THE EFFECT OF PREPARATION ON THE SPINNING QUALITY OF COTTON

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Abstract

Spinning laboratory experiments using cottons from two crop years and three growing areas showed that cottons with rough preparation result in little or no significant difference in yarn quality compared to cottons with equivalent fiber properties and normal preparation. However, manufacturing waste is significantly higher (approximately 1%) for cotton with rough preparation compared to equivalent cotton with normal preparation.

Introduction

Historically, cotton has been classified for marketing and trade purposes in terms of grade and staple length according to strict standards developed by USDA, Agricultural Marketing Service (AMS), Cotton Division. Until 1991 U.S. cotton was classed by subjective, manual determination of skilled cotton classers. Classification by staple length involved pulling out a typical portion of fibers from a sample and comparing it to official staple types. For grade, classification was based on the visual appearance of the sample by the integration of three factors--color, leaf, and ginning preparation.

In addition to the above quality determinations, cotton was further classified for special conditions as observed and noted by the classer. Some of these special conditions include: cotton which has been gin-cut, reginned, water-packed, or fire-damaged; extraneous matter (which includes bark and grass); and rough preparation. These special conditions were determined by visual inspection in comparison with normal cotton standards. No specific, physical standards for these special conditions were available for use in making a determination. This subjective, manual classification system served the industry well for decades. However, with the change to modern processing and the pressure for improved quality, more objective classification was desired. After several years of evaluation that resulted in highly efficient operation and control procedures, USDA (with advice and consent from the entire industry) began in 1991 to classify U.S. cotton using HVI instruments. Instrument measurements for important quality parameters--including length, strength, fineness, color and trash--were implemented. However, no instruments were available to evaluate special conditions. Even though classers were no longer involved in determining staple length, they were retained to assign color grade and leaf grade and special classifications.

This partially dual system has been maintained since 1991, but it now appears that instrument measurements of color and trash might be adequate for determining color grade and leaf grade without assistance from the classers. However, at this time there are no instruments available to deal with the special conditions classification. These special conditions cottons constitute a very small percentage of the U.S. cotton crop and are relatively unimportant except for the individual producers who suffer losses in market value of their cotton because of them. How the classification of special conditions is dealt with in the future remains to be seen, since they normally occur because of very unusual circumstances that are unpredictable and occur randomly in localized growing areas. One of the special conditions--rough preparation--has recently been the subject of controversy relevant to attempts to implement new ginning technology.

Discussion

The term preparation is used to describe the degree of smoothness or roughness with which the cotton has been ginned and the relative neppiness or nappiness of the ginned lint. Rough preparation often results from wet harvesting, gleaning, or other unusual handling conditions and/or poor ginning. The resulting cotton contains curled or napped lumps; and, when the degree of rough preparation exceeds limits as observed by the classer relative to the official standards, the bale is designated rough preparation or Prep. Historically, cotton with the Prep designation has been reduced in market value. Table 1 summarizes the percent of Upland cotton bales which were officially classified as having rough preparation for the last 10 years.

In response to textile demands for less cleaning and more gentle ginning to help preserve fiber quality, a number of gins in the U.S. have reduced the amount of cleaning equipment used and attempted to find optimum combinations of seed cotton cleaning, ginning rates, and lint cleaners to respond to these demands. In addition, new technology developed by the U.S. Cotton Ginning Laboratory at Stoneville, MS, and being implemented by Zellweger-Uster, Knoxville, TN, is resulting in bales of cotton produced with varying ginning equipment based on the condition of the seed cotton entering the gin. These bales sometimes have the appearance of cotton that the classer normally associates with rough preparation. In some cases in the past, this technology has been associated with increases in the number of bales classified for rough preparation. All of this together probably is reflected in the increased percentage of bales being classified for abnormal preparation in crop years 1993 - 1996.

