TEXAS TECH UNIVERSITY
International Textile Center

2006 PROGRESS REPORT

TEXAS PLAINS COTTON PERFORMANCE IN HIGH-VALUE-ADDED RING SPINNING APPLICATIONS

COTTON INC. TEXAS STATE SUPPORT COMMITTEE PROJECT # 05-610TX

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PERFORMING INSTITUTION

Texas Tech University

PROJECT #05-610TX: TEXAS PLAINS COTTON PERFORMANCE IN HIGH VALUE ADDED RING SPINNING APPLICATION

SUMMARY: Texas plains cotton has historically been penalized on the domestic textile market because of its shorter staple and its lower performance in ring spinning. Important high value-added market sectors are denied to this cotton and significant price disadvantages are endured by the producers. Yet, in recent years new varieties have emerged that appear to offer improved fiber quality. With the changing face of the cotton market becoming more and more competitive and globalized, it is vital that these new fibers be accurately compensated by the international market. It is important that Texas plains producers gain access to the high-value-added sectors in the global market.

Analysis of the Texas Plains commercial cotton quality trends shows this significant and continuous improvement over the last 5 years. The rationale behind seeking access to high value-added markets for West Texas cotton producers is compelling and is strengthening year after year. At present, this applies to a small percentage of the crop (at the upper quality percentiles), but represents a substantial number of bales. Better appraisal and increased high-value-added market demand on this portion of the Texas Plains crop may represent major economic opportunities for West Texas cotton producers. The central focus of our research is to evaluate the competitive value of this portion of Texas crop in high-value applications.

For the second year in a row, our results showed that Texas plains cottons compared favorably to SJV and coastal bend cottons <u>of similar HVI properties</u>. Plains cottons processed in this second year of the project appeared to have higher trash and dust contamination but had lower fiber entanglements (neps) and seed-coat neps. Overall, these properties were advantageous for the Texas plains bales after spinning preparation, i.e., low neps and seed coat neps were perceptible even at the card sliver stage, but the initial higher trash content appeared to be offset by the cleaning efficiency of the opening-cleaning and carding processes. Plains cotton showed slightly higher numbers of ends-down than SJV cottons. However, the difference was not statistically significant. Furthermore, patterns obtained in both 2006 and 2005 trials suggest that the higher numbers of ends-down are primarily observed for the shortest staples among the tested bales. Bales with staples 37 and longer did not appear to show differences in the number of ends-down between the Texas Plains and SJV. Finally, yarns spun from the selected plains bales had quality levels (evenness, imperfections, hairiness, strength) that were generally close to those of SJV levels.

In summary, results for 2006 confirm those obtained for 2005. It appears that quality ring-spun yarn can be obtained from Texas plains cottons (when compared to some market benchmarks, such as SJV cottons). Results obtained so far are encouraging, but further confirmation is needed in order to confidently communicate these findings to spinners around the world. In order to confirm and validate these results, the number of samples has to be multiplied and the range of bales broadened to cover multiple crop seasons. We are currently in the process of purchasing the bales for the trials to be conducted for the year 2007.

1. INTRODUCTION

When purchasing cotton, spinners consider several factors other than measured quality characteristics. These factors include the growth area's history of producing certain quality characteristics with consistency. Texas plains cotton has historically been penalized on the local and foreign market due to its fiber quality, notably its shorter length, and to the resulting lower performance in ring spinning. This has restricted the cotton's access to important high-value-added market sectors resulting in lower market prices for it.

Over the past several years, new cotton varieties have emerged that are well adapted to the growth conditions of the Texas plains and have superior fiber properties. Widespread adoption of these varieties has resulted in a significant portion of the Texas Plains crop having superior fiber properties that approach Acala-type cottons. Thus, in the 2003-04 season, almost 20% of the bales classed in Abilene, Lamesa and Lubbock had HVI staples of 36 and longer. This represented more than 600,000 bales. In the 2005 crop, the number of bales classed 36 and longer in Abilene, Lamesa and Lubbock exceeded 2,100,000 bales.

Therefore, significant work has been and continues to be done to provide producers in West Texas with the opportunity to produce cotton with improved fiber quality, and thus to compete favorably for a share on the global cotton market. In addition to the commercial successes that resulted in the improvements seen in the last few years, breeding efforts continue to yield very encouraging results and promising genotypes are already available to maintain and further improve the quality of Texas Plains commercial crop. For instance, new lines obtained at Texas Tech University, Plant and Soil Science department (Auld *et al.*, 2004; Krifa *et al.*, 2007), using chemical mutagenesis showed HVI staple lengths greater than 38 and HVI strength in excess of 34 g/tex, along with the short-season adaptation and the storm resistance required in the Texas Plains.

In order for Texas producers to take full advantage of these advances, it is essential that the new varieties already on the market, as well as the developments to come, not be wrongly discounted or denied high-value-added applications. Cotton buyers on the world market should be made aware of the real industrial potential of this significant portion of Texas cotton crop in order to transcend their reluctance to demanding this fiber in favor of other production areas.

The present research aims at conducting an assessment of the overall spinning performance of this fiber against the market benchmarks. This will allow treating both aspects of the textile use-value of cotton fiber, i.e., quality and productivity. The outcome will allow either demonstrating the competitiveness of Texas plains fiber in the high quality market, or identifying the performance problems to be resolved. Either way, results will contribute towards opening new market outlets thus far denied to much of Texas Plains cotton.

In this document, we report on progress made in the second season of this project. We will first present an update on the commercial crop and on the improvements observed not only when considering staple length, but also when taking into account other fiber traits that are critical to the processing performance of cotton. We will then examine the results we obtained on the bales we selected from the 2005 crop for the testing and processing trials conducted in 2006.

Note that some of the general information (methods used, construction of the report) presented here is similar to that included in the first year progress report of this project. However, all discussions and conclusions are based on 2006 experiments. Discussion of spinning performance results will include results obtained in both seasons. In addition, a summary section at the end of the report will review and recapitulate the conclusions obtained so far over the two crop seasons.

2. OBJECTIVES

The major objective of this research is to evaluate the competitive value of new cotton varieties grown in the Texas Plains with comparison to other U.S. growth areas reputed for being adapted for high quality products, and to determine the factors limiting the access of this fiber to high-value-added application.

The specific objectives are:

1- Assess the spinning performance of Texas-grown varieties with reference to cottons having comparable HVI fiber properties and grown in other production areas.

2- Identify the performance issues related to the growth area and not represented by HVI data.

3- Determine the potential for using cottons in the upper portion of the Texas Plains quality distribution in high-value-added applications.

4- Communicate findings to Texas plains cotton producers through educational meetings, media contacts, and various reports.

3. TEXAS PLAINS COTTON CROP: 2000 TO 2005 - A QUALITY BOOM?

As mentioned in the introduction above, quality of the Texas Plains' and more generally of the entire Texas state's upland cotton crop has been significantly improving in the last few years. In the 2003 Texas crop, more than one million bales (1,150,800 according to USDA-AMS statistics) were classed as staple 36 and longer. This number grew to more than two million bales in 2004, and then to 2,358,350 bales in 2005 (nearly 30% of the state's crop). This represents nearly 10 times the number of bales classed 36 and longer in 2000.

Among all US cotton production areas, the San Joaquin Valley (SJV) has generally stood as the primary source of high quality upland fiber suitable for ring spinning, and has become an established benchmark for high value-added applications. In order to examine the market potential of the improved Texas Plains crop, we will use classing data and experimental results from this established benchmark. Comparative analysis of fiber quality and processing performance with reference to the market benchmark will allow determining whether Texas plains crop has become a potential source of fibers that could claim a share in the high value-added market.

We first consider the staple chart of the Texas Plains crop (bales classed in Abilene, Lamesa and Lubbock) and examine how it evolved through the last few years in comparison with that of SJV crop. Figure 1 depicts staple distributions of SJV and Texas Plains 2000 crops as reported in the EFS® USCROP (TM) database (assembled and published by Cotton Inc). Figure 2 and Figure 3 show similar data for the 2002 and 2005 crops, respectively.

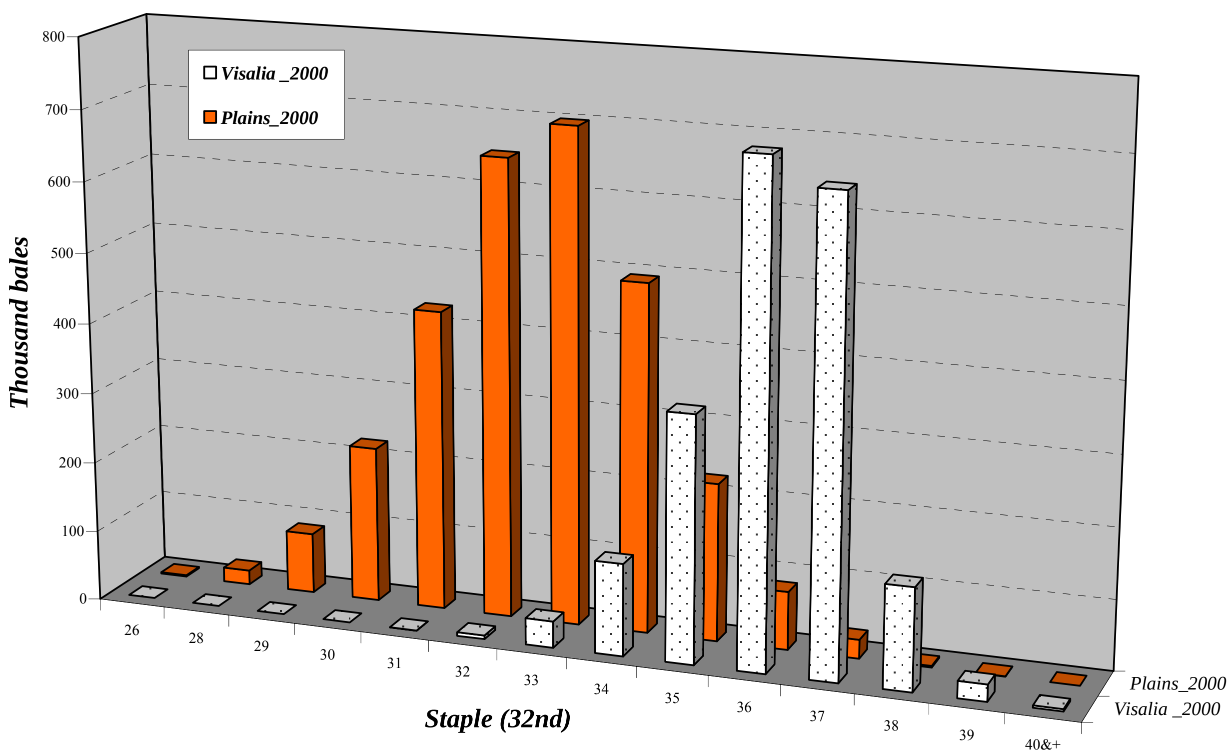

Figure 1: 2000 crop staple chart – Texas plains vs. California.

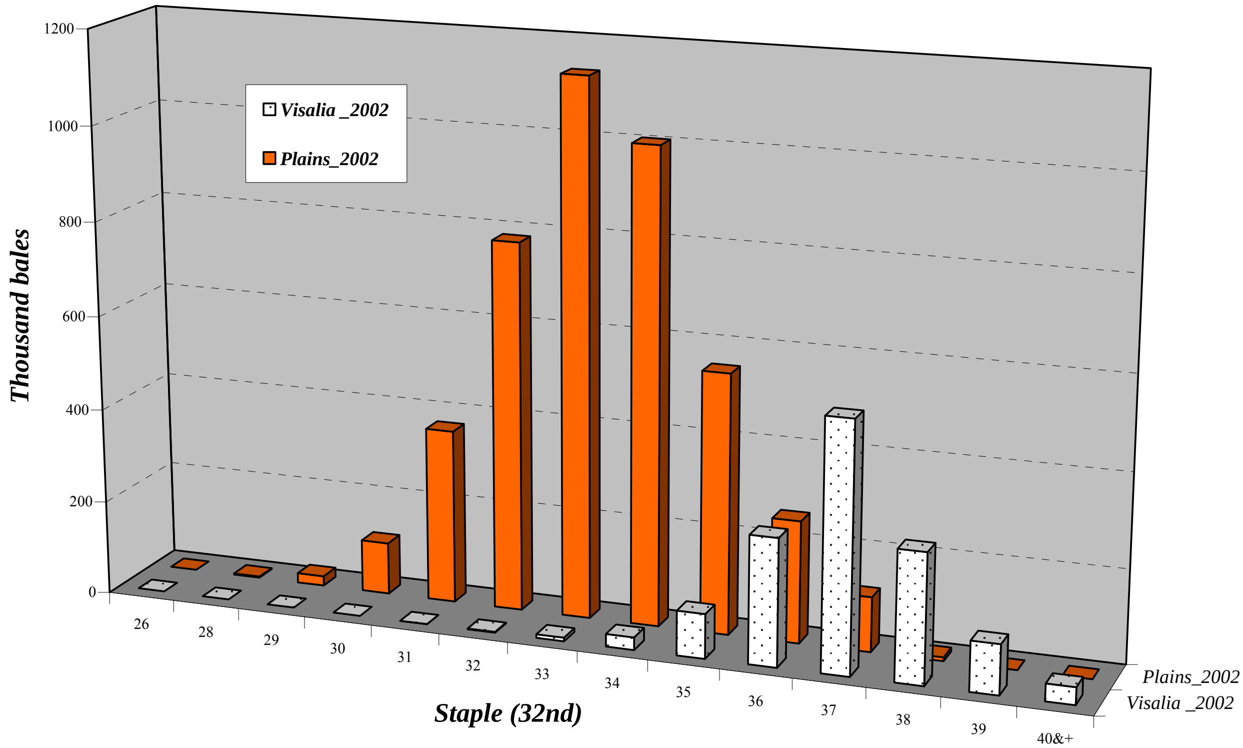

Figure 2: 2002 crop staple chart – Texas plains vs. California.

