EFFECT OF COTTON PREPARATION ON AFIS AND HVI MEASUREMENTS

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Abstract

To some extent, the modification of the fiber preparation with mechanical processes influences all HVI and AFIS measurement parameters with the exception of AFIS neps, trash and dust. Using these instruments to measure the input/outputs of the Textile yarn preparatory processes (opening/cleaning, carding, drawing, roving) can lead to biased conclusions.

Introduction

The basic purpose of this study was to examine the use of the AFIS and the HVI to improve performance of the spinning process. Since the various mechanical processes modify the state of the fibers, we must first determine the effects of fiber preparation on instrument readings.

Discussion

Cotton processing machines that mechanically work the cotton fiber from bale to yarn are designed with the intent of minimizing fiber damage. Nevertheless, opening, cleaning and blending equipment shorten the staple length while increasing short fiber content and neps. Carding and combing reverse this by removing a percentage of the short fibers and neps. Drawing is thought to have a minimal effect on fiber physicals, its purpose being to improve sliver evenness and fiber orientation.

With machine settings and speeds optimized, a comparison of the fiber properties of stock-in compared with stock-out provides valuable information for achieving further optimization.

Procedure

When processing a combing study jointly funded by the State Support Committee of Cotton Incorporated and the Texas Food and Fibers Commission, fiber samples were collected before and after each processing machine. Fiber samples were tested on Uster AFIS and HVI Spinlab 900B and data analyzed. The sequence of processing and sample collection is given in Exhibit 1.

Nine of the cottons used in this study were Texas cottons with three fiber length groups (1.00”, 1 1/32”, 1 3/32”) and with three micronaire levels within each length group (3.5, 4.0, and 4.5). In addition to these nine bales, one California bale with a 3.7 micronaire and a length of 1 3/32” was used in comparison to the Texas cottons.

When these ten bales were received, samples were taken from each bale and analyzed in the Materials Evaluations Laboratory of the International Textile Center. Each bale was processed into two yarn counts through 12 different processing routes. These involved both rotor and ring-spinning, single and double-drawing, carding only, and light and normal combing. The twelve different production combinations used for processing on each of the bales of cotton are shown in Table 1.

Opening, Cleaning and Carding

Each of the ten bales was processed through opening and carding as shown in Figure 1. The cottons were processed through a Hunter Hopper Feeder, a Rieter Mono-cylinder operating at 750 rpm, a Rieter ERM B5/5 operating at 850 rpm, and finally through another Rieter ERM B5/5 operating at 950 rpm.

Single carding was performed on a Rieter C4 Card fitted with a Hollingsworth Trashmaster TM 2000. The production rate used on all the bales was 100 pounds per hour producing a 60 grains/yard sliver. Waste was collected from all the major cleaning points, weighed and expressed as a percentage of the total weight fed.

Carded Yarn Processing

The processing route for the carded yarns is shown in Figure 2. Each bale sample card sliver was processed through a Rieter RSB-851 Drawframe. Then a portion of the single-drawn sliver went through a Saco Lowell Rovematic FC-1B Frame to a Saco Lowell SF-3H ring-spinning frame operating at a 10,000 rpm spindle speed. Another portion of the single drawn sliver went directly to a Schlafhorst Autocoro rotor-spinning machine operating at a 90,000 rpm rotor speed. The remainder of the single-drawn sliver was processed through another drawing and then to the roving frame on into ring spinning, and also from finisher drawing to rotor spinning. For ring spinning both the single-drawn and double-drawn samples were spun into N_e 18/1 at a 4.0 twist multiplier, and into N_e 36/1 at a 4.0 twist multiplier. Each of the single-drawn and double-drawn samples was spun on the rotor spinning system into N_e 18/1 and N_e 36/1, both at a 4.8 twist multiplier.