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The perception of poor quality and low processing performance associated with rough-looking cotton has persisted for sometime; and, therefore, has been integrated into the classification system. Historically, bales with a rough appearance have been designated for prep by cotton classers. Now, cotton bales which have been ginned with less than the normal amount of ginning equipment have a rougher than normal appearance. This apparently results in these bales being classified for rough preparation.

Not much research has been done on cottons classified for rough preparation to determine whether or not these designations are justified. Review of the literature shows little previous work on the processing performance of these cottons. Newton, in 1959, concluded that cottons with rough preparation do not follow through to produce important differences in spinning results although smoothly ginned cotton generally results in less waste and produces slightly smoother yarn than roughly ginned cotton. Even when reduced in grade because of preparation, some bales are not significantly different in waste or yarn appearance from more smoothly ginned bales. Newton further observed that classers generally seem to give substantial weight to smoothness or roughness as a factor in determining grade of cotton (Newton, 1959).

There are still questions about whether or not cottons classified for rough or abnormal preparation process any differently than equivalent cottons that have a smoother appearance. Because of these doubts and the interest in implementing Process Control Technology in ginning that can result in rough-appearing cotton, the process of how cottons are classified for rough preparation and the economic significance of this appearance are under discussion.

In cooperation with Cotton Division, AMS, two experiments were conducted at the Cotton Quality Research Station at Clemson, SC, relating to preparation. The cottons used in these experiments were selected by AMS from commercial sources covering two crop years. Attempts were made to find bales within each lot with very similar fiber properties whose only observed difference was preparation. Some of the bales were classified for rough preparation, and some were normal. Midsouth and Southeast cottons were used in the first and second experiments and cottons from the Southwest area were added for the second experiment.

Classification results for the cottons used are shown in Tables 2 and 3. In each case efforts were made to obtain cottons with consistent fiber properties within each lot. One- to three-bale lot sizes were selected. Prior to processing, the bales for each lot were thoroughly blended to provide uniform, experimental material. In the Pilot Spinning Laboratory at Clemson the cottons were processed into carded, ring-spun yarns as follows: carding--70 pounds/hour; breaker drawing--53 grain; finisher drawing--55 grain; roving--1.0 H.R.; spinning--30/1 and 40/1 ring, 3.50 t.m. Processing conditions were typical of those used in the textile industry; and modern, Truetzschler cleaning and carding equipment and Zinser spinning equipment were used. Three replications were performed for each experimental condition.

Standard quality and processing efficiency measurements were made, including processing waste and yarn strength and appearance. Average test data are shown in Tables 4 and 5 for the first experiment and in Tables 6 and 7 for the second experiment. Data were analyzed using PC-SAS. Multiple regression was used to establish relationships between either standard HVI classification results, or growing location where fiber properties were the same, and important processing and yarn quality characteristics. In one experiment, the combination of standard HVI classification values was selected that gave the closest relationship between fiber properties and each processing and yarn quality. Once this optimum or best combination of fiber properties was established for each processing or yarn quality, another term was added to the regression model to reflect whether or not the cotton was designated normal or rough preparation by the classer. The changes in the multiple correlation coefficients were observed to evaluate the effect of preparation on the spinning quality of the cotton. If preparation had a significant effect, the multiple correlation coefficients could be expected to increase--since about half the cottons in each experiment were cottons that had been judged by official classification to have rough preparation. In the other experiment, where fiber properties were very similar within each growing area, two different yarn numbers were used for each cotton. The initial analysis of this data was performed using growing location and yarn number as the independent variables. This was followed by another analysis in which the preparation condition was added as another independent variable. Tables 8 and 9 show the coefficients of determination, R-square, from the regression analysis for the first and second experiments, respectively. These data are shown graphically in Figures 1 and 2.

Figure 1 shows the results of the first experiment performed using cottons from two growing areas. The second series on this graph shows the results of the analysis when the designation for rough preparation was added to the multiple regression model. For this experiment, adding the prep designation significantly increased the multiple correlation coefficients for opening and general processing wastes (indicated by the first two sets of bars on the graph). The remaining quality parameters show little or no change in the multiple correlation coefficients when the prep designation was added, indicating that the prep designation makes very little difference for these quality parameters.