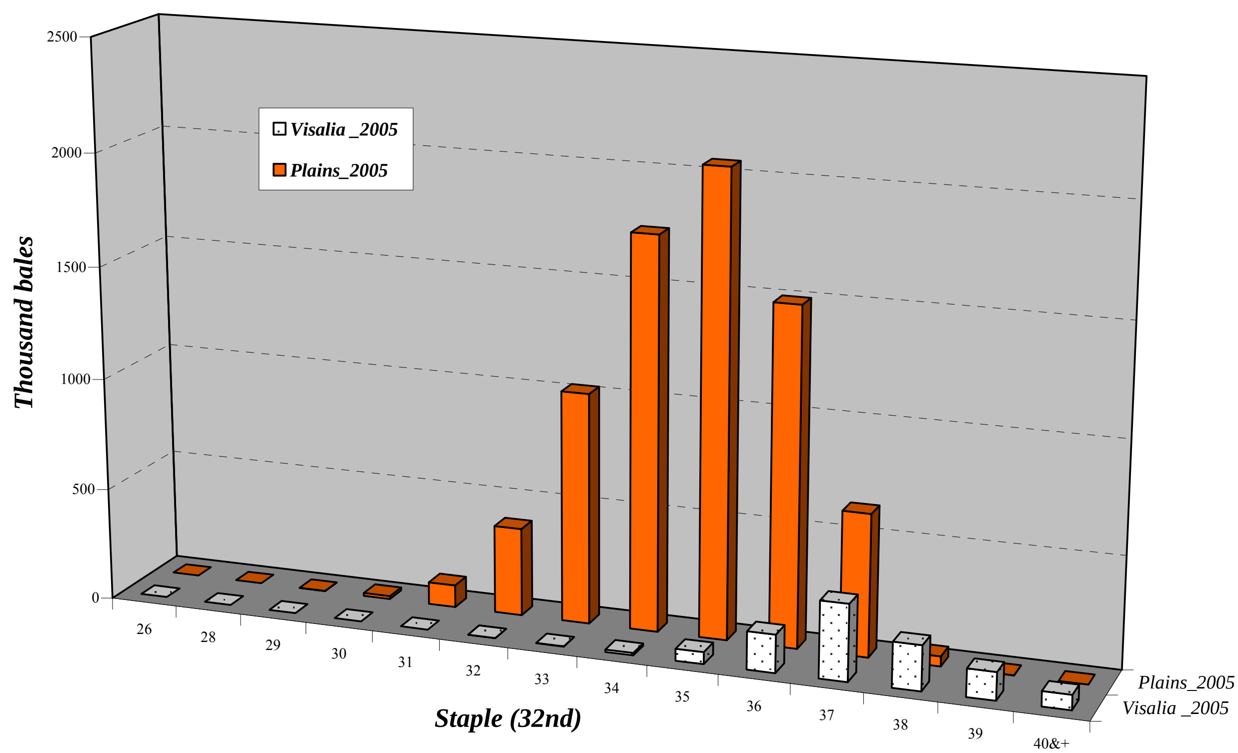

Figure 3: 2005 crop staple chart – Texas plains vs. California.

The positive shift of the Plains crop with comparison to that of SJV is apparent on the three Figures. Figure 1 shows that in 2000, the two staple distributions cover substantially different ranges. There is relatively few bales classed 35 and longer in the Texas Plains crop whereas most of the bales from California were 35 and longer. Figure 2 shows that in 2002 there were more bales classed 35 in the Texas Plains than in California and approximately as many bales classed 36 as in California. This appears to be a result of an increase of the Texas Plains production with a shift of the distribution towards longer staples. However, staples ≥ 37 originated primarily from California. Finally, Figure 3 shows that in 2005, the Texas Plains crop conquered one more staple level and became a more abundant source of bales classed 37 than SJV. However, the difference between the two crops remains present for the right tail of the staple distribution (38 and longer).

In summary, comparing the staple chart of the Texas Plains crop to that of California crop shows that a significant number of West Texas bales have staple lengths that are comparable to California cottons. Furthermore, this number has been increasing significantly over the last 5 years, which in 2005 made West Texas crop a predominant source of bales classed 36 and 37. Figure 4 is a clear illustration of this significant staple improvement in West Texas. It shows the substantial increase in the number of bales classed 36 and longer between 2000 and 2005.

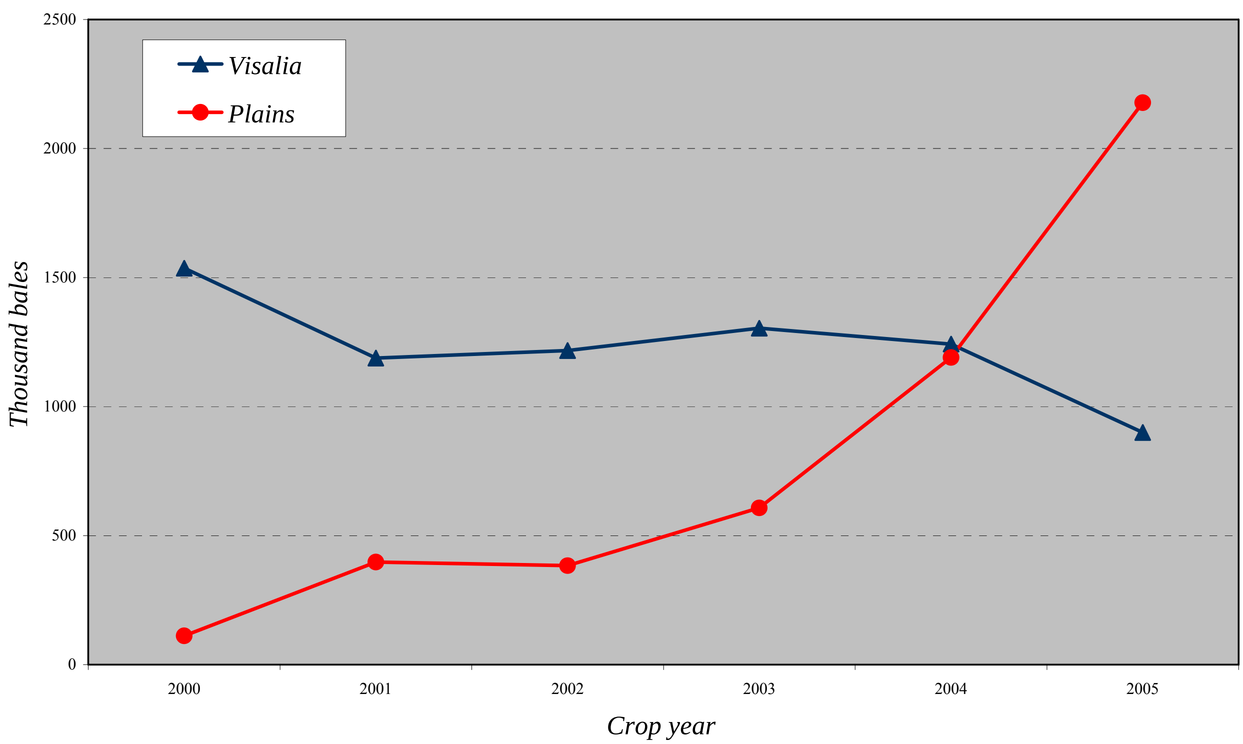

Figure 4: Texas plains crop improvement between 2000 and 2005 – number of bales classed 36 and longer.

These results and the consistent trend they show are very encouraging. However, although length is usually considered as the most crucial fiber property, other criteria are to be taken into account in assessing the high value-added potential of the improved crop.

It is also to be noted that all the figures above are represented using numbers of bales. Obviously, if we were to consider average values or fiber trait distributions in percentage terms, the overlap between the two growing regions will be less apparent. California cottons will appear far superior to the those produced in the Texas plains (see Figure 5 below). Therefore, it is important here to bear in mind the fact that we are not comparing the entire crops of the two production areas. What we are interested in is the small but consistently increasing portion of West Texas crop that shows fiber traits similar to those of an average or even less than average Acala-type California cotton. With the volume produced in the Texas plains, even a small percentage of the crop may represent a significant number of such bales (Figure 3), and thus could constitute a significant economic opportunity for West Texas producers.

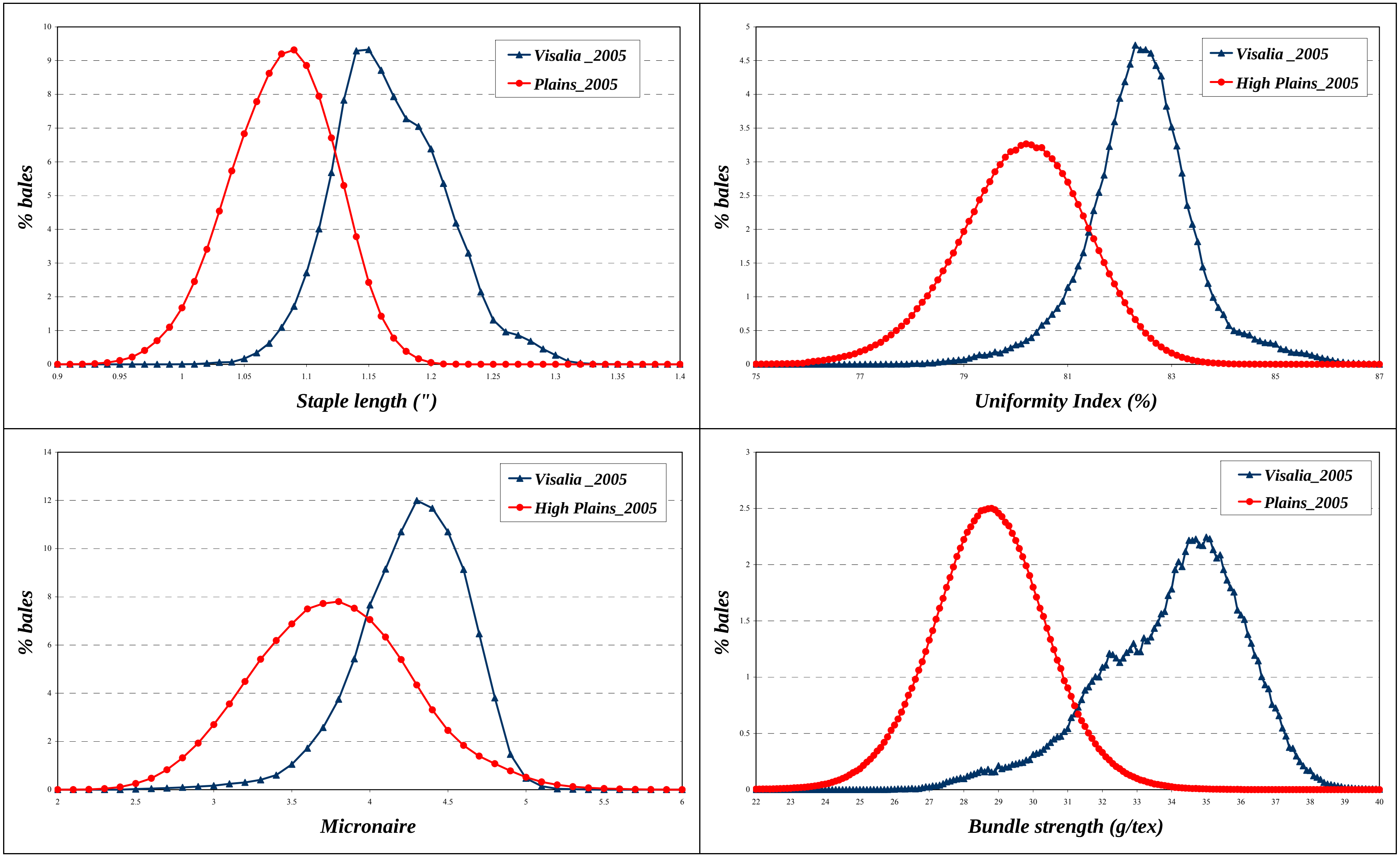

Figure 5: Staple, Uniformity, Micronaire and Bundle strength distributions of Plains and California 2005 crops (in % bales).