Combed Yarn Processing

The processing route for the combed yarns is shown in Figure 3. The card sliver was processed through a Saco Lowell DE-7C Drawframe using a light draw procedure (6 ends up) in

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preparation for lapping. Sliver was then processed through a Rieter Unilap E 5/3 Lapper and then through a Rieter E 7/6 Comber. The comber was first adjusted to remove a minimum percentage of noils, at which approximately one half of each sample was combed. The comber was then readjusted to remove a normal percentage of comber noils, at which the remainder of the sample was processed. One-half of each combed sample was then processed through one drawing frame, and the other half was processed through two drawing frames as shown in Figure 3. At ring- and rotor-spinning, the combed samples were spun into N_e 18 and N_e 36 yarns. The same twist multipliers were used as with the carded only yarns. The noils removed during combing at both settings were collected, weighed and expressed as a percentage of the weight fed to comber.

There are slight AFIS variations in the apparent fiber diameter when going from a processing stage to another. It seems that the ERMII results in a slight increase, which could be due to the removal of dead fibers in the opening line. Certainly the card also removes neps and dead fibers; however, the diameter appears to decrease slightly (Figure 8). We have also a significant decrease due to the drawing. These mechanical processes cannot modify the diameter. The only logical explanation is an artifact effect. In the card sliver and the drawing slivers the fibers are oriented and paralleled, this removes the crimp. The length of the electronic signal and its height are then modified giving higher length readings and lower diameter readings.

The HVI micronaire values (Figure 9) vary slightly in the opening line, perhaps due to the removal of some dead fibers. The carding seems to reduce the micronaire, which is not explainable. Then the drawing leads to an increase in micronaire. The theory of the micronaire instruments is based on airflow passing through a sample constituted of randomly oriented fibers. In the drawing process the fibers are made parallel, which probably leads to an easier flow of air through the cotton sample and results in an apparent higher micronaire. As the micronaire is used to calculate the beard mass (function of optical density and micronaire) for the strength test, any positive micronaire bias will lead to a negative HVI strength bias (Figure 10). In addition, the drawing process is similar in effect to an increase in the brushing time (or force) on the HVI combs. Taylor (TRJ, 1986, 93-102) has shown the effect of increasing brushing force on HVI strength readings. In his experiment two sample preparations were tested, hand brushing and HVI brushing (harder brushing than by hand). The results show an increase by 1.9 g/tex when using the HVI brushing device. In our case, we think that the drawing sliver samples have a lower optic density (for a given number of fibers in the comb) than the raw cotton. This results in a lower calculated mass of the sample to be broken. As the HVI strength is calculated by dividing the force applied to break the sample by the calculated mass, this results in an apparent higher HVI strength. In conclusion, we have two antagonist effects; the positive bias in micronaire reading leads to lower strength readings and the brushing-type effect leads to higher strength readings. Measurements taken indicate that the net effect is to increase the fiber strength readings of the drawing sliver.

As expected, the AFIS nep counts (Figure 11) increase with passage of the fibers through the opening line. The Mono-cylinder increases the average nep count by 75, then the first ERM (operating at 850 rpm) by 136 and the second ERM (operating at 950 rpm) by 240; that is 451 neps in total. The card removes 540 neps and the drawing frames have no effect.

The AFIS trash and dust counts (Figure 12 & 13) decrease as expected after each cleaning stage. The mono-cylinder removes nearly 37% of the trash. The first ERM removes 34% of the trash remaining in the fiber after the first cleaning stage and the second ERM 27% of the trash remaining after the second cleaning stage. The card is also extremely effective, removing as much as 84% of the remaining trash. The cleaning efficiency for the dust is very similar to the trash removal efficiency.

The HVI reflectance (Figure 14) increases slightly after each cleaning stage. The drawing seems to also have an effect on the reflectance readings. This is not due to trash removal but more likely to an artifact because the paralleled fibers are not reflecting the light the same way as the randomly oriented fibers.