Figure 2 shows the results of the second experiment performed using cottons from the same growing areas as the first experiment and including Southwestern cottons--again, designated either normal or rough in terms of preparation. HVI data were used as the independent variables in this experiment. As shown by this graph, there are little or no differences in the test results for these cottons except in the case of opening waste and general processing waste.

These results seem to substantiate previous work by Newton on the effect of rough preparation--little or no differences in yarn quality but significant differences in manufacturing waste in processing.

The following quotation from The Classification of Cotton (June 1965) apparently continues to accurately describe the effect of rough preparation on processing and yarn quality:

> "Differences in roughness or smoothness of preparation are sometimes very apparent to the observer. However, laboratory tests do not support the belief that these easily recognized differences in degrees of preparation of the raw cotton will follow through to produce equally important differences in spinning results. As a general rule smoothly ginned cotton results in less waste and produces slightly smoother and more uniform yarn than roughly ginned cotton. Except for cases in which the roughness is excessive enough to cause the cotton to be reduced in grade, materially below that of cotton having normal ginning preparation, laboratory experience does not show significantly lower results for yarn quality."

Of immediate concern are cottons that receive less than normal ginning and result in a somewhat rough appearance--sufficiently rough for cotton classers to assign the Prep designation according to the rules of classification. Cotton producers are reluctant to support changes in gin processing that result in lower net return per cotton bale. Cotton classers cannot distinguish between cotton that truly has rough preparation (due to wet harvesting, ginning or whatever the cause might be) and cotton that has received gentle ginning (to protect fiber properties). This dilemma appears to be a major obstacle in implementing new technology in ginning that promises to provide improved cotton quality more closely matching the demands of textile manufacturers.

There appears to be two possible solutions to this problem. Both solutions may be equally difficult to achieve: (1) change the rules of classing to eliminate the Prep designation except for extreme roughness; or (2) develop machines or machine modifications that result in ginned lint with a smoother appearance . This possibly might involve something like the fine opener often used in textile processing before carding where the cotton needs to be very smooth and open.

Conclusions

The quality of yarns from cottons with rough preparation is not significantly different from cottons with normal preparation and equivalent fiber properties.

Manufacturing waste for cottons with rough preparation is significantly higher than for cottons with normal preparation and equivalent fiber properties.

References

Newton, Franklin E. 1959. Roughness as a factor of cotton grade measured by spinning tests. Cotton Division, AMS-USDA, Washington, DC. Administrative Report. 6 pp.

U. S. Department of Agriculture Miscellaneous Publication 310, The Classification of Cotton, June 1965.

Table 1. Number of U.S. cotton bales classed for rough preparation.

Year	Bales	Crop%
1987	12,153	0.09
1988	11,764	0.08
1989	13,645	0.12
1990	7,170	0.05
1991	30,390	0.18
1992	11,847	0.08
1993	79,419	0.52
1994	106,836	0.58
1995	39,909	0.24
1996	51,760	0.29

Table 2. Fiber properties of cottons in first experiment.

CGRD	Mike	UHM	STR	UI
		---Midsouth Area---		
31*	4.4	1.15	28.6	81
31*	4.2	1.15	28.5	82
31*	4.2	1.12	27.6	81
Avg.	4.3	1.14	28.2	81.3
		---Southeast Area---		
42*	4.5	1.08	29.7	82
42*	4.5	1.11	30.4	82
42*	4.6	1.09	30.6	81
Avg.	4.5	1.09	30.2	82.0
		---Midsouth Area---		
31	4.2	1.14	27.5	82
31	4.3	1.14	27.5	82
31	4.2	1.14	28.0	82
Avg.	4.2	1.14	27.7	82.0
		---Southeast Area---		
42	4.5	1.08	30.1	82
42	4.6	1.08	29.5	82
Avg.	4.5	1.08	29.8	82.0

*These cottons were designated rough preparation in classing.