As shown above in Figure 5, fiber strength is among the criteria considered in this study. Fiber strength is of fundamental importance because it directly affects the mechanical properties and thus the durability of the final product. Other important fiber properties that we considered in evaluating Texas plains crop improvement were Micronaire and length uniformity.

In each of these properties, West Texas crop had a significant number of bales that are within the SJV ranges (this was previously noted for staple length in Figure 3). As an illustration, we show the case of Micronaire in Figure 6 and that of strength in Figure 7.

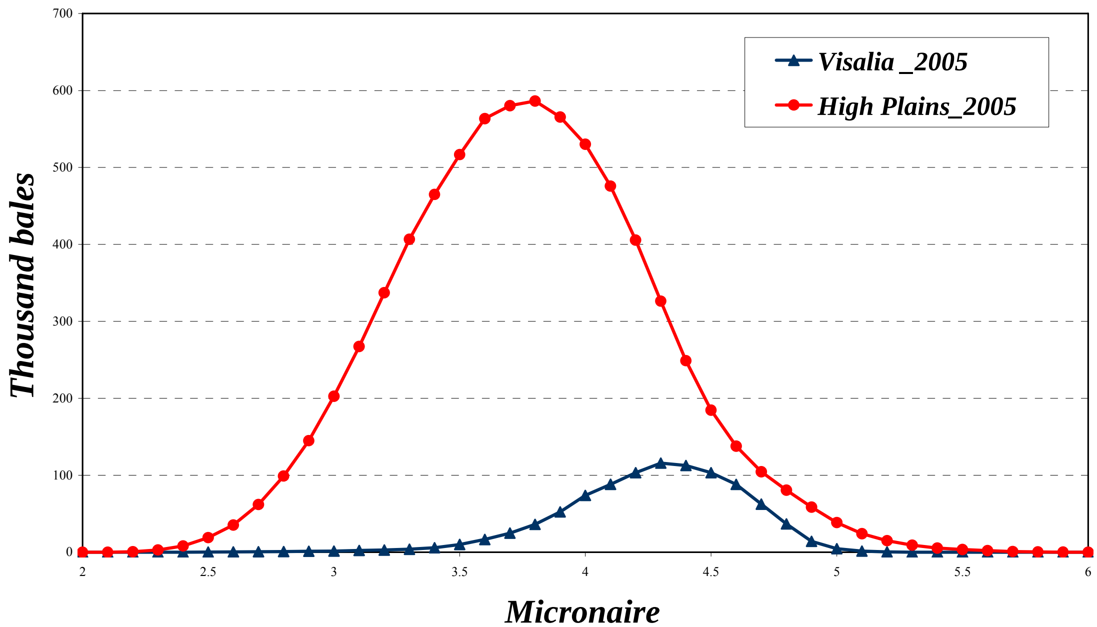

Figure 6: Micronaire distribution of Plains and California 2005 crops (in number of bales).

The example of Micronaire (Figure 6) is striking as it shows how by virtue of the volume produced in west Texas, there is a sufficient number of bales that cover the SJV Micronaire range despite the difference observed on the average Micronaire values and in the distributions plotted as percentage of bales (Figure 5). In the case of fiber strength, the overlap between the two distributions occurs mainly at the lower end of the SJV strength range (approximately 30 to 34 g/tex, Figure 7). The distribution of uniformity values showed a pattern similar to that of staple length with a significant number of bales from West Texas having uniformity values that are in the SJV range (overlap between 81 and 83%, see Figure 8).

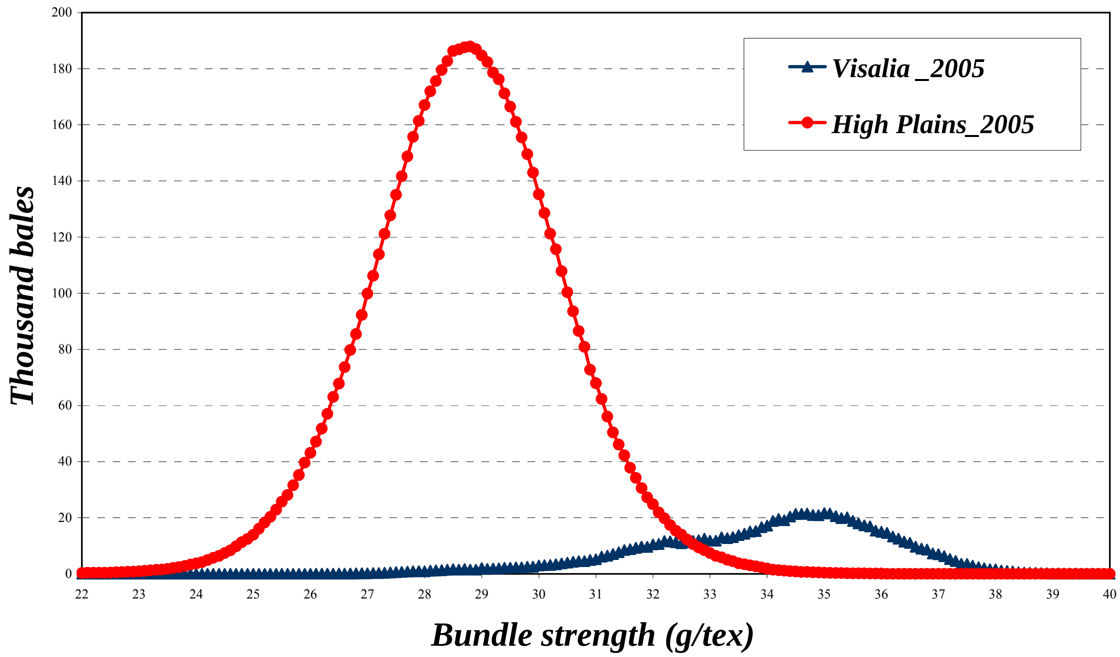

Figure 7: Bundle strength distribution of Plains and California 2005 crops (in number of bales).

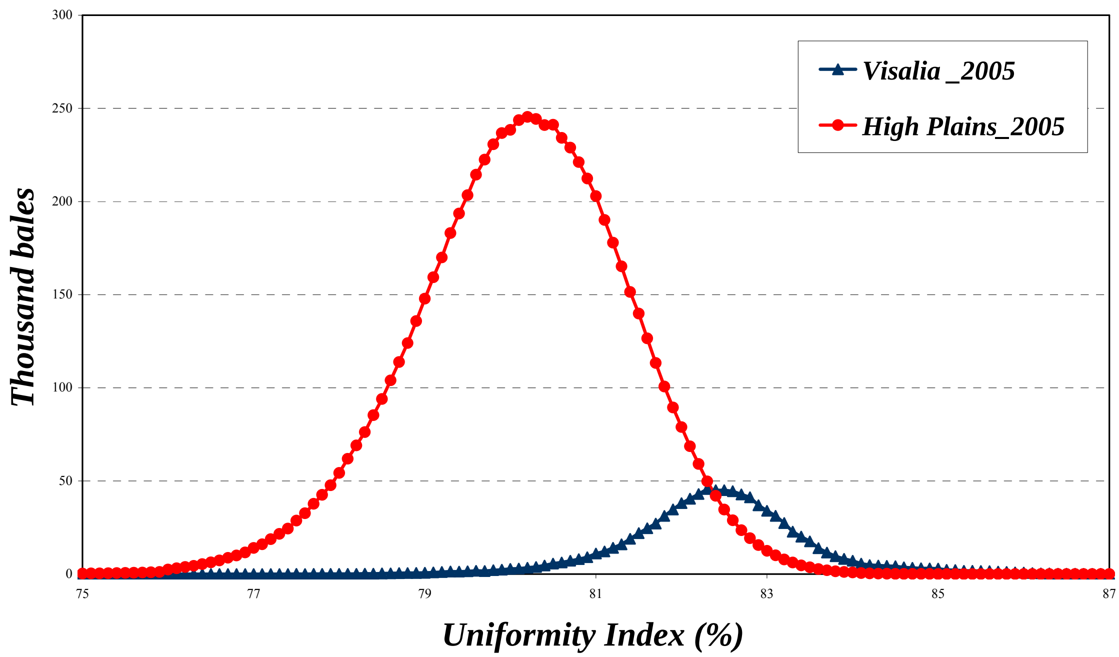

Figure 8: Length uniformity distribution of Plains and California 2005 crops (in number of bales).

Beyond the single HVI properties described above, combination of adequate levels of each trait is fundamental to ensure proper processing performance. It is therefore important to narrow our pool of bales that are promising for high value-added market to those that not only show long staples but also combine high strength and uniformity levels. Thus we examined the evolution of the crop using strength and uniformity as selection criteria in conjunction with length. The criteria used were: staple of 36 and longer, strength>29 g/tex, and uniformity > 81%. We represented the results in Figure 9 in a similar way as done previously with length as only criterion (Figure 4).

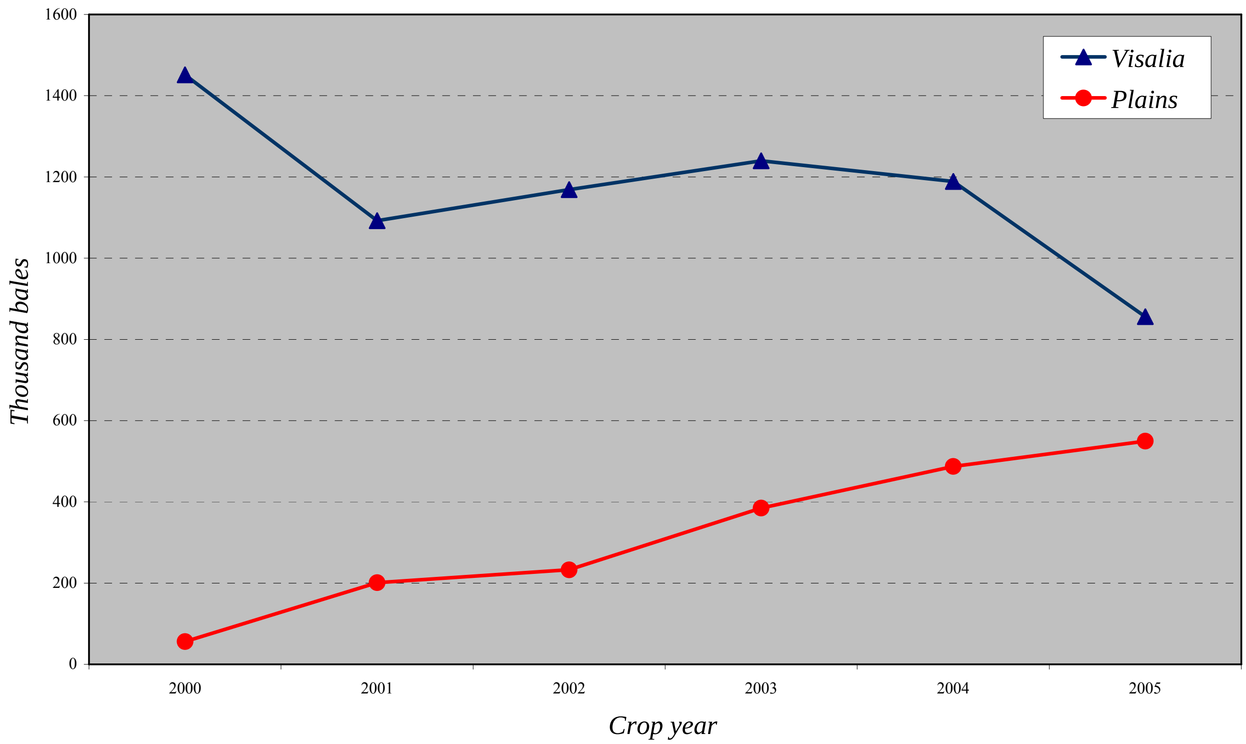

Figure 9: Texas Plains crop improvement between 2000 and 2005 – number of bales classed 36 and longer, Uniformity ≥ 81%, Strength ≥ 29 g/tex.