The changes in yellowness (Figure 15) are quite small but significant. The most important change is due to the drawing. This is, as for the reflectance, probably due to an artifact.

Combed Process (Figures 16 to 28)

Combing affects AFIS Upper Quartile Length, Mean Length, Short Fiber Content and HVI Upper Half Mean Length and Uniformity Ratio. As expected the fiber length parameters all increase when the cotton is combed, with the exception of the Short Fiber Content. The drawing also affects the length parameters; as discussed before, it is probably an artifact. It is interesting to note that combing increases the length by 0.006 inch (minimum noil settings) and that the first drawing increases it by 0.027, i.e. nearly five times more. The artifact effect seems to be much more important than the real mechanical effect.

The combing process seems to have no effect on the fiber diameter (Figure 21). The drawing, as discussed before, decreases the diameter (artifact).

The HVI micronaire (Figure 22) increases when combing is applied, mainly because the removal of short, weak and immature fibers during the combing process increases the average maturity level. As discussed before the drawing has a positive effect on micronaire (artifact effect).

The HVI strength (Figure 23) also increases with combing, because of the removal of short fibers. The drawing, as discussed before, increases the apparent HVI strength (artifact effect).

The AFIS neps (Figure 24) are removed during the combing process as expected (-62% for the minimum noil setting to –91% for the normal noil setting).

The combing also removes trash and dust. The decrease in trash is (Figure 25) nearly 60% for both types of settings. The decrease in dust (Figure 26) is about 40% for the minimum noil setting and 60% for the normal noil setting. As these are removed the HVI reflectance increases as expected and the yellowness decreases. The drawing effect on both parameters is an artifact, as discussed before.

Summary

With the exception of AFIS nep, trash and dust counts all the parameters are influenced by fiber preparation to some extent. Monitoring the spinning process using these instruments will lead to biased conclusions unless we can find a way to prepare the samples in such a way that the fibers are randomly oriented.

References

Taylor, Robert, TRJ, 1986, 93-102

Table 1. Production Combinations

(Each One Producing Counts of N_e 18/1 and 36/1)	
Setup 1:	Carding - Breaker Drawing- Rotor Spinning
Setup 2:	Carding - Breaker Drawing - Ring Spinning
Setup 3:	Carding - Breaker Drawing - Finisher Drawing - Rotor Spinning
Setup 4:	Carding - Breaker Drawing - Finisher Drawing - Ring Spinning
Setup 5:	Carding - Lapper - Comber (minimum % Noils) - Breaker Drawing Rotor Spinning
Setup 6:	Carding - Lapper - Comber (minimum % Noils) - Breaker Drawing - Ring Spinning
Setup 7:	Carding - Lapper - Comber (minimum % Noils) - Breaker Drawing – Finisher Drawing - Rotor Spinning
Setup 8:	Carding - Lapper - Comber (minimum % Noils) - Breaker Drawing – Finisher Drawing - Ring Spinning
Setup 9:	Carding - Lapper - Comber (normal % Noils) - Breaker Drawing – Rotor Spinning
Setup 10:	Carding - Lapper - Comber (normal % Noils) - Breaker Drawing – Ring Spinning
Setup 11:	Carding - Lapper - Comber (normal % Noils) - Breaker Drawing Finisher Drawing - Rotor Spinning
Setup 12:	Carding - Lapper - Comber (normal % Noils) - Breaker Drawing Finisher Drawing - Ring Spinning

