EFFECT OF PREP ON PIMA COTTON TEXTILE QUALITY

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Abstract

The only reliable source of Pima cotton that is classed as having excessive preparation is cotton that has been ginned in a commercial gin plant and then given the preparation designation during the normal classing operation. Representative Pima cotton bales that were classed both preppy and non-prep were obtained from each of the three major Pima cotton production areas. The goal was to obtain pairs of bales from each of the three production areas whose only significant difference was the preparation designation. The goal was not completely met for micronaire, but other HVI properties were in the normal range. Data analysis showed that there were significant differences between growing areas, as might be expected, in most of the raw fiber properties measured for the six bales tested. When comparing raw fiber properties between paired bales from a given production area's prep and non-prep bales, the prep bales tended to be lower in strength, micronaire, grade, color, neps, and length. Evaluation of yarn and cloth properties also showed significant differences between production areas as would be expected due to the initial differences in raw fiber properties between production areas. This test indicates that there are small but significant differences in some yarn properties and dyeing performance when comparing prep and non-prep Pima cotton. Yarn made from Pima cotton classed as preppy was not as uniform as the yarn made from cotton that did not receive the preparation designation. Also, the preppy cotton resulted in dyed cloth that was significantly higher in white specks than cloth made from non-prep cotton. One factor that could have affected the quality of yarn and cloth, apart from the preparation designation, was the low micronaire cotton included in the test. To verify this result, the test should be repeated with all fiber properties in the normal or premium range for both the prep and non-prep bales.

Introduction

Preparation, or "prep", has an official definition that is used by the USDA, Agricultural Marketing Service (AMS) in the classing of both upland and Pima cotton. The official definition is: "Preparation is the classer's determination of the degree of roughness or smoothness of the ginned lint cotton. The harvesting and ginning of cotton which contains too much moisture may result in lint cotton with a twisty, knotty appearance. Such cotton is difficult to process and produces inferior yarn. Abnormal preparation in upland cotton has greatly diminished in recent years, due to improvements in harvesting and ginning practices, and now occurs in less than one-half of 1 percent of the crop" (AMS, 1993). This definition assigns both a cause for preparation (high moisture) and an effect of preparation (inferior yarn) that is not entirely justified. Preparation can be caused by other things besides moisture, and the effect of preparation on yarn quality is unknown. The practical result of Pima bales being given a preparation call is that they are usually discounted by buyers in comparison to other Pima bales that may be identical in all other fiber quality measurements.

An example of the shortcoming of the prep definition occurred in the San Joaquin Valley of California a few years ago on upland cottons. The season's quality was very good with a large percentage of high white grades. A gin in that region chose to use only one lint cleaner on several thousand bales while all its competitors continued to use two lint cleaners. This particular gin received a much higher percentage of "prep" grades than its competitors because the cotton looked rougher to the classer's eye than the cotton from the rest of the gins in the Valley. Lint cleaners comb and smooth the cotton's appearance at the same time as they remove trash. The apparent roughness occurred because two lint cleaners did relatively more smoothing than one lint cleaner and the one lint cleaner sample looked rougher to the eye. It was a dry harvest season for the whole valley so moisture was not a problem. Also, additional testing showed that the "preppy" bales were of equal or higher quality, in terms of all other fiber properties, and apparently made comparable or better yarn than that made from similar cotton not reduced for prep. The prep call was only a matter of visual appearance with questionable relation to real fiber quality.

Preparation is usually more of a problem in roller-ginned Pima cotton than in saw-ginned upland cotton. Lint cleaning equipment in roller gins is typically less aggressive and does not comb the ginned fiber to the extent that is done during lint cleaning in saw-gins. For this reason, roller-ginned Pima cotton is rougher in visual appearance than typical upland cotton. It is also generally agreed upon that poor production and harvest practices that result in high trash contents, spindle twists, or high moisture levels can be a source of preparation (Feaster, 1990, and Van Doorn, 1990). Preparation can also be caused or made worse by ginning equipment that is improperly adjusted, or by insufficient drying used during seed cotton processing.

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Preparation grades caused by production and harvesting practices or gin processing can usually be eliminated by improving production and ginning practices. Preparation can also be caused by factors other than those already mentioned. During the 1989 ginning season, Pima gins in Texas, New Mexico and Arizona experienced unusually high levels of preparation calls. These preparation designations seemed to be at random and could not be readily attributed to any particular production or ginning practice such as high moisture levels or improperly adjusted ginning equipment. A Pima Cotton Quality Task Force was formed and an emergency meeting, attended by area producers, ginners, and scientists, was held at the USDA-AMS Phoenix Classing Office. At this meeting, a large number of Pima classing samples, chosen at random, were examined by members of the Task Force. It was apparent that generally those samples classed as being preppy were rougher in appearance than those not being reduced for prep, but no suitable explanation for the high incidence of prep was easily discernable.