When combining the 3 criteria, the number of eligible bales is reduced significantly (in comparison to using staple as only criterion). Nevertheless, the positive trend showing overall improvement of Texas plains crop is still present and significant. In 2005, the number of bales combining the staple, strength and uniformity levels shown above was approximately 550,000 bales. Although this only represents about 7% of the crop, the number of bales is substantial and the economic impact of increased demand and appropriate appraisal of this portion of the crop could be significant. Moreover, the number of such high-end bales is constantly increasing and further improvement is already perceptible in the 2006 crop.

Note that addition of Micronaire to the three selection criteria considered above by limiting the acceptable range to that of SJV crop (approximately 3.5 to 5) further reduces the number of bales. However, this number remains above 440,000 bales for 2005 and the increasing trend remains significant.

In summary, the rationale behind seeking access to high value-added markets for West Texas cotton producers is compelling and is strengthening year after year. At present, this applies to a small portion of the crop and it is important to stress once more that in average, Texas plains crop remains far from the established quality benchmark, i.e., SJV cottons. However, there is a substantial number of bales combining quality levels at the upper end of West Texas crop that could compare favorably to Acala-type cottons from the lower end to average portions of California crop. This portion of the crop constitutes the central focus of our research.

Obviously, significant work remains to be done and is being done in order to further improve the varieties available to West Texas producers and adapt production and processing practices to suit the new high quality portion of the crop. This will maintain the improvement pace seen in the last 5 years and will lead to an even greater portion of the crop meeting the high-value added requirements. However, more work has also to be done to demonstrate the competitiveness of this cotton on the world market. It is essential that this cotton not be wrongly discounted or denied high-value-added applications. To prevent this from happening, we need to adequately assess and demonstrate the competitive value of this portion of Texas crop in such applications. This constitutes, as stated above, the long term objective of our research.

4. EXPERIMENTAL ASSESSMENT OF TEXAS PLAINS COTTON PERFORMANCE IN RING SPINNING

4.1. MATERIAL AND METHODS

In 2005, a first range of fifteen commercial cotton bales was selected from three different growth areas: Texas plains, South Texas (Coastal Bend) and San Joaquin Valley. The bales were selected to form similar HVI fiber quality ranges, with 5 higher than average staple levels (35 to 38) from each of the three growth areas. Staple length constituted the main selection criterion. Other fiber properties were held in a range as narrow as possible to avoid interactions among multiple fiber attributes. The bales were spun in identical conditions and spinning preparation performance parameters (cleaning efficiency, fiber breakage), spinning performance parameters (ends-down), as well as yarn quality parameters were measured for each bale.

Results obtained on the first range of samples were very encouraging; however, given the high variability of the quality parameters and performance measures of interest, the sample range has to be broadened and extended over multiple crop-seasons. Therefore, in order to achieve the objectives of this research, evolution of the results has to be closely monitored on a yearly basis over a long period of time.

Thus in 2006, a second range of 15 bales was selected (Table I). The data in the table correspond to classing office results used to select the bales. In addition to staple length, the selection criteria were: a Micronaire of 4.1 to 4.3, Uniformity ≥ 82%, strength of 29 to 31 g/tex, color grade of 42 or better, and leaf grade ≤ 4. These specifications are consistent with those of the previous crop season. Table I shows that, based on classing office data, the specifications on all fiber traits were met, with the exception of one bale from the Texas Plains for which we had to make a compromise with regard to Micronaire (3.9) in order to obtain the 39 (1/32") staple level.

Again, it is worth emphasizing that the objective of this selection was not to obtain cottons that are representative of ranges of HVI properties predominant in each growth area, but to constitute ranges of bales with similar HVI properties and with the growth area (and eventually some related non-HVI quality traits) as main performance variation source. Obviously, those bales will originate from the upper tail of the Texas plains quality chart and the lower tale of the California quality chart as mentioned in the previous sections of this report.

Table I: Selected bales – Classing office data

Origin	Staple length Specs	Mike	Staple	Length (inch)	Uniformity (%)	Strength (g/tex)
Plains	**35**	4.3	35	1.09	82	30
Plains	**36**	4.1	36	1.11	83	29
Plains	**37**	4.3	37	1.17	85	31
Plains	**38**	4.3	38	1.18	82	30
Plains	**>38**	3.9	39	1.21	82	29
South TX	**35**	4.3	35	1.08	82	31
South TX	**36**	4.1	36	1.12	82	30
South TX	**37**	4.2	37	1.15	82	30
South TX	**38**	4.1	38	1.18	83	31
South TX	**>38**	4.2	38	1.20	82	30
SJV	**35**	4.2	35	1.10	82	30.9
SJV	**36**	4.1	36	1.13	82	30
SJV	**37**	4.1	37	1.16	82	30.2
SJV	**38**	4.3	38	1.2	82	30
SJV	**>38**	4.3	39	1.22	82	30.2

Sampling and raw fiber testing proceeded shortly after all the bales were received. The bales were sampled on 10 layers throughout in order to obtain fiber data that is representative of the bale. The samples were put through ITC's high-accuracy procedure on the HVI (4 replications for Micronaire, 4 for color, and 10 for length and strength).

The fifteen bales were then spun simultaneously on a 240-spindle Suessen Fiomax 1000 ring spinning frame into 40 Ne, 3.8 TM yarn. The spinning process (see outline in Figure 10) was monitored for ends-down. Fiber samples were collected at all phases of the process (opening-cleaning, carding). The waste was also collected and quantified. The yarn was tested for evenness, hairiness and tensile properties.

As described in the project's protocol and in previous progress reports, the targeted duration of the spinning trials was intended to total 5250 spindle*hours (i.e., 350 hours on 15 spindles). Indeed, given the low frequency of the occurrence of yarn ends-down when spinning under normal conditions (see next section), it is necessary to run long tests in order to obtain an accurate assessment of the cotton spinning performance. The ASTM standard method D2811-77 (ASTM, 1991) describes four different options for running the test, with the number of spindle hours ranging from 84 (small laboratory scale) to 25,000 (mill scale). The laboratory scale procedure (84 spindle hours) is presented as a rough screening method. Early efforts to investigate the accuracy of spinning performance assessment were reported in the literature by Ruby and Parsons (Ruby and Parsons, 1949) who suggested a minimum number of 5,000 spindle*hours to achieve acceptable accuracy under controlled testing conditions.

Therefore, for the purpose of our study, we selected the test procedure recommending 5,000 spindle*hours (pilot mill scale). In order to allow simultaneous spinning of all the bales, 10 lots of 15 roving bobbins were constituted from each bale (one lot per layer) and each lot was used to complete 35 spinning hours. Spinning positions were assigned randomly to each lot in order to eliminate possible errors due to variations among spindles. In total, each bale was spun on 15 positions for 350 hours to complete 5,250 spindle*hours.

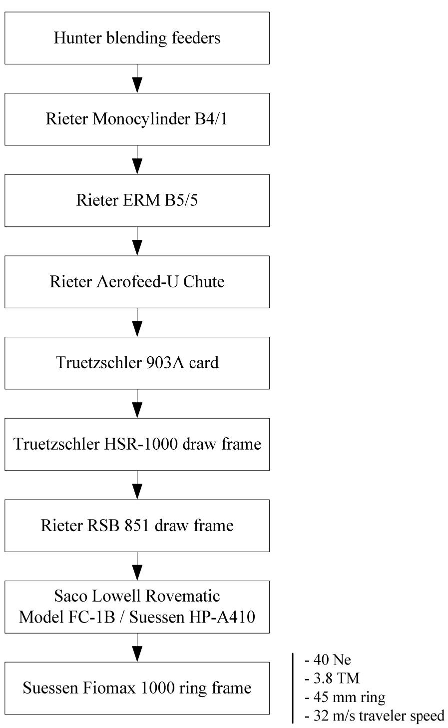

Figure 10: Spinning procedure

After completion of all spinning trials, yarn end-breakage data was compiled for all the tests. A total of 150 yarn samples were produced, with 7 doffs (7 bobbin changes) per sample in order to complete the required 5250 spindle*hours. The middle doff (doff 4) was taken to the Material Evaluation Lab for testing. The yarn was tested for evenness, hairiness and tensile properties.

As previously mentioned, fiber samples were collected at all phases of the process (raw, opened-cleaned, carded sliver). These were tested on AFIS for neps and trash contents, as well as for individual fiber properties (length, fineness, maturity). The waste was also collected and quantified at all steps of the sinning process.

4.2. RESULTS AND DISCUSSION

Table II shows results of HVI tests conducted on the 10-layer samples using the high-accuracy procedure. The results are somewhat different from the classing office data. These differences in fiber properties are considered and accounted for in all following discussions.

Table II: HVI results on the 10-layer samples.

Origin	Mic.	Length	Unif.	Strength	Elon.	Rd	+b	Leaf
SJV	4.1	1.13	82.3	30.7	4.8	78.5	8.3	1
SJV	3.9	1.15	81.9	30.5	5.8	80.1	9.0	1
SJV	4.0	1.15	82.0	30.7	4.9	78.5	8.3	1.2
SJV	4.3	1.23	82.8	33.0	6.2	77.4	9.3	1
SJV	4.2	1.25	83.3	33.6	6.3	77.8	9.2	1
Plains	4.2	1.09	81.5	29.6	3.5	74.0	9.1	2.1
Plains	4.1	1.13	83.3	29.2	5.4	76.4	10.2	2
Plains	4.3	1.16	83.5	29.6	4.8	75.7	9.4	1.6
Plains	4.3	1.17	82.8	30.7	4.8	75.6	9.1	2.1
Plains	3.9	1.22	82.5	28.5	5.4	75.2	9.1	2
South TX	4.3	1.08	82.1	29.3	7.2	78.4	9.7	1
South TX	4.0	1.10	81.6	29.6	6.0	78.8	9.2	1.1
South TX	4.1	1.15	81.7	30.2	4.4	78.0	9.2	1.5
South TX	3.8	1.16	81.8	30.6	5.1	79.3	8.7	1.2
South TX	3.9	1.19	82.3	31.3	4.3	76.5	8.5	2.7

Differences between growth areas within each targeted quality levels can be examined in Figures 11 to 14. Although the bales were selected to constitute similar quality ranges from the three growth areas, Figure 11 shows that bales purchased from California were generally longer than those from both Texas origins. As for Micronaire values (Figure 12) the results show more than one bale that fall outside the targeted range of 4.1 to 4.3 (2 from SJV, 1 from Plains, and 3 from south TX). Figure 13 shows that some of the bales were slightly below the targeted minimum uniformity level of 82 %. However, these differences were within the typical tolerance limits for uniformity. It can also be seen on Figure 13 that bales selected from Texas plains had significantly better than average uniformity levels (except for the shortest bale). Finally, Figure 14 shows that even though the minimum strength requirement of 29 g/tex was met for all the bales (except for the longest Plains bale), cottons from SJV were generally stronger than their counterparts from the other two areas. In fact, strength levels we obtained through the 10-layers sampling protocol and the high-accuracy HVI testing procedure were higher than those assigned to the SJV bales at the classing office.

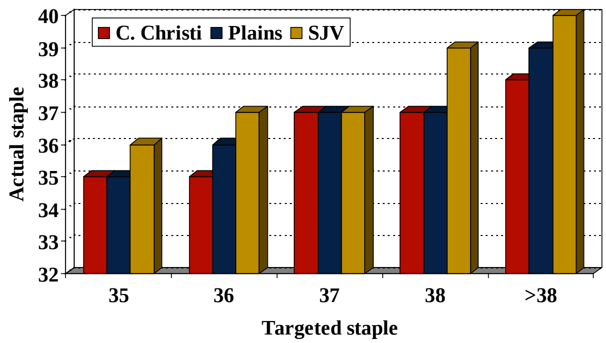

Figure 11: 10-layer staple results for the 15 bales.

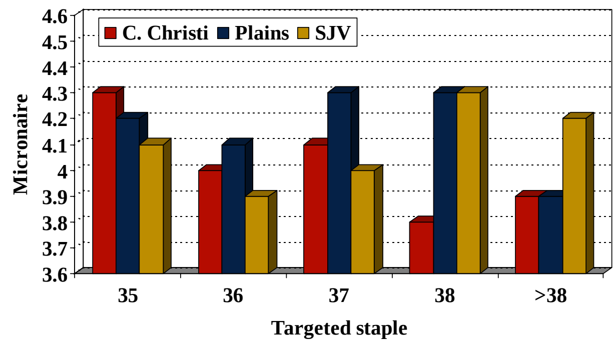

Figure 12: 10-layer Micronaire results for the 15 bales.

