percent area, respectively, for high, medium, and low moisture contents. Means ranged from a high of 1.26% for the extractor-feeder/gin stand only treatment down to 0.32% for the standard treatment. Uniformity was significantly affected by machine, moisture, and cotton. Uniformity was 83.5 for the high moisture content as compared to 82.5 for the low moisture content. Means ranged from 83.8 for the cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand treatment to 82.5 for the standard treatment. Fiber length was significantly different for moisture, machine, and cotton. Means ranged from a high of 28.96 mm (1.14 in.) for the extractor-feeder/gin stand only treatment down to 28.19 mm (1.11 in.) for the treatments involving two lint cleaners. Strength was significantly influenced by machine, moisture, and cotton as well as the cotton x moisture interaction. Means ranged from a high of 29.4 g/tex for the extractor-feeder/gin stand treatment to 28.8 g/tex for the treatments with two lint cleaners as well as the cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand, and one line cleaner treatment. The moisture content at ginning significantly affected the strength of the fiber as measured by the HVI system several weeks later. The strength in grams/tex was 29.6, 29.1 and 28.3, respectively, for high moisture, medium moisture, and low moisture cotton.

Shirley Analyzer

The total waste in the gin lint samples as measured by the Shirley Analyzer was significantly different for machine, moisture, cotton, machine x moisture, machine x cotton, and cotton x moisture (Table 1). Means ranged from 6.5% for the extractor-feeder/gin stand only to about 2.8% for the treatments with two lint cleaners (Table 2). The total waste content was 4.5% for high moisture as compared to 3.3% for low moisture. The visible waste based on the Shirley Analyzer ranged from a high of 4.8% for the extractor-feeder/gin stand only treatment to a low of 1.3% for the standard machine sequence.

Fiber Length Distribution

The short fiber content by number was significantly impacted by machine, moisture and cotton as well as the interaction between cotton and moisture (Table 7). Short fiber content by number was 20.3, 16.8, and 12.4%, respectively, for the low, medium, high moisture contents (Table 8). The short fiber content by number ranged from a low of 12.5% for the extractor-feeder/gin stand only treatment to a high 19.5% for the standard sequence. The mean fiber length by number as determined by the Peyer instrument, was significantly different for machine, moisture, cotton, and moisture x cotton. Mean fiber length ranged from a high of 20.83 mm (0.82 in.) for the extractor-feeder/gin stand only treatment to a low of 19.30 mm (0.76 in.) for the standard treatment.

Machine, moisture, cotton and the interaction between moisture and cotton were significant for the short fiber content by weight (Table 7). Means ranged from 9.9% for the extractor-feeder/gin stand the two lint cleaners and the standard treatment to 6.2% for the extractor-feeder/gin stand only treatment (Table 8). Short fiber content by weight was 10.5, 8.4, and 6.0%, respectively, for the low, medium, and high moisture contents.

Neps

The number of neps per gram of lint cotton was significantly influenced by machine, moisture, cotton, machine x moisture and machine x cotton (Table 7). The number of neps ranged from 226 per gram for the standard treatment to 138 for the extractor-feeder/gin stand only treatment (Table 8). The number of neps was much higher for low moisture content (217) than for medium (181) or high moisture content (154).

Value

Monetary value was significantly affected by all factors except the three-way interaction (Table 5). For machines, value ranged from $371.52 per bale for the stick machine, extractor-feeder, two lint cleaner treatment to $377.70 for the cylinder cleaner, extractor-feeder, one lint cleaner treatment (Table 6). These were not the optimum sequences for each cotton because of the significant machine x cotton interaction. Selecting the optimum machine sequence for each cotton increased monetary returns to the farmer by $16.72 per bale and ranged from $12.22 to $21.35/bale. These differences were not evident in means across all cottons because the optimum machine sequence differed for each cotton. The standard machine sequence yielded the highest monetary returns only for cotton 1. The value of the medium moisture cotton was higher than that of the cotton at low or high moisture. Cotton 5 had the highest monetary value, primarily because of the high lint yield (turnout) per unit of seed cotton. Smooth-leaf cottons required fewer cleaning machines to maximize monetary returns and provided higher returns than hairy-leaf cottons.