Exhibit 1. Sample Identification

Carded Stock	
Raw	: Unprocessed fiber from bale
Mono	: Rieter Mono-cylinder B 4/1 Stock
ERM I	: Rieter ERM B5/5 Universal Cleaner Stock
ERM II	: Rieter ERM B5/5 Universal Cleaner Stock
Card	: Rieter C-4 card sliver
CD-DI	: Rieter RSB-851 First Drawing Sliver
CD-DII	: Rieter RSB-851 Second Drawing Sliver
Combed Stock Minimal Noil Removal	
Noils	: Rieter E 7/6 Comber Waste
Combed	: Rieter E 7/6 Comber Sliver
Cm-DII	: Rieter RSB-851 Second Drawing Sliver
Cm-DIII	: Rieter RSB-851 Third Drawing Sliver
Combed Stock Normal Noil Removal	
Noils	: Rieter E 7/6 Comber Waste
Combed	: Rieter E 6 Comber Sliver
Cm-DII	: Rieter RSB-851 Second Drawing Sliver
Cm-DIII	: Rieter RSB-851 Third Drawing Sliver

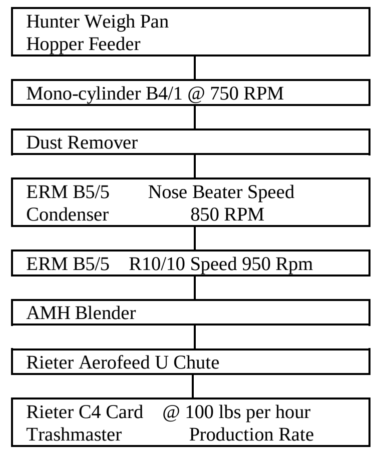

Figure 1. Outline of Processing Route From Opening Through Carding

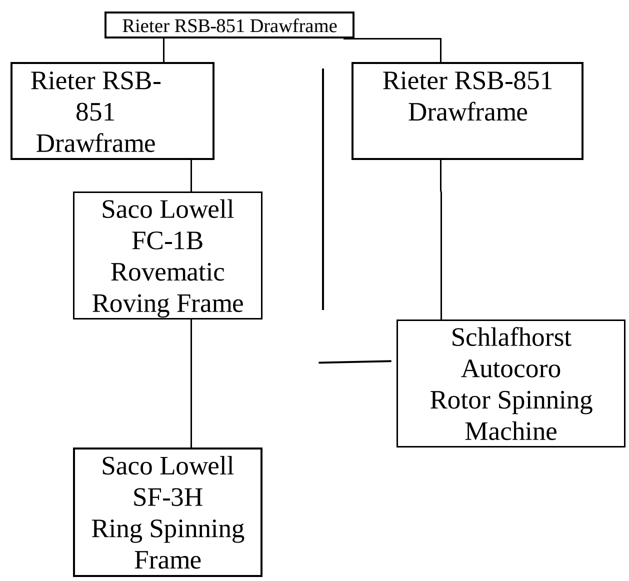

Figure 2. Outline of processing route for carded yarns

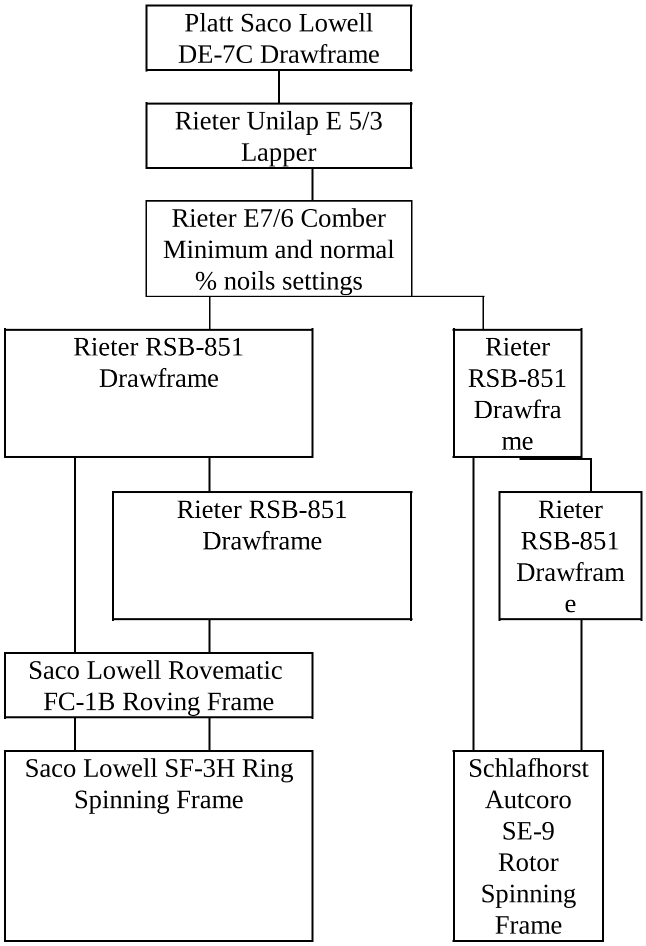

Figure 3. Outline of processing route for combed yarn

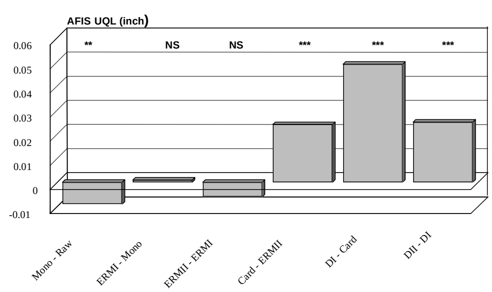

Figure 4. Evaluation of the AFIS UQL: Carded Process

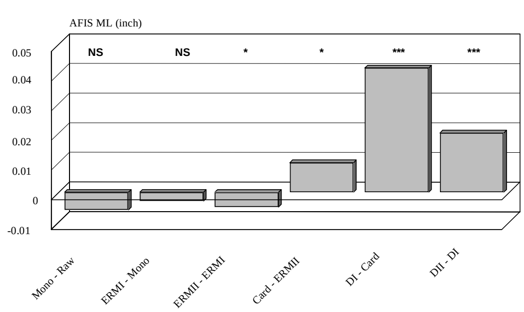

Figure 5. Evolution of AFIS ML: Carded Process

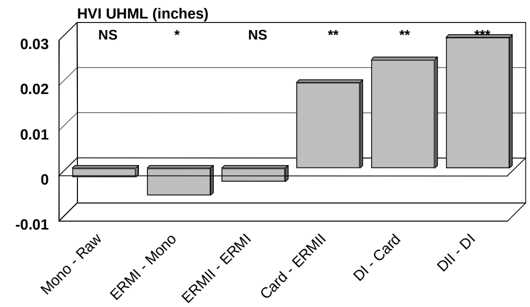

Figure 6. Evolution of the HVI UHML (inches): Carded Process

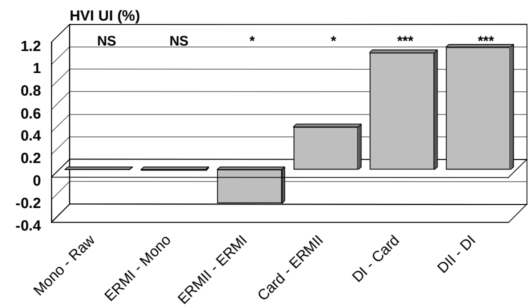

Figure 7. Evolution of the HVI UI (%): Carded Process