Additional data analysis of the entire 1989 Pima crop showed that there was a high statistical correlation between low micronaire readings and preparation calls (Hughs, 1990). The 1989 growing season was such that a significant amount of the Pima grown over its production area had lower micronaire than normal. This lower micronaire cotton tended to result in a rougher classing sample and a significantly higher incidence of prep calls by the classer. Micronaire for the 1990 Pima crop was more normal and the incidence of preparation during the 1990 ginning season was much lower than the 1989 season. Experience has shown that besides low micronaire, fiber stickiness caused by aphids or white flies could also be a factor in the rougher appearing classing samples that results in preparation grades.

Subsequent cooperative research between the USDA, ARS, Southwestern Cotton Ginning Research Laboratory, Mesilla Park, NM and the USDA, ARS, Clemson Pilot Spinning Plant, Clemson, SC attempted to produce preppy cotton from otherwise mature, high quality Pima cotton by varying the harvesting (moisture content) and ginning (amount of cleaning) practices. This cotton was processed into yarn to determine what quality differences there might be between cotton that was identical except for harvesting and ginning practices. This test was inconclusive because preppy grades could not be reliably produced by any combination of harvesting and ginning practices tried.

Preparation grades in Pima cotton are still an ongoing quality and economic problem for the Pima industry. For example, during the 1998 harvest season, 2.1 and 12.7% of the Pima cotton classed in the Phoenix and Visalia classing office, respectively, were classed as preppy. Similar numbers for the 1997 harvest season were 2.6% and 13.5%. In other words, for the 1998 harvest season, a total of 41,198 bales, or approximately 10%, of the U. S. Pima cotton bales were reduced in market value due to preparation. Undoubtedly, some of the bales classed as preppy resulted from low micronaire, or high moisture content during harvesting and processing, or for other reasons resulting in measurable differences in fiber quality. However, other bales given the preparation designation may not differ in any appreciable way in fiber properties from non-prep bales. The question remains as to what is the effect on textile processing of Pima bales designated as preppy as compared with bales with equivalent fiber properties that are not given the preparation designation. What follows is a report on an attempt to help define the textile quality differences between preppy and non-prep Pima cotton bales.

Materials and Methods

Past research has shown that preppy cotton could not be reliably manufactured in the laboratory. Also, preppy cotton produced in the laboratory may not duplicate the same conditions under which prep grades are generated in the field. Therefore, the most reliable means of obtaining preppy cotton was to acquire commercial bales that had already been given the prep designation by official USDA classification. Pima cotton is grown in Arizona (AZ), California (CA) and the Rio Grande Valley of New Mexico/West Texas (NM/TX). A bale of Pima cotton that had been given the prep designation was obtained from a storage warehouse in each of these three growing areas. In addition, a companion Pima bale was obtained from each area that was similar to the prep bale except for the preparation designation.

Table 1 shows the average HVI designations for each of the 6 bales selected for the test. Each measurement shown in Table 1 is the average of four sub-samples. Bale selections were made based on the original HVI class. Selection criteria was that, other than the preparation designation, the paired bales were to have as much as possible the same staple length and grade designation as well as premium micronaire. The averages shown in Table 1are from HVI measurements made on the sub-samples selected from the bales immediately prior to textile processing. It can be seen from Table 1 that there are differences in the HVI measurements of the paired bales from each production area, but, other than for the micronaire and strength of the California pair, the criteria for selecting paired bales was met.

These six bales were sent to the Clemson Pilot Spinning plant to be processed into yarn and fabric, and quality comparisons made. The nominal yarn size was combed 60 singles. Yarn quality measurements were made to compare preppy versus normal cotton. The yarn was then made into a knitted jersey fabric that was scoured and dyed with direct blue 80 dye. White spots were counted on the dyed jersey fabric to

determine if there were any dyeing differences attributable to preparation grades.

Results and Discussion

Spinners ask at least three questions when obtaining raw cotton for processing. These three questions can be summarized as follows:

1. How well does the cotton process? This is indicated by mill waste and ends down during spinning.
2. How good does the yarn look? Uster measurements and a visual yarn appearance index are used to answer this question.
3. How strong is the yarn? Yarn strength is evaluated by strength and break factor measurements.