Table 3. Fiber properties of cottons in second experiment.

CGRD	Mike	UHM	STR	UI
42*	4.3	1.12	29.4	82
42*	4.2	1.13	29.2	83
42*	4.3	1.12	30.4	83
Lot 1 Avg.	4.3	1.12	29.7	82.7
42*	4.5	1.12	28.0	81
42*	4.5	1.10	29.7	83
42*	4.8	1.14	27.5	82
Lot 2 Avg.	4.6	1.12	28.4	82.0
42*	4.2	1.07	29.9	81
42*	4.2	1.09	30.9	82
42*	4.0	1.09	30.6	82
Lot 3 Avg.	4.1	1.08	30.5	81.7
42*	4.5	1.15	29.4	82
42*	4.5	1.15	29.4	82
42*	4.2	1.13	30.5	82
Lot 4 Avg.	4.4	1.14	29.8	82.0
42*	4.2	1.13	28.8	81
42*	4.2	1.13	28.8	81
42*	4.2	1.13	28.8	81
Lot 5 Avg.	4.2	1.13	28.8	81.0
32*	3.5	1.03	30.8	79
32*	3.4	1.06	30.1	79
Lot 6 Avg.	3.5	1.05	30.5	79.0
42	4.3	1.09	30.5	81
42	4.7	1.12	31.2	81
42	4.5	1.12	29.8	81
Lot 7 Avg.	4.5	1.11	30.5	81.0
42	4.7	1.11	30.4	82
42	4.7	1.12	29.6	81
42	4.8	1.11	29.4	82
Lot 8 Avg.	4.7	1.11	29.8	81.7
42	4.4	1.11	28.9	83
42	4.5	1.11	29.2	82
42	4.6	1.10	28.5	82
Lot 9 Avg.	4.5	1.11	28.9	82.3
32	3.6	1.06	30.2	79
Lot 10 Avg.	3.6	1.06	30.2	79.0

*These cottons were designated rough preparation in classing.

Table 4. Waste and yarn properties* for first experiment.

Loc**	OW	PW	YN	ABF	SES
		---- 30/1 Yarn ----			
MS***	2.4	1.45	29.8	1901	12.1
MS	1.4	1.32	29.4	1952	12.54
SE***	2.15	1.66	30.1	1710	11.15
SE	1.25	1.57	29.9	1712	10.99
		---- 40/1 Yarn ----			
MS***	2.32	1.60	40.0	1747	11.42
MS	1.20	1.33	40.0	1782	11.69
SE***	2.05	1.61	39.3	1490	10.73
SE	1.30	1.56	40.4	1482	10.23

* OW = Opening Waste
PW = Processing Waste
YN = Yarn Number
ABF = Adjusted Break Factor
SES = Single End Strength
** Growing locations: MS = Midsouth, SE = Southeast
*** These bales were designated rough preparation in classing.

Table 5. Yarn properties* for first experiment - continued.

Loc**	NEPS	THCK	THIN	UCV	APP
		---- 30/1 Yarn ----			
MS***	1740	3915	6928	22.8	91
MS	1938	4012	6988	22.9	88
SE***	1793	4247	7558	23.8	91
SE	2183	4321	7607	23.9	89
		---- 40/1 Yarn ----			
MS***	2582	4782	8212	25.3	68
MS	2725	4807	8121	25.2	66
SE***	2762	5021	8897	26.2	73
SE	3344	5227	9097	26.6	70

* NEPS = Neps in yarn
THCK = Thick places in yarn
THIN = Thin places in yarn
UCV = Uster evenness in yarn
APP = Yarn appearance
** Growing locations: MS = Midsouth, SE = Southeast
*** These bales were designated rough preparation in classing.

Table 6. Waste and yarn properties for second experiment.