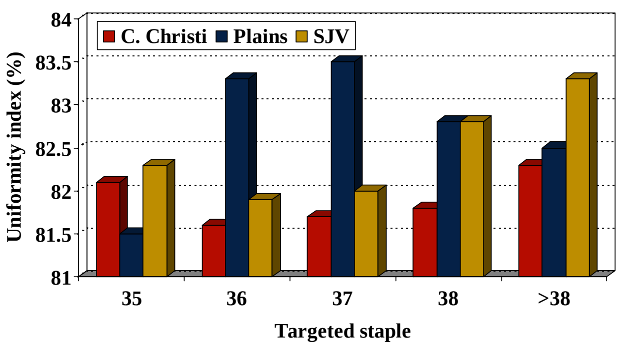

Figure 13: 10-layer uniformity results for the 15 bales.

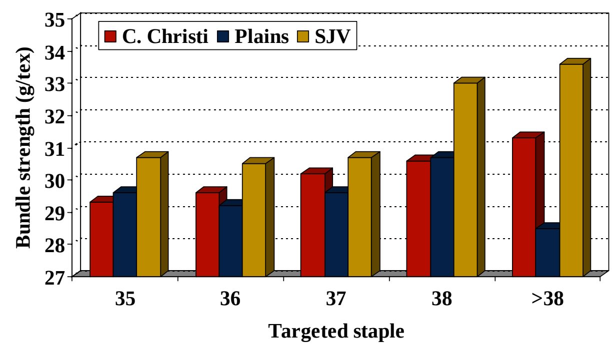

Figure 14: 10-layer strength results for the 15 bales.

Results discussed above show that in spite of the efforts made to obtain bales with the same properties from the 3 areas, inevitable errors related to classing office results (sampling/testing conditions errors…) are such that the actual bale value determined through more rigorous sampling and testing procedures (10 layers with more replications on the HVI) deviate some from the values used to select the bales. The differences observed are however within acceptable ranges. Furthermore, this deviation is taken into account in the analyses conducted in this study and in the conclusions drawn based on the results.

At present, we will examine the behavior of the cottons during spinning preparation based on single-fiber properties measured on the Advanced Fiber Information System (AFIS). A discussion of spinning performance (ends down) data will follow. Finally we will examine some of the main yarn quality parameters.

4.2.1. *Spinning Preparation*

Raw fiber quality (as measured by HVI or other instruments) is often an excellent indication of the industrial potential of the cotton. However, the decisive factor in a yarn spinner's choice of one cotton over another is the fiber quality resulting in the sliver destined to produce the yarn, which is a function of both the initial fiber quality (raw fiber) and the alterations that occur in the course of the different processing stages (fiber-machine interactions).

Among the most critical fiber quality alterations that occur during spinning preparation we find fiber breakage phenomena, which in addition, are typically accompanied by some short fibers removal with the processing waste. As a result of these combined effects, optimized processing conditions during spinning preparation (i.e., gentle mechanical handling to preserve fiber length) usually result in unchanged percentages of short fiber after the major opening-cleaning and carding operations (Krifa, 2004).

Figure 15 depicts the variation of short fiber content as measured using the AFIS® among bales from the three origins, as the cottons are put through spinning preparation stages (opening-cleaning and carding). Single dots correspond to single bales with the staple specifications shown on the abscissa axis. The different line patterns and point markers are used to distinguish between the three growth areas. Finally, the three distinctly shaded areas of graph correspond to the three processing stages considered (raw bales, opened lint, and card sliver).

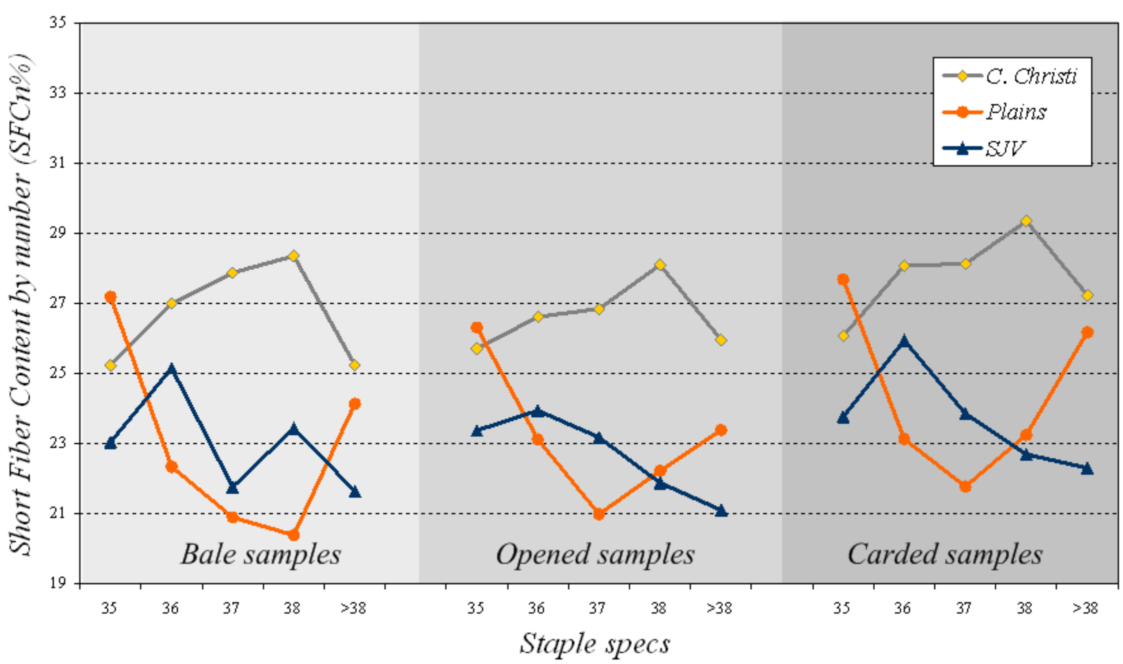

Figure 15: Short fiber content variation among origins and through spinning preparation.

Results in Figure 15 reflect those typically observed (Krifa, 2004). The short fiber content appears to vary very little from bale to opened fiber and then from opened cotton to card sliver. However, there appears to be a significant variation between bales from the three growth areas. Except for the shortest one, bales from Texas plains appear to generally rank well compared to those from Corpus Christi and SJV and do not appear to show severe breakage problems.

Results related to cleaning efficiency of the bales are shown in Figure 16 (below). It depicts the variation of the percentage of visible foreign matter *(VFM%)* as a function of the spinning preparation stages for the bales from each growth area (in a similar way to above). Examination of these plots show that bales from the Texas plains had higher percentages visible foreign matter than those from the other two production areas (except for the longest bale which was exceeded by its South Texas counterpart). Bales from California appear consistently cleaner when considering bale samples. Differences between bales from the three production areas appear to diminish after opening-cleaning operation (i.e., when considering the opened samples in the middle of the figure below). After the ultimate cleaning step included in this process (i.e., the card), differences between growth areas in the percentage of foreign matter disappear completely. Therefore, the initial higher contamination of the selected Texas plains bales does not appear to negatively impact the percentage of visible foreign matter detected in the processed sliver.

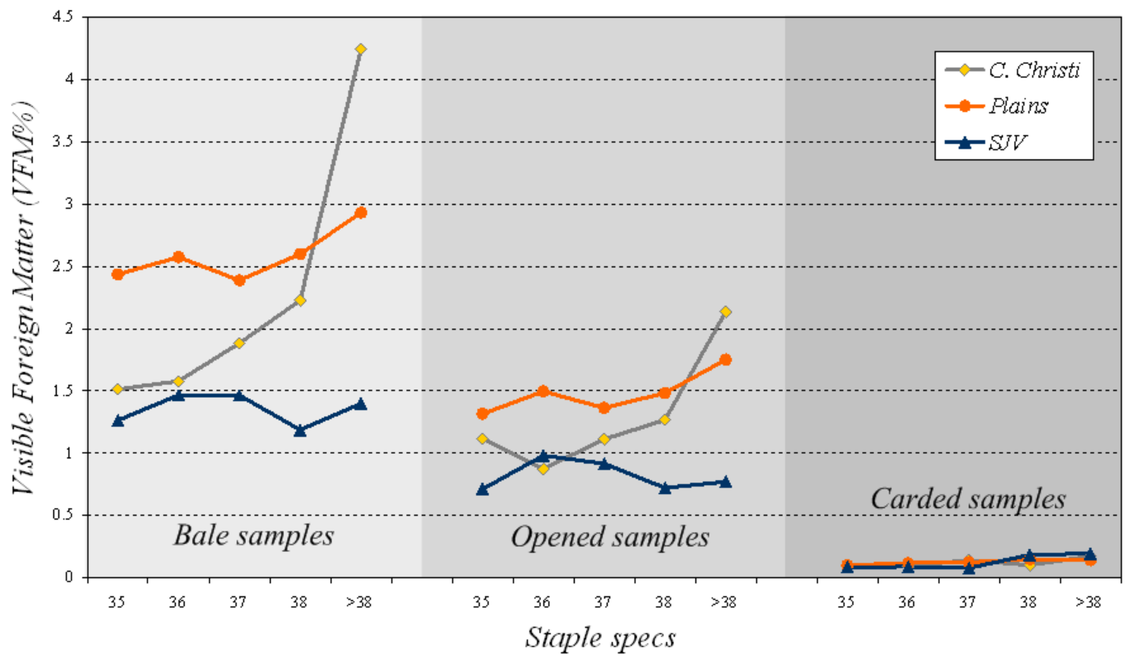

Figure 16: Visible foreign matter variation among origins and through spinning preparation.

Figure 17 represents the effects of opening-cleaning and carding on the number of neps (fiber entanglements) detected in the bales we tested. Again, the different line patterns represent the three growth regions and the three shaded areas of the graph represent processing stages (raw fiber/bale samples, opened samples, and carded fiber, from left to right). The plots show the expected overall increase in the number of neps after opening and cleaning stages, then the dramatic decrease of neps occasioned by carding.

Based on the results represented in the figure below, the 5 bales selected from Texas plains 2005-06 crop appear to have a clear advantage when considering the number of neps detected using the AFIS. This advantage is apparent in bale samples and throughout the spinning preparation process and remains perceptible even after carding. Indeed, although the difference among growth areas appears to be attenuated after carding, bales from Texas plains still appear to have lower numbers of neps. Further analysis of the significance of this effect will be conducted when the number of bales included in the study is sufficient to ensure a powerful statistical test.

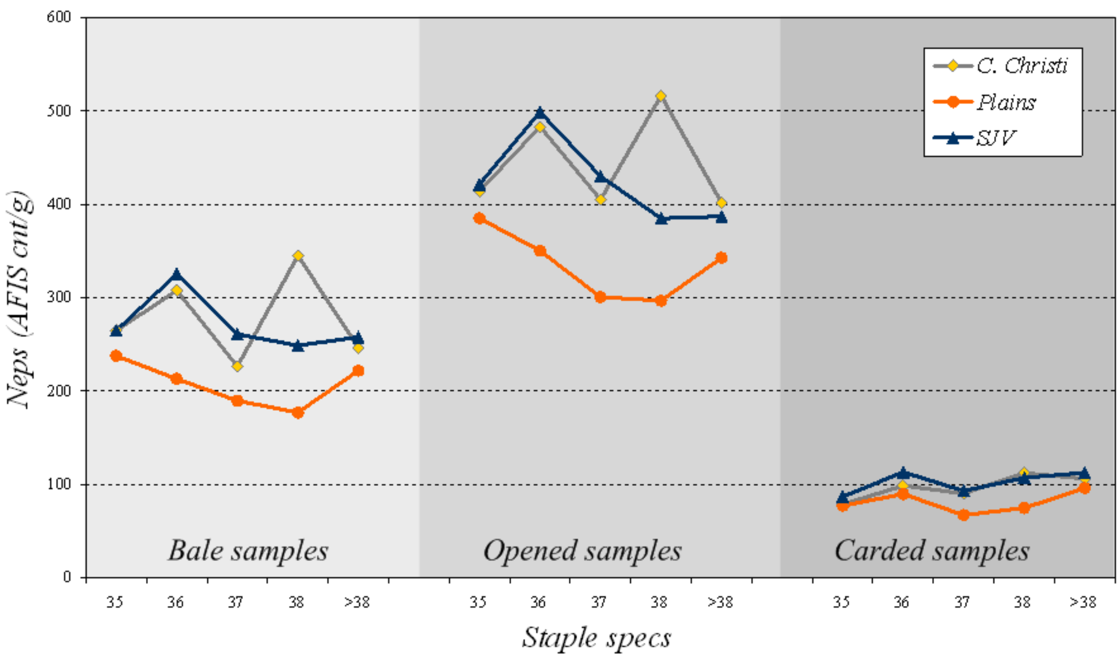

Figure 17: Fiber neps variation among origins and through spinning preparation.