There are other questions such as cost of the raw product, availability of supply, etc that are also important, but the preppy and normal Pima cottons were evaluated based on the above three questions. HVI measurements are important indicators of how well a particular cotton may answer their needs. Table 2 is an evaluation of the statistical differences (SAS, 1989) in basic HVI fiber properties of the Pima cottons used in this test. There are significant differences between regions in both micronaire and strength as well as some differences in color as indicated by yellowness (+b) and classer's grade as shown by statistical comparisons. Any region averages followed by different letters in Table 2 (also Tables 3, 4, and 5) were determined to be significantly different at the 5% level by Duncan's Multiple Range Test. For example, the average micronaire for the Pima from the New Mexico/Texas region (4.06) was significantly higher than that from either Arizona or California (3.75 and 3.66 respectively). There was no statistical difference in the average micronaire from Arizona and California. Likewise, there was no statistical differences in the average upper half mean lengths from Arizona, California or New Mexico/Texas at 1.33, 1.33 and 1.32 respectively. Part of the micronaire difference between regions probably originates with the low micronaire prep bale that was obtained from California, as shown in Table 1.

These same significant differences in micronaire, strength, grade, and color also occur, and are even more pronounced, between the prep and non-prep bales shown in Table 2 as the observed significance level (OSL). Any calculated OSL level that was greater than 0.10 was determined to be not significantly different (NS) at the 10% level of confidence. Also, the preppy bales have a slightly lower (0.8%) but statistically significant difference in fiber uniformity (UHF) as shown by the OSL of 0.0006.

Additional raw fiber property measurements were made (Table 3) prior to spinning in an attempt to better define the quality of the prep and non-prep bales. Again, there were several significant differences in the Suter Webb and Peyer fiber length measurements between growing areas as might be expected due to climate. There were also significant differences in length between prep and non-prep bales with the prep bales tending to be a little shorter in upper quartile or mean length measurements. Total card waste was significantly different between areas with New Mexico/Texas having the lowest waste (3.5%) and Arizona and California being significantly higher (4.0 and 3.9% respectively). Total card waste averages were also significantly higher for the preppy versus non-prep bales at 4.0 versus 3.6% respectively. Fiber neps as measured by the AFIS were also shown to be significantly higher in the preppy cotton.

Tables 4 and 5 show the measured yarn and cloth properties for this test cotton. There were significant differences in yarn strength, yarn appearance, and cloth dyeing properties between growing areas as might be expected. However, Table 4 shows that there was no difference in yarn strength, when comparing the prep to the non-prep cotton, but Table 5 shows there was a significant difference in the visual yarn appearance index at 98 and 108 respectively. The cotton classed as preppy also had yarn that had significantly more neps and thick places compared to the non-prep cotton. Total dye speck levels comparing growth area and prep classification were low; however, the preppy cotton had a significantly higher number of white specks in the dyed cloth (Table 5).

Apart from the prep designation, there was a difference in some of the other initial fiber properties of the paired bales chosen from each region. After the analysis was done, that was shown in Tables 2 through 5, there was still a question of whether the quality factor defined by prep designation was the determining factor in the significant textile quality effects observed, or whether some of the other initial fiber properties contributed to the significant differences seen. Table 6 shows the result of the multiple linear regression analysis done (SAS, 1989) to examine the effects of all the initial HVI measurements, including prep designation, on yarn and cloth quality. The textile measurements shown in Table 6 were the ones that were shown to be significantly different due to prep in Table 5. All other HVI measurements were combined into prep in the analysis in Table 5. Separating out the effects by regression analysis shows that only micronaire and fiber strength significantly affected thick places, neps, yarn appearance and dye specks. Prep designation was non-significant for all of the textile quality measurements in Table 6.

Conclusions

The only reliable source of test cotton that is classed as having excessive preparation is cotton that has been ginned in a commercial gin plant and then given the preparation designation during the normal classing operation. Representative cotton bales that were classed both preppy and non-prep were obtained from each of the three major Pima cotton production areas. The goal was to obtain pairs of bales from each of the three production areas whose only significant difference was the preparation designation. The goal was not completely met for micronaire and strength, but other HVI properties were reasonably similar.

These six Pima cotton bales were then further analyzed for raw fiber quality and then processed into yarn and cloth. There were significant differences between growing areas, as might be expected, in most of the raw fiber properties measured for the six bales tested. When comparing raw fiber properties between prep and non-prep bales, preppy bales were significantly lower in strength, micronaire, grade, color, AFIS neps, and some length measurements.

Evaluation of yarn and cloth properties again showed significant differences between production areas as would be expected from the significant differences in raw fiber properties. Yarn made from Pima cotton classed as preppy was less even, even though yarn strength was the same, than the yarn made from cotton that did not receive the preparation designation. In addition, the preppy cotton resulted in dyed cloth that was significantly higher in white specks than cloth made from non-prep cotton. None of the white speck counts were high for any of the cottons, but the differences were statistically significant.

Further statistical analysis showed that only micronaire and fiber strength were significant factors affecting yarn and dyed cloth quality. Fiber quality as expressed by the prep designation was not statistically significant. This test indicates that, for some cottons, fiber quality factors other than the prep designation may be causing significant differences in some yarn properties and dyeing performance when comparing prep and non-prep Pima cotton. These other significant quality factors are being combined with the prep designation. The results of this test are inconclusive as to the effect of prep on textile quality. In order to clarify the effect of prep, the test should be repeated with a better effort to obtain bales of cotton with similar HVI fiber properties, including strength and micronaire, for both the prep and non-prep bales.