Conclusion

In most cases, fewer machines than are currently recommended were the most profitable and most of the other fiber quality factors were higher. The differing results in terms of machinery sequence recommendations suggest that each cotton must be ginned on to its own merits to maximize profits and maintain fiber quality. Selection of the optimum sequence for different cottons can be accomplished with an automated process control system developed by Anthony *et al.*, (1995). Processing cotton to achieve optimum monetary value improves fiber quality parameters such as short fiber and neps.

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Table 1. Analyses of variance for foreign matter and moisture.

Source of variation	DF	Mean squares for foreign matter				MS for moisture	
		Seed Cotton[1]		Lint cotton[2]			
		Wagon	Feeder	Total	Visible	Wagon	Lint
Machine	7	4.34	13.47**	101.54**	80.08**	0.89	0.29**
Cotton	5	14.89**	21.30**	50.86**	47.19**	12.53**	1.27**
Moisture	2	9.45	10.31**	53.19**	52.09**	126.16**	385.59**
Machine*Cotton	35	9.45	0.20	1.74**	1.53**	0.53	0.07
Machine*Moisture	14	4.56	0.23	1.73**	1.50**	0.37	0.04
Cotton*Moisture	10	3.32	0.49*	1.54**	1.25**	0.67	0.50**
Machine*Cotton*Moisture	70	5.58	0.21	0.33	0.20	0.77*	0.02
Error	297	4.59	0.18	0.48	0.33	0.56	0.06

* Significant at the 5% level of probability
** Significant at the 1% level of probability
[1] Based on fractionation
[2] Based on Shirley Analyzer

Table 2. Means for foreign matter (%) and moisture (%).

	Foreign Matter				Moisture	
	Seed cotton		Lint cotton			
	Wagon	Feeder	Total	Visible	Wagon	Lint
Machine						
EFGS	4.5a	3.3a	6.54a	4.78a	8.6a	5.0dc
CC;SM;CC;EFGS	4.1a	2.2c	5.26b	3.61b	8.6a	5.1a
EFGS; 1LC	4.4a	3.2a	3.76c	2.27c	8.6a	4.9dc
CC;EFGS;1LC	4.3a	2.8b	3.61c	2.18c	8.4a	5.0bc
CC;SM;CC;EFGS;1LC	3.9a	2.2c	3.22d	1.80d	8.3a	5.1ba
EFGS;2LC	3.7a	3.2a	2.90e	1.56e	8.5a	4.9dc
SM;EFGS;2LC	3.8a	2.8b	2.89e	1.53e	8.5a	5.0dc
CC;SM;CC;EFGS;2LC	3.9a	2.2c	2.65e	1.32f	8.3a	4.9d
Moisture						
Low	4.3a	2.5c	3.27c	1.80c	7.7c	3.4c
Medium	3.8a	2.7b	3.81b	2.35b	8.2b	5.0b
High	4.1a	3.0a	4.47a	2.99a	9.5a	6.6a
Cotton						
1	4.7a	3.3a	4.89a	3.34a	9.0a	5.2a
2	4.3ba	3.0b	4.15c	2.75c	7.9d	4.9dc
3	4.3ba	3.4a	4.68b	3.16b	8.3c	5.1b
4	3.9bc	2.4d	3.26d	1.74d	8.6b	4.9c
5	3.9bc	2.0e	2.97e	1.54e	8.2c	4.8d
6	3.4c	2.5c	3.15ed	1.72d	8.7c	5.0b

Table 3. Analyses of variance for high volume instrument measured variables.

		Mean squares for high volume instrument classification			
Source of variation	DF	Color grade index	Rd	+b	Strength
Machine	7	489.09**	154.62**	1.74**	5.09**
Cotton	5	329.39**	273.73**	10.75**	62.59**
Moisture	2	107.39**	22.66**	1.54**	66.14**
Machine*Cotton	35	10.26**	1.11**	0.12**	0.58
Machine*Moisture	14	2.51	0.30	0.08	0.46
Cotton*Moisture	10	9.02**	6.53**	0.14*	0.92*
Machine*Cotton*Moisture	70	5.14**	0.63	0.05	0.53
Error	297	3.39	0.57	0.06	0.48

* Significant at the 5% level of probability
** Significant at the 1% level of probability

Table 3. Analyses of variance for high volume instrument measured variables - continued.