As mentioned in previous progress reports, seed-coat fragments or seed-coat neps (as detected by the AFIS) are another significant contaminant of cotton and are particularly critical in the high-value-added ring spinning applications we target here (Krifa *et al.*, 1999; Krifa *et al.*, 2001; Krifa *et al.*, 2002a). Results concerning seed-coat neps are shown in Figure 18 in a similar way as above.

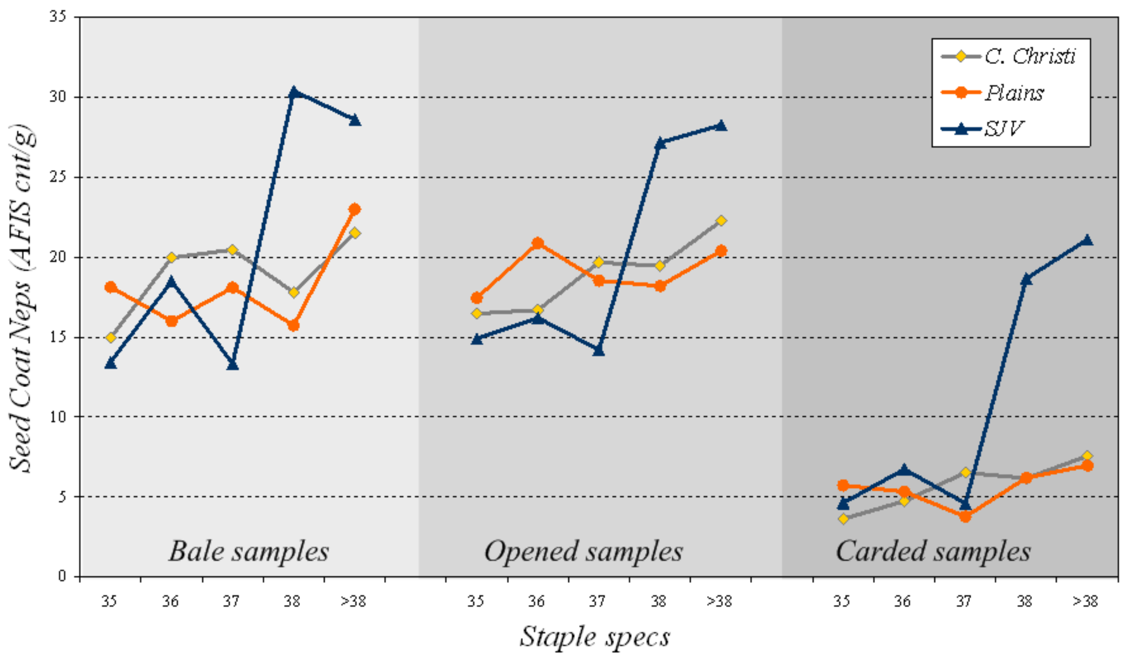

Figure 18: Seed coat neps variation among origins and through spinning preparation.

Based on the results represented in Figure 18, the card appears as the only step in this spinning preparation process to result in a significant reduction in seed coat neps. This result is expected because of the combination of seed-coat fragments removal and fragmentation (size reduction) phenomena during opening and cleaning operations which result in virtually no change in the number of seed-coat neps detected using the AFIS® (Anthony *et al.*, 1988; Verschraege, 1989; Mangialardi, 1992; Krifa *et al.*, 2002a).

More importantly, Figure 18 also shows that unlike other trash-type contaminations (examined above using the visible foreign matter parameter), contamination with seed coat neps persists throughout the spinning preparation process. In other words, bales that contained the most seed coat neps at the raw fiber stage were those that had the highest seed coat neps contamination after spinning preparation. In so far as growth areas are concerned, the bales showing a seed coat neps problems were the two longest ones selected from California.

Overall, examination of non-HVI properties (i.e., AFIS measured properties) of the bales tested this year showed that those selected from Texas plains appeared to have some advantages that are of significance from the spinner's perspective. Three of those bales exhibited the lowest short fiber content (SFC) in the raw cotton among all the bales tested and ranked among those with the lowest SFC after opening cleaning and carding. Another significant advantage was related to neps (fiber entanglements). Bales we selected from the Texas plains had the lowest number of neps compared to the other two origins, and this throughout the spinning preparation process.

Finally, bales from the Texas plains did not show a sizeable seed coat fragment contamination, unlike two of the California bales.

Contamination with trash and dust particles (as represented by the VFM% in this report) appeared as a potential drawback of Texas plains bales when considering raw fiber results (i.e., bale samples). However, higher percentages of Visible Foreign Matter in these bales appear to be offset by the high cleaning efficiency of the opening and carding processes, with respect to this type of particles (as seen above, this does not apply to seed coat fragments). Indeed, Texas plains bales had levels of contamination that are similar to those of bales from the other two origins after carding (based on VFM%).

4.2.2. Performance during spinning

As stated in previous sections, ends-down were monitored during the spinning trials in order to provide an assessment of the spinning performance of the cottons from the three growth regions. In normal spinning conditions, ends-down are rare events, which explains the need for long spinning tests in order to obtain a relevant ends-down assessment.

Figure 19 reports the frequency distribution corresponding to the occurrence of ends-down events per unitary spinning trial of 5 hours on 15 spindles (1 doff). Results are shown for the trials conducted during the first year (2005) as well as for the new 2006 bales. It can be seen from the graph that results are consistent over the two years; the vast majority of doffs (approximately 85%) had only between 0 and 2 ends-down events. Only about 9% had between 2 and 4 ends-down and very few had more than 4 ends-down.

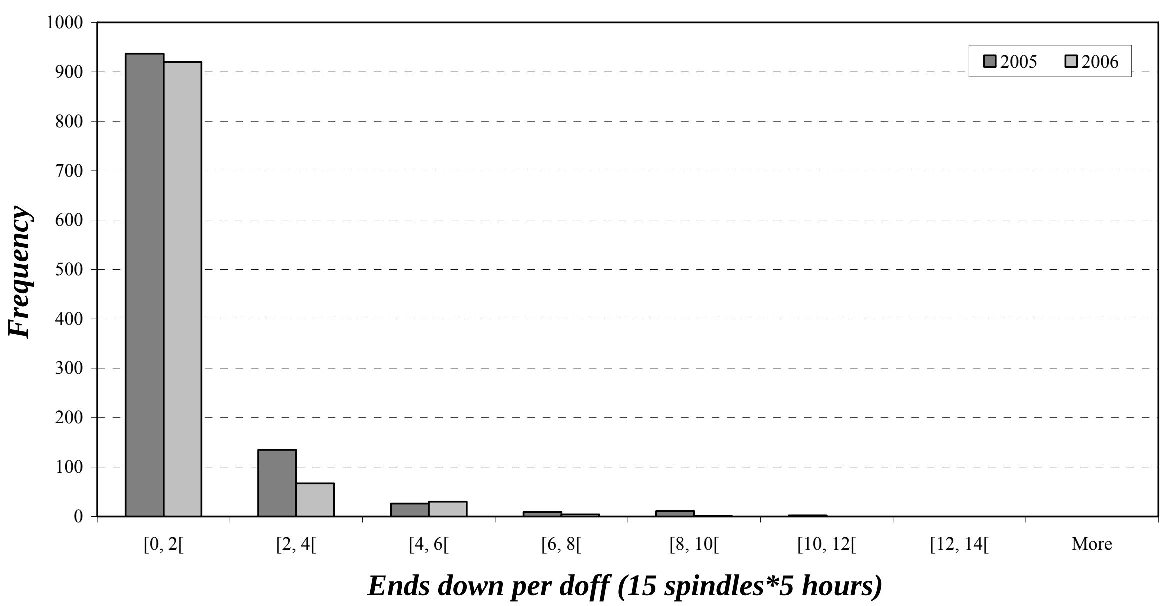

Figure 19: Ends down occurrence per doff (15 spindles*5 spinning hours).

Figure 20 shows average ends-down numbers per bale and per growth region. The bales are sorted by increasing staple within each growth area. As in the previous year, the results show a perceptible trend for the cottons from SJV to have lower frequencies of ends-down occurrence; bales from South Texas appear to have the highest frequency; their counterparts from the Texas plains are in between the two other regions. It is worth noting that the difference between Plains and SJV cotton is mainly seen for the two shortest staple levels. The longest bales from the Texas plains, i.e., staples 37, 38 and 39 exhibited similar or lower numbers of ends-down compared to their counterparts from SJV.

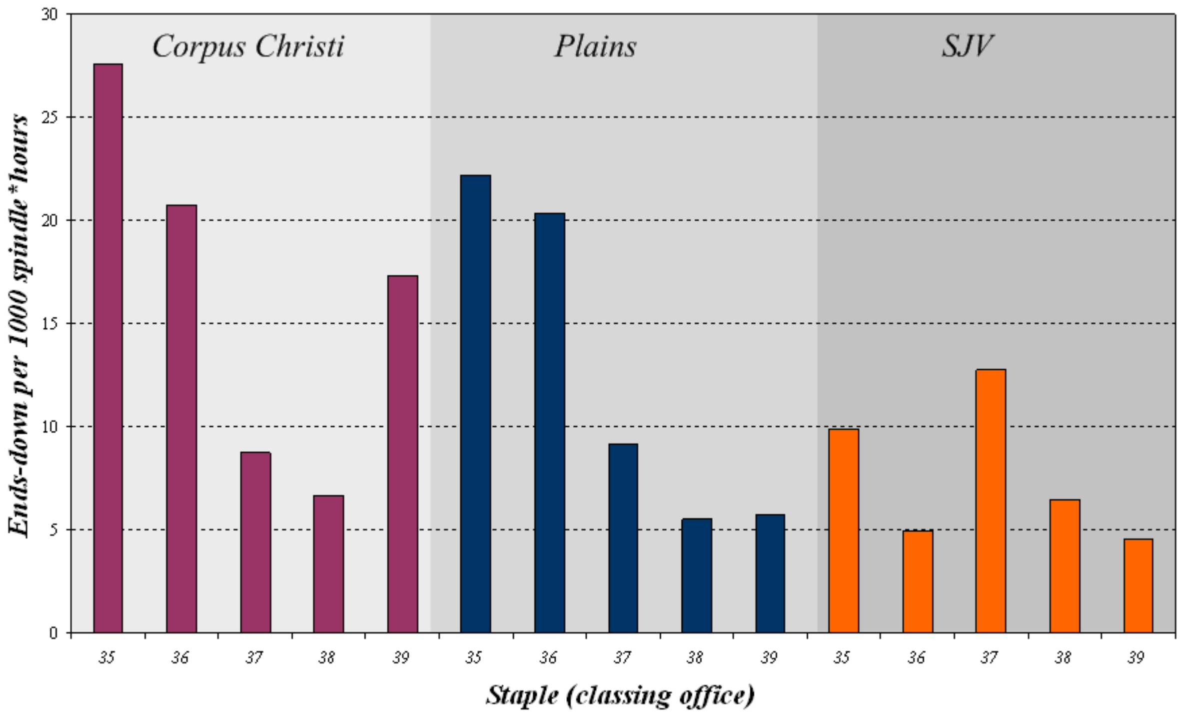

Figure 20: End-down occurrence per bale and per growth origin.

The results above were further scrutinized using analysis of covariance (ANCOVA) in order to include both categorical factors (growth region) and continuous predictors or covariates (fiber properties) that affect the number of yarn ends-down during spinning. A summary of the ANCOVA results can be seen on Figure 21, showing average values of ends-down frequency per growth region adjusted for staple length as a covariate, with the confidence intervals corresponding to the region effect.

The trend described above based on Figure 20 appears clearly in Figure 21. However, average ends-down levels appear to differ very little form a growth origin to another and show overlapping confidence intervals. The overall effect appears non significant based on the ANCOVA results ($p > .05$).