Lot	OW	PW	YN	ABF	SES
1*	2.41	1.77	35.1	2109	13.46
2*	2.67	1.77	35.2	1878	12.15
3*	2.68	1.56	35.4	2256	14.23
4*	2.43	1.53	35.4	2092	13.03
5*	2.23	2.07	35.0	2024	12.64
6*	3.31	2.50	35.0	2016	13.08
7	1.34	1.50	34.9	2211	13.71
8	1.68	1.10	35.7	2181	14.01
9	1.44	1.50	35.1	1984	12.36
10	1.29	1.31	35.5	2126	13.77

* These bales were designated rough preparation in classing.

Table 7. Yarn properties for second experiment - continued.

Lot	NEPS	THCK	THIN	UCV	APP
1*	1659	2893	5610	19.6	81
2*	1267	2724	5525	19.5	89
3*	1331	2598	5315	19.0	92
4*	1092	2431	4967	18.8	95
5*	2007	3259	6228	20.3	79
6*	1939	3495	6752	21.2	61
7	1293	2520	4934	18.8	96
8	784	1898	4125	17.8	110
9	1309	2580	5170	18.9	95
10	1524	2992	5879	20.1	77

* These bales were designated rough preparation in classing.

Table 8. Coefficients of determination, R-Square, for first experiment.

Property	NoPrep*	Prep
OW	0.310	0.968
PW	0.506	0.880
YN	0.994	0.997
ABF	0.959	0.968
SES	0.835	0.896
NEPS	0.865	0.987
THCK	0.962	0.979
THIN	0.970	0.976
UCV	0.979	0.984
APP	0.960	0.974

* NoPrep = Prep designation not included in regression model.
Prep = Prep designation included in regression.

Table 9. Coefficients of determination, R-Square, for second experiment.

Property	NoPrep*	Prep
OW	0.287	0.944
PW	0.336	0.512
YN	0.068	0.068
ABF	0.758	0.815
SES	0.654	0.672
NEPS	0.738	0.738
THCK	0.813	0.829
THIN	0.843	0.874
UCV	0.804	0.841
APP	0.715	0.745

*NoPrep = Prep designation not included in regression model.
Prep = Prep designation included in regression model.

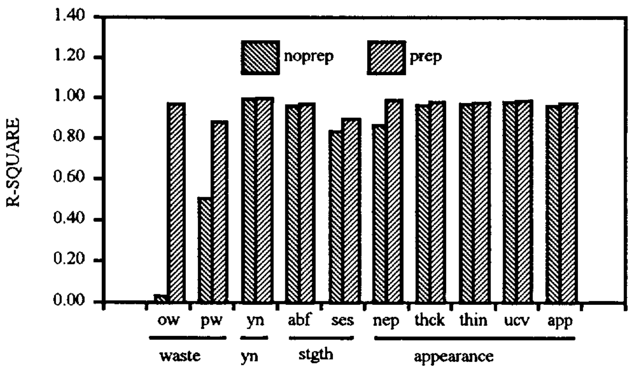

Figure 1. Coefficient of determination, first experiment.

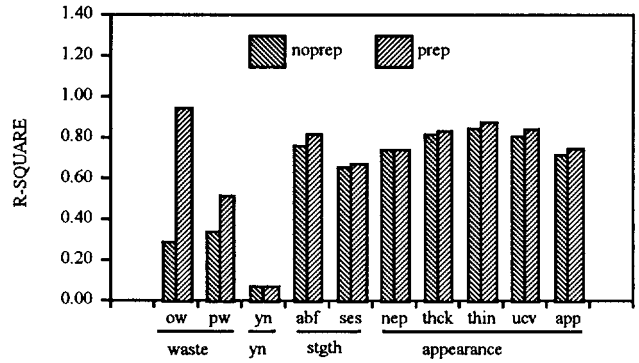

Figure 2. Coefficient of determination, second experiment.