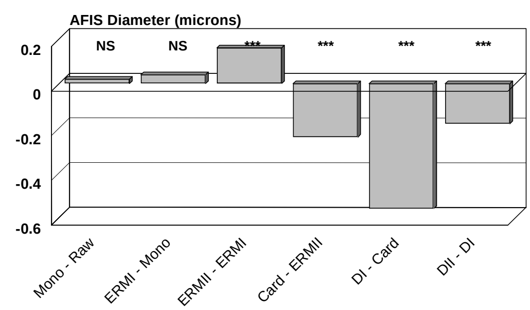

Figure 8. Evolution of the AFIS Diameter: Carded Process

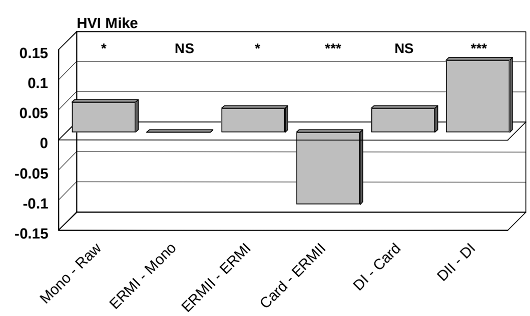

Figure 9. Evolution of the HVI Mike: Carded Process

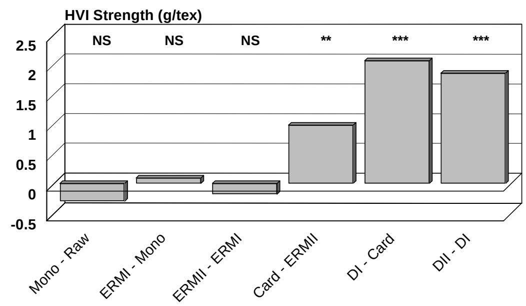

Figure 10. Evolution of the HVI Strength (g/tex): Carded Process

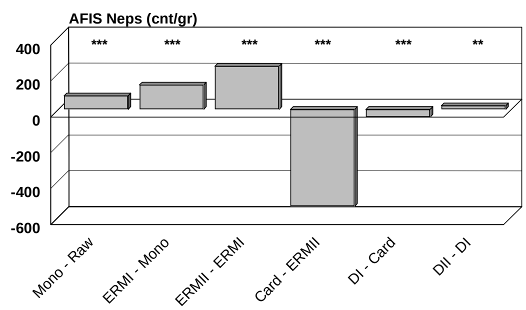

Figure 11. Evolution of the AFIS Neps: Carded Process

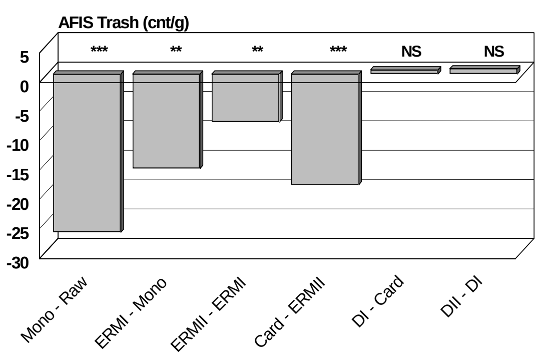

Figure 12. Evolution of the AFIS Trash: Carded Process

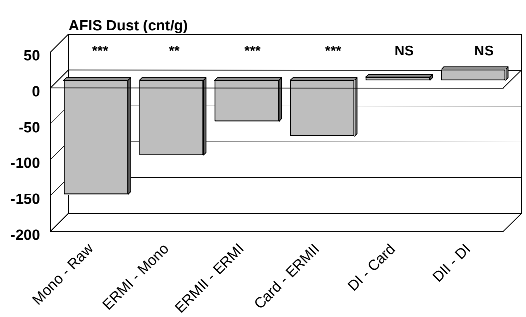

Figure 13. Evolution of the AFIS Dust: Carded Process

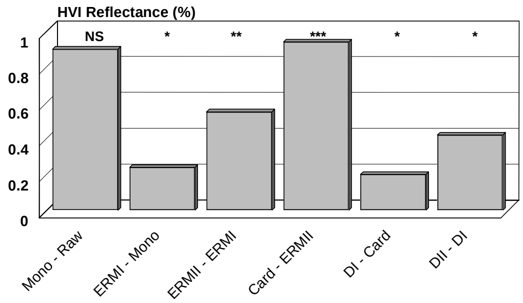

Figure 14. Evolution of the HVI Reflectance(%): Carded Process