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Table 1. Average HVI Measurements of Bales from Each Growing Area.

Location	Preparation	Micronaire	Strength, g/tex	Classer's Grade	Reflectance	Yellowness	Upper Half Mean, in.	Uniformity, %
AZ	yes	3.6	37.2	2.8	66.3	12.2	1.3	85
AZ	no	3.9	38.7	1.0	71.5	12.0	1.3	85.8
CA	yes	3.1	37.0	2.0	67.5	12.5	1.3	84.5
CA	no	4.3	41.3	1.0	69.5	12.8	1.3	86.0
NM/TX	yes	4.0	36.3	1.0	68.5	13.2	1.3	85.5
NM/TX	no	4.1	35.8	1.3	68.0	13.2	1.3	85.8

Table 2. Statistical Analysis of HVI Measurements.

Location	Micronaire	Strength, g/tex	Classer's Grade	Reflectance	Yellowness	Upper Half Mean, in.	Uniformity, %
AZ	3.75 b	37.9 a	1.88 a	68.9	12.1 c	1.33	85.4
CA	3.66 b	39.1 a	1.5 ab	68.5	12.7 b	1.33	85.2
NM/TX	4.06 a	36.0 b	1.12 b	68.2	13.2 a	1.32	85.6

Table 2. Continued

Preparation	Micronaire	Strength, g/tex	Classer's Grade	Reflectance	Yellowness	Upper Half Mean, in.	Uniformity, %
Yes	3.55	36.8	1.92	67.4	12.6	1.33	85.0
No	4.09	38.6	1.08	69.7	12.7	1.33	85.8
OSL	0.0002	0.0044	0.0010	0.0007	NS	NS	0.0006

Table 3. Other Fiber Property Analysis.

Location	AFIS Neps	Suter Webb UQL, in.	Suter Webb Mean Length, in.	Shirley Analyzer Total, %	Suter Webb Short Fiber, %	Peyer Mean Length, in.	Total Card Waste, %
AZ	286	1.40	1.14 b	2.70	7.1 a	1.08 a	4.0 a
CA	286	1.40	1.17 a	2.24	5.3 ab	1.07 ab	3.9 a
NM/TX	287	1.39	1.16 a	1.70	4.6 b	1.06 b	3.5 b

Table 3. Continued

Preparation	AFIS Neps	Suter Webb UQL, in.	Suter Webb Mean Length, in.	Shirley Analyzer Total, %	Suter Webb Short Fiber, %	Peyer Mean Length, in.	Total Card Waste, %
Yes	319	1.39	1.15	2.43	6.1	1.05	4.0
No	254	1.41	1.17	1.99	5.3	1.08	3.6
OSL	0.0001	NS	0.0135	NS	NS	0.0099	0.0001

Table 4. Average Yarn Strength.

Location	End Breaks, No.	Single End Strength, g/tex	Adjusted Break Factor
AZ	24	21 b	3290 b
CA	14	22 a	3437 a
NM/TX	20	18 c	2900 c

Table 4. Continued

Preparation	End Breaks, No.	Single End Strength, g/tex	Adjusted Break Factor
Yes	19	20	3211
No	20	20	3207
OSL	NS	NS	NS

Table 5. Average Uster Measurements and Dye Specks.

Location	Uster Evenness, %CV	Uster Yarn Neps, No./1000 yds	Uster Thick Places,	Visual Appearance	White Specks, No./10 sq. in.
AZ	16.1 b	412 a	968	103 a	0.62 ab
CA	16.2 ab	468 a	980	94 b	0.95 a
NM/TX	16.4 a	294 b	1012	112 a	0.37 b

Table 5. Continued

Preparation	Uster Evenness, %CV	Uster Yarn Neps, No./1000 yds	Uster Thick Places, No./1000	Visual Appearance	White Specks, No./10 sq. in.
Yes	16.2	458	1008	98	0.83
No	16.2	325	967	108	0.47
OSL	NS	0.0014	0.0267	0.0107	0.0390

Table 6. Examination of HVI Classification Relative to Textile Quality.

	Official USDA Quality Factors and Observed Significance Levels					
Textile Measurement	Micronaire	Strength, g/tex	Reflectance, Rd	Yellowness, +b	Uniformity, %	Prep Designation
Thick Places, No./1000 yds	NS	NS	NS	NS	NS	NS
Neps, No./1000 yds	0.0001	0.0147	NS	NS	NS	NS
Appear. Index	0.0009	0.0170	NS	NS	NS	NS
White Specks, No./10 sq. in.	0.0278	0.0685	NS	NS	NS	NS