Source of variation	DF	Mean squares for high volume instrument classification			
		Trash, % area	Length, x1000	Uniformity	Micronaire x 1000
Machine	7	5.83**	4.97**	13.29**	23.33*
Cotton	5	4.84**	31.83**	32.13**	3107.88**
Moisture	2	4.86**	30.12**	41.14**	6.74
Machine*Cotton	35	0.17**	0.13	0.39	7.12
Machine*Moisture	14	0.09**	0.09	0.37	7.50
Cotton*Moisture	10	0.21**	0.18	0.56	54.29*
Machine*Cotton*Moisture	70	0.01	0.12	0.351	3.26
Error	297	0.20	0.11	0.3310	5.87

* Significant at the 5% level of probability
** Significant at the 1% level of probability

Table 4. Means for high volume instrument measured variables.

	Color grade index	Rd	+b	Strength g/tex	Trash, % area	Length mm (in)	Uni-formity	Micro-naire
Machine								
EFGS	89.6e	70.3f	8.0e	**29.39a**	1.26a	**28.96 (1.14)a**	83.6b	4.81a
CC,SM,CC,EFGS	92.8d	72.0e	8.3d	**29.39a**	0.92b	**28.70 (1.13)ba**	**83.8a**	4.80a
EFGS,1LC	95.4c	73.8d	8.4bc	29.05b	0.60c	28.45 (1.12)cb	83.1c	4.78b
CC,EFGS,1LC	96.5b	74.2c	8.5bc	29.09b	0.51d	28.45 (1.12)c	82.9c	4.82ba
CC,SM,CC,EFGS,1LC	96.5b	74.3c	8.4c	28.81c	0.45e	28.45 (1.12)b	83.0c	4.78b
EFGS, 2LC	**97.6ab**	74.8b	**8.5a**	28.73dc	0.39f	28.19 (1.11)d	82.6d	4.83a
SM,EFGS,2LC	**97.9a**	74.8b	**8.5ab**	28.56d	0.38f	28.19 (1.11)d	82.6d	4.81ba
CC,SM,CC,EFGS,2LC	**98.1a**	**75.2a**	**8.6a**	28.80dc	**0.32g**	28.19 (1.11)d	82.5d	4.83a
Moisture								
Low	**95.9a**	**74.0a**	8.4b	28.26c	0.43c	28.19 (1.11)c	82.5c	4.80a
Medium	**96.2a**	73.8b	8.5b	29.10b	0.60b	28.19 (1.12)b	83.0b	4.81b
High	94.6b	73.3c	8.3b	**29.58a**	0.79a	**28.96 (1.14)a**	**83.5a**	4.82c
Cotton								
1	92.9d	73.1f	**8.9a**	**29.93a**	0.93a	28.96 (1.14)b	83.4b	4.49e
2	95.5c	73.1d	8.6b	29.60b	0.70c	28.70 (1.13)c	83.5b	4.68d
3	93.2d	71.8e	8.6b	29.73b	0.85b	**29.21 (1.15)a**	**83.8a**	4.77c
4	96.2b	74.7c	8.1d	27.60e	0.40d	27.94 (1.10)e	82.2d	4.85b
5	**97.7a**	**76.2a**	7.9e	28.31d	0.32e	27.94 (1.10)e	82.3d	5.02a
6	**97.8a**	75.0b	8.5c	28.68c	0.42d	28.19 (1.11)d	82.8c	5.03a

Bold indicates most desirable values for machine treatments, if appropriate.

Table 5. Analyses of variance for manual classification, turnout, and value.

Source of variation	DF	Mean squares				
		Color grade index	Classers' leaf grade	Staple length	Turnout	Value
Machine	7	446.64**	36.35**	4.57**	43.02**	260.43**
Cotton	5	137.14**	74.74**	29.88**	51.45**	8353.60**
Moisture	2	177.69**	29.89**	28.53**	22.80**	822.45**
Machine*Cotton	35	4.86**	0.23**	0.15	0.54*	287.75**
Machine*Moisture	14	3.22	0.03	0.08	0.34	166.37**
Cotton*Moisture	10	32.36**	0.01	0.22	4.37**	351.11**
Machin*Cotton*Moistu	70	2.24	0.12	0.15	0.25	47.42
Error	297	2.43	0.11	0.13	0.35	75.51

* Significant at the 5% level of probability
** Significant at the 1% level of probability

Table 6. Means for manual classification, lint turnout and monetary value.