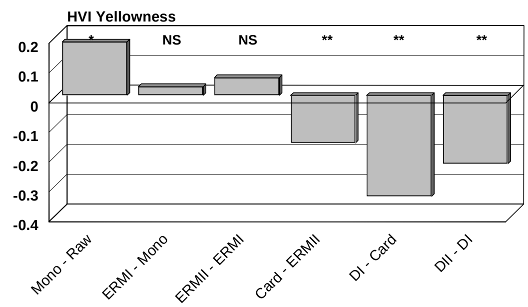

Figure 15. Evolution of the HVI Yellowness: Carded Process

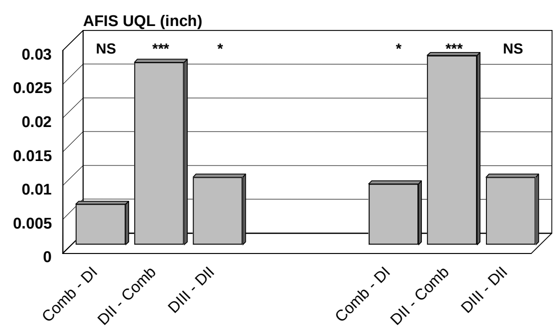

Figure 16. Evolution of the AFIS UQL: Combed Process – Minimum Noil – Normal Noil

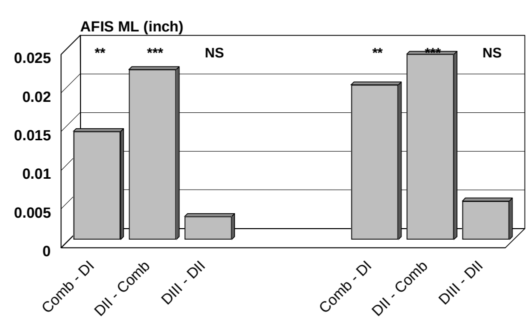

Figure 17. Evolution of the AFIS ML: Combed Process – Minimum Noil – Normal Noil

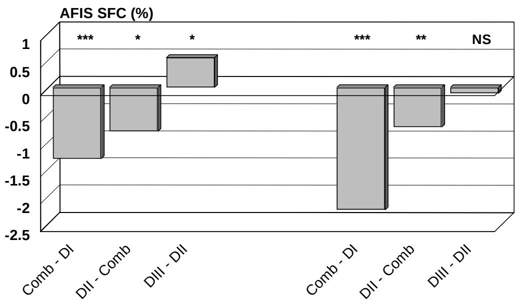

Figure 18. Evolution of the AFIS SFC: Combed Process – Minimum Noil – Normal Noil

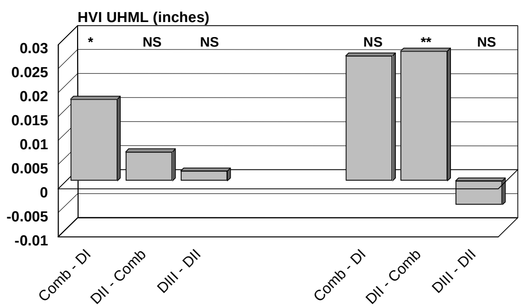

Figure 19. Evolution of the HVI UHML (inches): Combed Process – Minimum Noil – Normal Noil

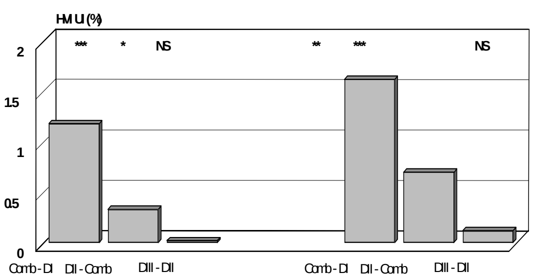

Figure 20. Evolution of the HVI UI(%): Combed Process – Minimum Noil – Normal Noil