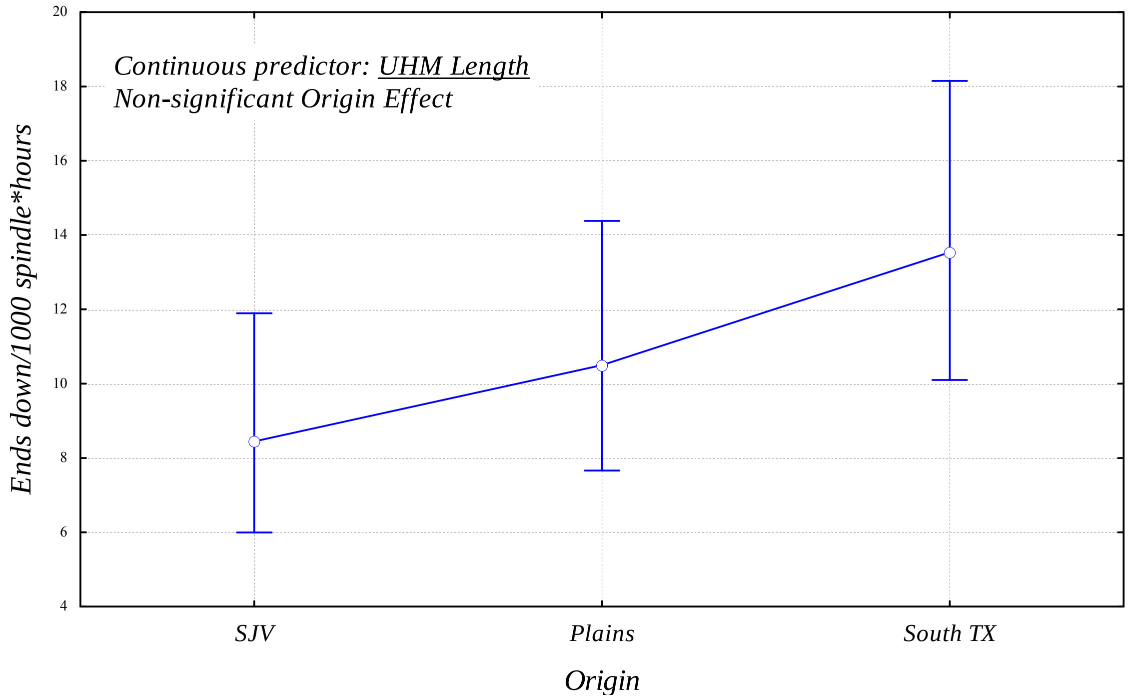

Figure 21: Ends-down occurrence, analysis of covariance results.

As seen above, staple length appeared as a significant covariate affecting yarn ends-down during spinning. We further examine this effect in the following discussion. Figure 22 depicts the relationship between ends-down levels and staple length for both Texas plains and SJV bales.

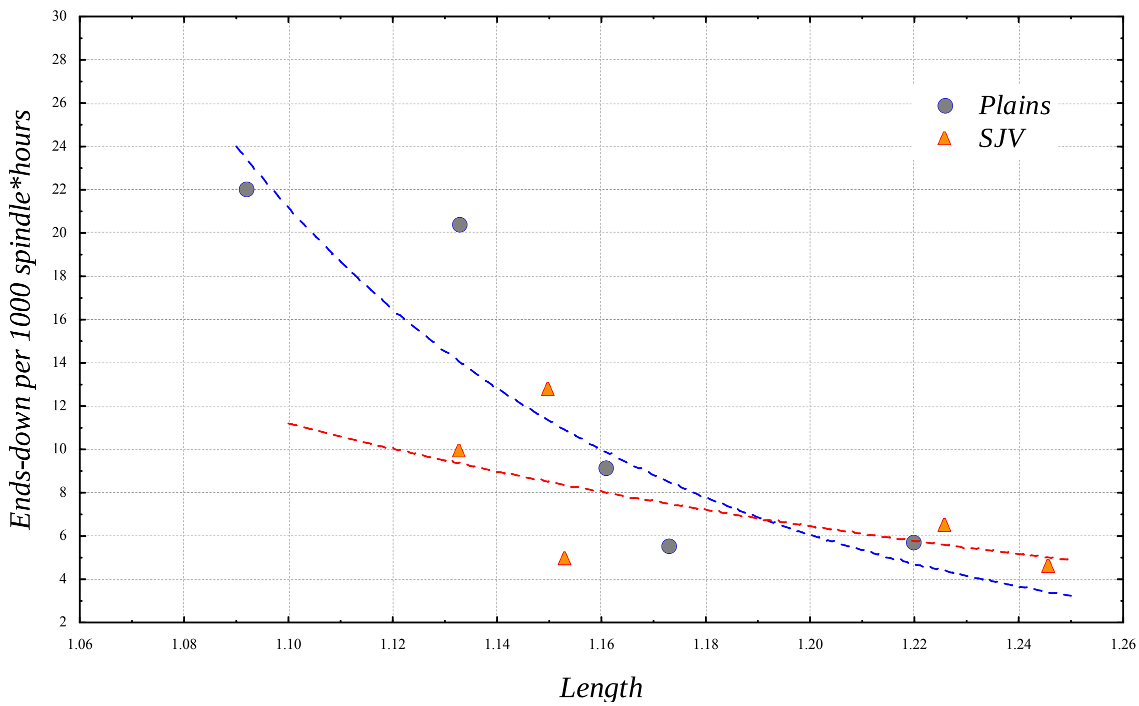

Figure 22: Relationship between ends-down occurrence and fiber length for Texas plains and SJV bales (2006 results).

Although the data points show a substantial degree of dispersion, there is a clear negative trend relating ends-down to staple length (lower ends-down for longer cottons, as expected). Moreover, the pattern of the scatter plots above (Figure 22) suggest that when considering the shorter staples, cottons from Texas plains tended to yield slightly higher numbers of ends-down than their SJV counterparts (for the same staple length). This is likely to be due to the combination of a multitude of quality parameters (other than staple length). However, for the longer staple levels, the two scatter plots appear to converge and the number of ends-down appears similar for both regions.

Again, with the limited number of bales at this stage of the project, we cannot be more conclusive concerning these trends. However, it is encouraging to note that these results are in concordance with those observed in the first year of the project.

We have grouped data obtained thus far from the 2005 and 2006 spinning trials and examined the trends involving yarn ends-down in a similar way as above (Figure 23). The grouped scatter plots of Figure 23 show a pattern that appears consistent with the observations made above. Further observations and confirmation of these results with a broadened range of bales from future seasons will help us decipher the intricate interactions involved in this effect.

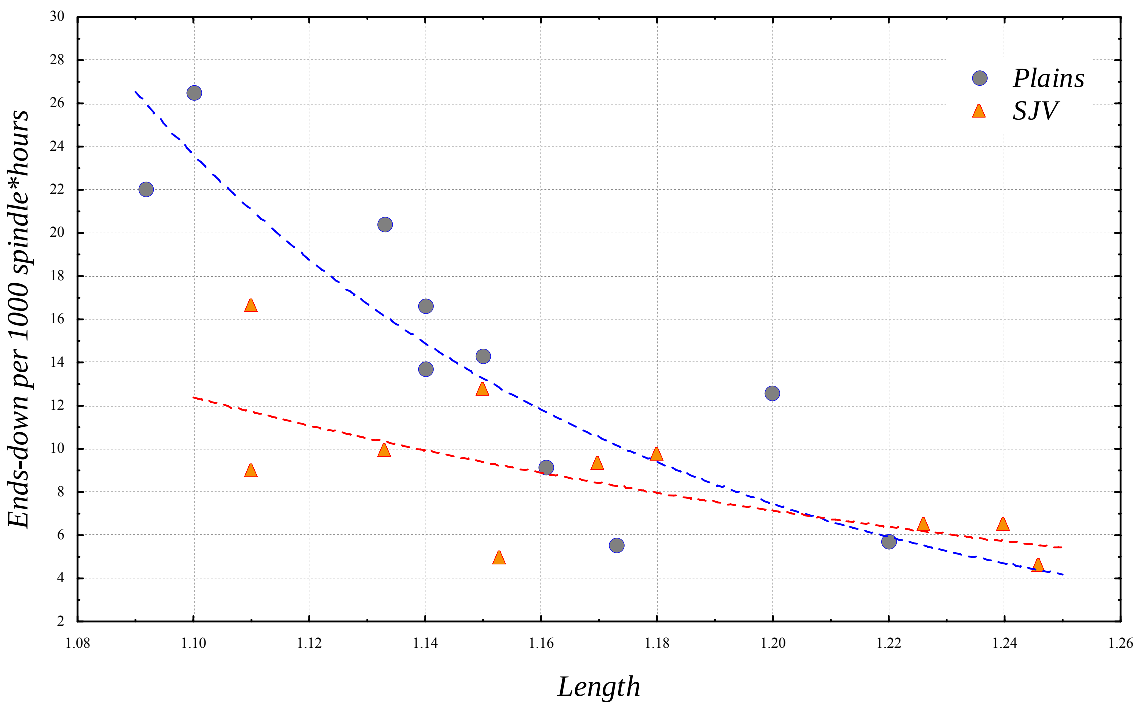

Figure 23: Relationship between ends-down occurrence and fiber length for Texas plains and SJV bales (2005 and 2006 results).

4.2.3. Yarn Quality

Previous research has consistently shown the possibility of producing high-quality ring spun yarns from a significant portion of Texas commercial cotton crop, including that of the Texas plains (Krifa *et al.*, 2002b). In addition to the spinning performance aspects discussed in the previous section, we have collected yarn quality data (evenness, hairiness, and tensile properties) in order to assess the overall performance of the cottons.

Yarn results were analyzed using ANCOVA in a similar way as previously. Continuous predictors were selected based on the relevant fiber properties that are significantly related to the yarn property being examined. In what follows, Results are presented in an analogous way as for ends-down data.

Figure 24 depicts results obtained for yarn unevenness (mass CV%). Among the fiber properties introduced in the ANCOVA model, length and uniformity were the significant covariates. Based on the ANCOVA results, the bale origin appeared to have a significant effect on yarn unevenness ($p = 0.039$, after adjusting for the length and uniformity effects). However, it is also apparent from Figure 24 that the significant effect is mainly due to a higher level of unevenness obtained with South Texas bales (possibly related to the higher short fiber content of the bales selected from this region, see Figure 15). As for the Texas plains and SJV bales, they show similar yarn mass CV% values.

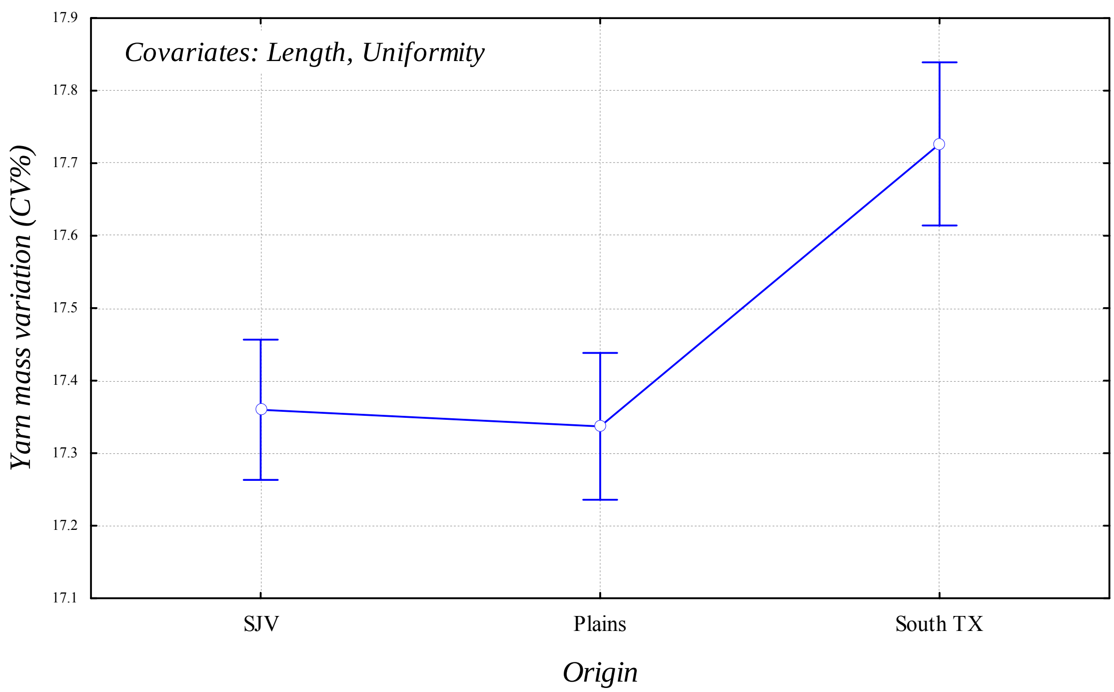

Figure 24: Yarn evenness (mass variation CV%), analysis of covariance results.