	Colour grade index	Classers' leaf grade	Turnout, %	Length		Value, $
				mm	in.	
Machine						
EFGS	92.1f	5.0a	**37.25a**	**28.96**	**(1.14)a**	373.03bc
CC,SM,CC,EFGS	93.8e	4.0b	36.51b	**28.70**	**(1.13)ba**	**376.87a**
EFGS, 1LC	97.8d	3.7c	35.48c	28.45	(1.12)cb	**374.17bac**
CC,EFGS,1LC	98.4dc	3.3d	35.58c	28.45	(1.12)c	**377.70a**
CC,SM,CC,EFGS,1LC	98.8bc	3.0e	35.23d	28.45	(1.12)b	**375.30ba**
EFGS,2LC	99.3ba	3.0e	34.97e	28.19	(1.11)d	373.22bc
SM,EFGS,2LC	99.2b	2.9f	34.83fe	28.19	(1.11)d	371.52c
CC,SM,CC,EFGS,2LC	**99.8a**	**2.5g**	34.74f	28.19	(1.11)d	372.00bc
Moisture						
Low	**98.2a**	**2.9c**	35.12c	28.19	(1.11)c	372.11b
Medium	97.8b	3.5b	35.73b	28.19	(1.12)b	3**76.86a**
High	96.2c	3.8a	**35.86a**	**28.96**	**(1.14)a**	373.67b
Cotton						
1	95.3e	4.6a	35.59d	28.96	(1.14)b	365.37e
2	97.4c	4.0c	35.30e	28.70	(1.13)c	370.08d
3	96.2d	4.3b	35.96b	**29.21**	**(1.15)a**	373.17c
4	98.2b	2.6d	34.11f	27.94	(1.10)e	363.34e
5	**98.8a**	**2.3e**	**36.62a**	27.94	(1.10)e	**392.07a**
6	**98.5ba**	2.6d	35.76c	28.19	(1.11)d	383.28b

Bold indicates most desirable values for machine treatments, if appropriate.

Table 7. Analyses of variance and significance levels for length (Peyer method) and neps (AFIS-N method).

Source of variation	DF	Length	Short fiber content, weight	Short fiber content, number	Number of neps per gram
Machine	7	4.57**	109.40**	382.16**	60363.86**
Cotton	5	29.88**	29.50**	1409.63**	7447.44**
Moisture	2	2853**	718.16**	2364.40**	144370.17**
Machine*Cotton	35	0.15	4.58	16.44	655.23*
Machine*Moisture	14	0.08	4.04	14.66	1297.19**
Cotton*Moisture	10	0.22	7.74**	25.28*	530.15
Machine*Cotton*Moisture	70	0.15	3.37	12.77	525.11
Error	297	0.13	3.18	11.73	447.16

* Significant at the 5% level of probability
** Significant at the 1% level of probability

Table 8. Means for length (Peyer method) and neps (AFIS-N method).

Machine	Length, mm	(in)	Short fiber content by weight, %	Short fiber content by number, %	Number of neps per gram
EFGS	**22.60**	**(0.89)a**	**6.16d**	**12.48d**	**138.2f**
CC,SM,CC,EFGS	**22.60**	**(0.89)a**	**6.58d**	**13.37d**	146.7e
EFGS, 1LC	22.01	(0.87)b	7.92c	15.80c	172.2d
CC,EFGS,1LC	22.01	(0.87)b	8.71b	17.40b	170.6d
CC,SM,CC,EFGS,1LC	22.01	(0.87)b	8.04c	16.05c	185.0c
EFGS,2LC	21.59	(0.85)c	9.91a	19.51a	214.0b
SM,EFGS,2LC	21.59	(0.85)c	9.19b	18.15b	218.7b
CC,SM,CC,EFGS,2LC	21.34	(0.84)d	9.89a	19.53a	225.7a
Moisture					
Low	21.08	(0.83)c	10.45a	20.35a	216.7a
Medium	22.01	(0.87)b	8.37b	16.84b	180.8b
High	**22.86**	**(0.90)a**	**6.04c**	**12.36c**	**154.3c**
Cotton					
1	22.60	(0.89)b	6.23dc	**12.57dc**	195.1a
2	22.35	(0.88)c	6.73c	13.47c	**172.5c**
3	**22.86**	**(0.90)a**	**5.79d**	**11.75d**	**172.7c**
4	21.34	(0.84)ed	10.14b	19.94b	194.0a
5	21.34	(0.84)e	10.69a	20.96a	189.3ba
6	21.59	(0.85)d	10.28ba	20.60ab	183.3b

Bold indicates most desirable values for machine treatments, if appropriate.