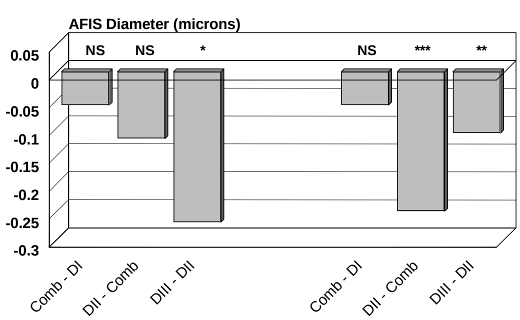

Figure 21. Evolution of the AFIS Diameter: Combed Process – Minimum Noil – Normal Noil

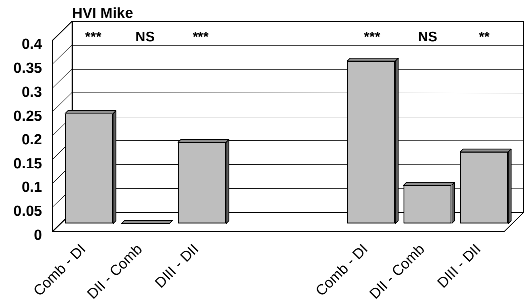

Figure 22. Evolution of the HVI Mike: Combed Process

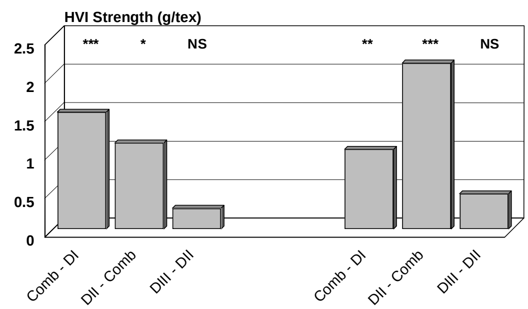

Figure 23. Evolution of the HVI Strength (g/tex): Combed Process – Minimum Noil – Normal Noil

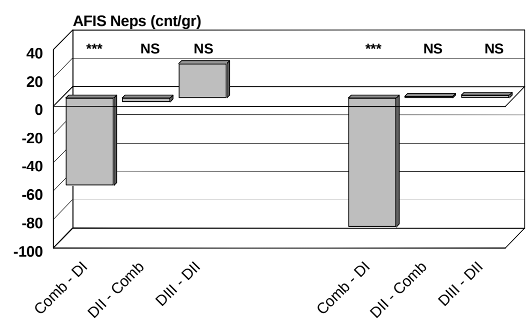

Figure 24. Evolution of the AFIS Neps: Combed Process – Minimum Noil – Normal Noils

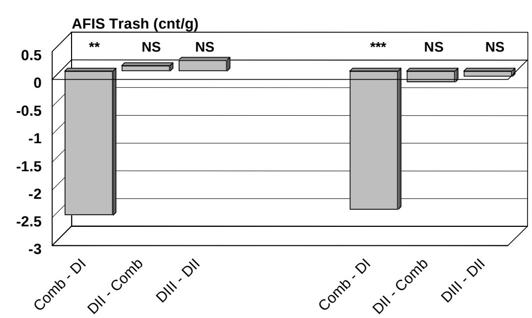

Figure 25. Evolution of the AFIS Trash: Combed Process – Minimum Noil – Normal Noil

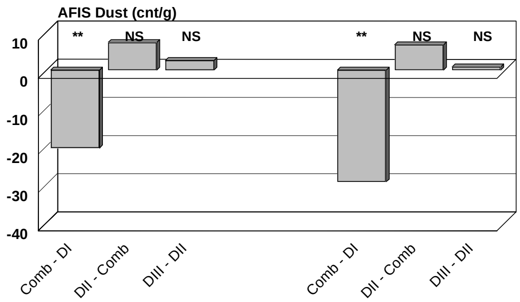

Figure 26. Evolution of the AFIS Dust: Combed Process – Minimum Noil – Normal Noil