Yarn neps (short defects) detected at +200% mass variation threshold represent another important yarn evenness parameter. Results relative to yarn neps are shown on Figure 25. Here too, the bale origin effect appears significant ($p < .001$). In addition, the covariates that appeared to significantly intervene in predicting yarn neps were fiber length, uniformity and seed coat neps. When examining the bale origin effect (Figure 25), it appears that cottons selected for the Plains had the least yarn neps, South Texas cottons had the highest number of neps, and finally, SJV cottons were in-between. This superior ranking of Texas plains cottons is most likely due to the combination of low short fiber content, low numbers of fiber entanglement and low seed coat neps contamination observed throughout the spinning preparation process (see section 4.2.1 page 18).

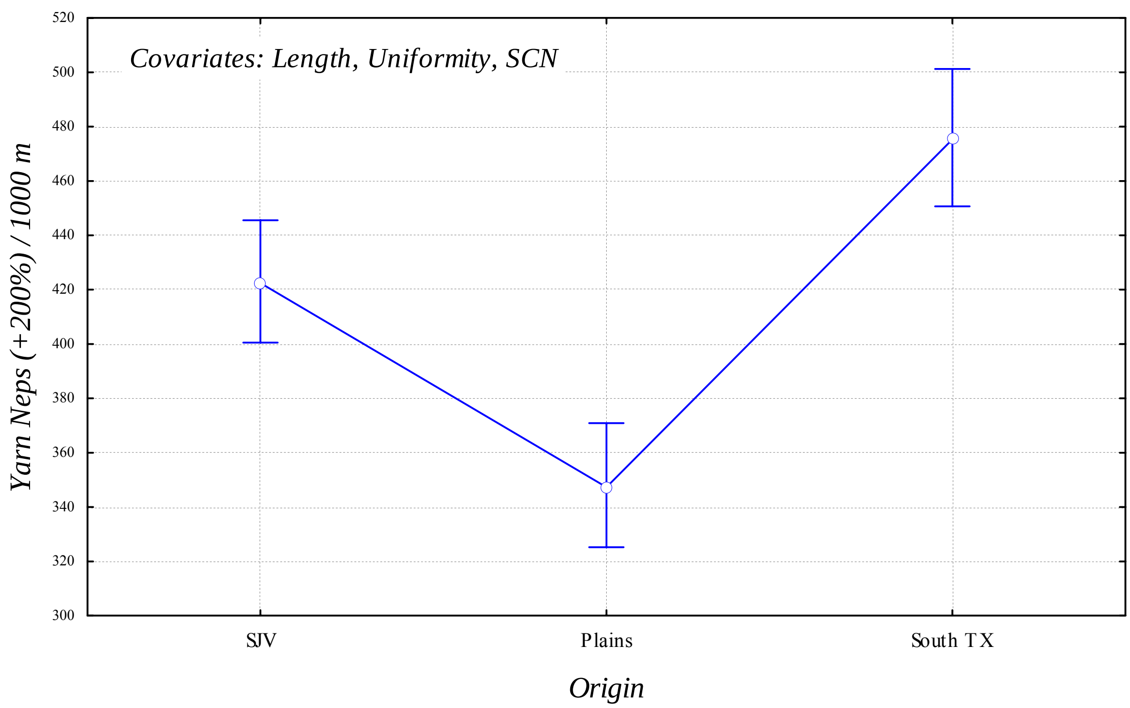

Figure 25: Yarn neps (+200%), analysis of covariance results.

Figure 26 and Figure 27 show yarn hairiness and tenacity results, respectively. In both cases, the bale origin effect was highly significant ($p < .001$). However, significant covariates differed between the two yarn parameters. For yarn hairiness, fiber length, uniformity and Micronaire appeared to have a significant effect on yarn hairiness, while in the case of tenacity, the covariates were length and strength (expectedly). The ranking of the three growth areas was similar in both cases. SJV cottons appeared to be the best performers, i.e., had the lowest hairiness and the highest yarn tenacity. Texas plains bales ranked second best, and yarns spun from South Texas bales had the highest hairiness and lowest tenacity values.

However, although these effects were statistically significant, the amplitude of the differences between growth regions was rather limited, particularly when considering the Texas plains and SJV and when examining hairiness results. Furthermore, comparison of these results with the Uster® Statistics industrial benchmarks (Uster-Technologies-AG, 2001)♣ showed that the quality levels achieved by the Texas plains cottons were within average or better than average ranges (hairiness results were better than the 25% level and tenacity results were between the 50th and 75th percentile).

Overall, and in accordance to results obtained in the first year of the project, none of the spinning performance or yarn quality parameters we tested revealed any major difference that could be attributed to the growth region, especially when considering Texas plains versus SJV.

Further confirmation of these results is needed before they can be confidently communicated to spinners around the world. This will be our focus in the follow-up to this research (with a widened sample range). However, results obtained thus far are very encouraging.

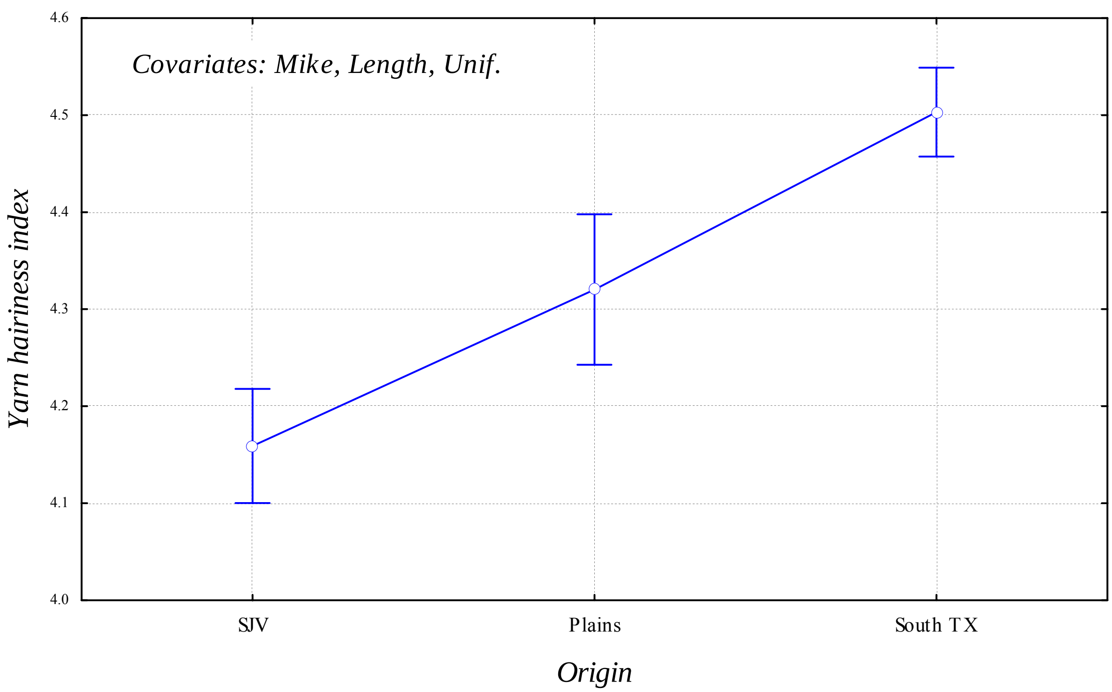

Figure 26: Yarn hairiness, analysis of covariance results.

♣ Uster® Statistics represents quality benchmarks compiled through the testing by Uster® Technology, AG of more than 6100 samples procured from their global clientele. The statistics are summarized as percentile curves, e.g., the quartile or 25% quality level represents the value reached and exceeded by only 25% of the samples tested.

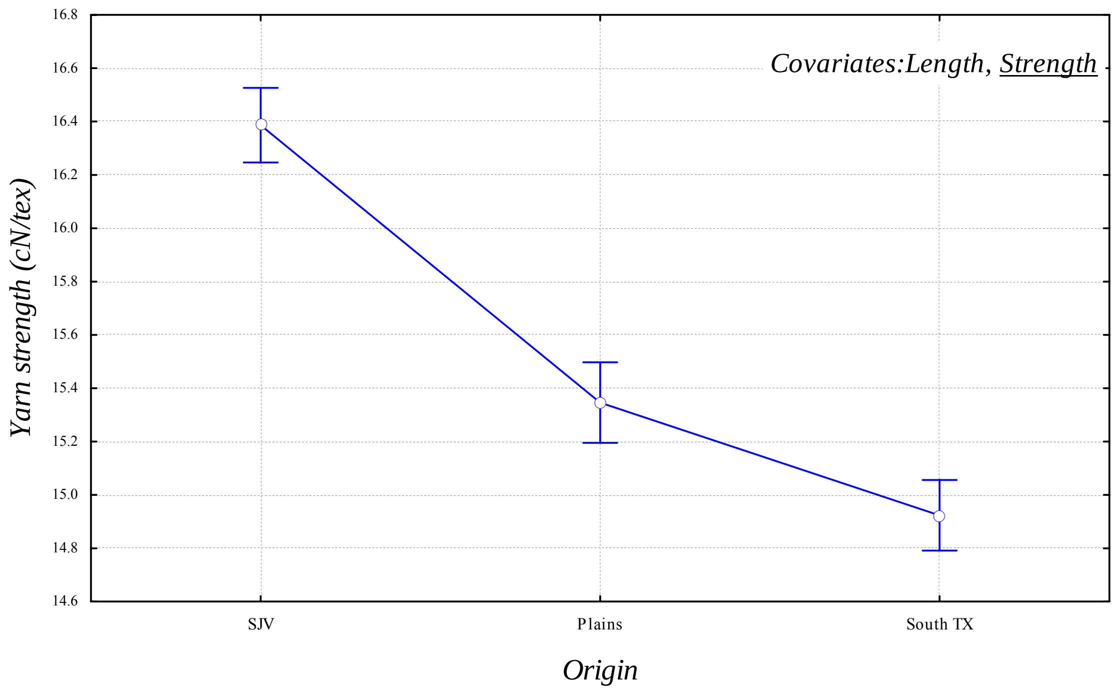

Figure 27: Yarn tenacity, analysis of covariance results.

5. SUMMARY - CONCLUSIONS

Analysis of the Texas Plains commercial cotton quality trends, based on classing office data, shows a significant and continuous improvement over the last 5 years. The rationale behind seeking access to high value-added markets for West Texas cotton producers is compelling and is strengthening year after year. At present, this applies to a small portion of the crop and it is important to stress once more that in average, Texas plains crop remains far from the established quality benchmark, i.e., California Acala-type cottons. However, there is a substantial number of bales combining quality levels at the upper end of West Texas crop that could compare favorably to Acala-type cottons from the lower end and average portions of SJV crop. Better appraisal and increased high-value-added market demand on this portion of the crop represent major economic opportunities for West Texas cotton producers. Achieving this objective constitutes the central focus of our research.

To achieve the objective above, we have conducted spinning trials and fiber quality evaluations of commercial cotton bales selected from three different growth areas: Texas plains, South Texas (Coastal Bend) and San Joaquin Valley. The bales were selected to form similar HVI fiber quality ranges, with 5 higher than average staple levels (35 to 38) from each of the three growth areas.

For the second year in a row, our results showed that Texas plains cottons compared favorably to SJV and coastal bend cottons of similar HVI properties. Plains cottons processed in this second year of the project (2006) appeared to have higher trash and dust contamination (higher VFM%) but had lower fiber entanglements (neps) and seed-coat neps. The higher percentages of visible foreign matter (VFM%) did not persist the processing of the bales through spinning preparation as all cottons appeared to have similar VFM% after opening-cleaning and carding. However, some advantageous properties of the Texas plains bales, i.e., low neps, seed coat neps and short fiber content were perceptible even at the card sliver stage.

Plains cotton showed slightly higher numbers of ends-down than SJV cottons. However, the difference was not statistically significant with the current range of bales. Patterns obtained in both 2006 and 2005 trials suggest that the higher numbers of ends-down are primarily observed for the shortest among the tested bales. Bales with staples of 37 and longer did not appear to show differences in the number of ends-down between the Texas Plains and SJV.

Finally, yarns spun from the selected plains bales had quality levels (evenness, imperfections, hairiness, strength) that were generally close to those of SJV levels. The latter had a lower hairiness and higher tenacity but higher neps than the plains cottons. Differences were limited in amplitude (even those that were found statistically significant), and the quality levels achieved by the Texas Plains bales ranked well in comparison to Uster® statistics.

In summary, results for 2006 confirm those obtained for 2005. It appears that quality ring-spun yarn can be spun from Texas plains cottons with processing performance levels that are comparable to some high-value market benchmarks, such as SJV cottons.

Results obtained so far are encouraging but further confirmation is needed to confidently communicate these findings to spinners around the world. In order to confirm and validate these results, the number of samples has to be multiplied and the range of bales broadened to cover multiple crop seasons. We are currently in the process of purchasing the bales for the trials to be conducted for the year 2007.

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