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CHARACTERIZING AND QUANTIFYING LENGTH REDUCTION POTENTIAL AND ABRASIVE DUST CLEANABILITY OF TEXAS-GROWN COTTON VARIETIES

COTTON INC. TEXAS STATE SUPPORT COMMITTEE
PROJECT # 06-804TX

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PROJECT #06-804TX: CHARACTERIZING AND QUANTIFYING LENGTH REDUCTION POTENTIAL AND ABRASIVE DUST CLEANABILITY OF TEXAS-GROWN COTTON VARIETIES

This research addresses two key issues relative to the use-value of West Texas cotton: length properties and abrasive dust. Both issues are seen by spinners as major drawbacks of Texas cotton for both ring-spinning and open-end spinning applications. Dealing with these problems will greatly enhance the economic opportunities for Texas cotton producers and processors.

Substantial progress has been made in breeding to develop longer staple cotton varieties that are adapted to the Texas plains. However, improved staple alone does not guarantee long-term desirability of the plains crop on the global market. 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. This is because the spinner's quality concerns are fundamentally determined by the way the fibers perform during processing; thus, by the properties that are achievable from the cotton after spinning preparation. When this is not strongly related to the HVI data, the spinner will eventually discriminate against the cotton. A sufficient reason for a weak relation is variation in the cleaning potential and in the process-related length component, i.e., in the fiber's response to mechanical stresses and its resistance to breakage.

This research uses quality characteristics measured on the fiber both during and after spinning preparation, in order to evaluate cleanability and length reduction at the gin and the spinning mill. Ginning and spinning preparation trials were conducted on five cotton varieties grown and stripper-harvested in Lubbock in 2005. Ginning treatments consisted of different numbers of lint cleaning stages. Fiber samples were collected throughout ginning and spinning preparation processes and were tested on AFIS for dust and trash particles, and for neps. The dust abrasiveness was evaluated by measuring its silica content. Length reduction potential of the varieties was also evaluated using repetitive opening actions and AFIS® measurement of fiber length distribution parameters.

Results indicated that the positive effects of lint cleaning, i.e., dust and trash removal, were neutralized by the cleaning done at the spinning mill. Thus cottons having been submitted to different lint cleaning treatments at the gin did not show significant differences in dust and trash contamination after spinning preparation. Furthermore, lint cleaning did not appear to affect the amount of silica in the residual dust collected in rotor spinning. On the other hand, cottons that had more neps as a result of more intensive lint cleaning remained more "neppy" after opening-cleaning and carding in the spinning mill. These results, if confirmed, would suggest that with the ever improving cleaning efficiency achievable with blowroom cleaners and modern cards, the benefit of extensive cleaning done at the gin may be questionable when viewed from the spinner's perspective. Results pertinent to fiber length reduction potential suggest cotton variety as the main influencing factor. Lint cleaning did not increase the fiber's propensity to break for the current range of samples.

Described here are results for one single crop-season (2005). Valid conclusions about the varieties can only be drawn if tests are conducted over several growing seasons. Therefore, the observations presented here remain preliminary and will be further scrutinized in the coming seasons. Research is continuing to further examine the quality criteria described in this report and to include other critical fiber properties that are affected by cleaning treatments both in the gin and in the textile mill.

1. INTRODUCTION

When asked why they favor cottons from regions other than West Texas, spinners often cite one of two major drawbacks of the Plains cotton (depending on the type of process they run and on the product range they target). The first is length properties, not only the shorter staple length but also and more importantly the lack of length uniformity and the high short fiber content. This is a critical issue for spinners targeting high value-added products made with ring spun yarns, where good length properties are indispensable for efficient processing and quality products.

The second reason cited by spinners is the excessive amounts of abrasive dust. This is especially detrimental to performance of open-end rotor spinning, where a large share of West Texas cotton is utilized.

The issues pertinent to the length distribution and cleanliness of cotton fiber are closely related. Cleaning the cotton, whether in the gin or the textile mill, usually involves its submission to aggressive mechanical processes, which in turn deteriorate its length properties. The close relationship between cleanness and length properties (and, in fact, other critical quality criteria such as neps) can be traced back to the field and to harvesting practices. For instance, stripper-harvested cotton will contain more impurities and therefore will require more cleaning at the gin. Thus, length has a strong process-related component due to its alteration under the stresses put on the fiber in harvesting, ginning and textile processing.

Substantial progress has been made in breeding to develop longer staple cotton varieties that are adapted to the Texas plains. However, improved staple alone does not guarantee long-term desirability of the plains crop on the global market. 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. When this is not strongly related to the HVI data, the spinner will eventually discriminate against the cotton. A sufficient reason for a weak relation is variation in the cleaning potential and in the process-related length component, i.e., in the fiber's response to mechanical stresses and its resistance to breakage.

Research conducted at the ITC (Krifa, 2004; Krifa and Hequet, 2005) suggests that a longer staple (in the bale) does not necessarily lead to better length properties in the processed fiber and therefore, may result in poor processing characteristics and low use-value of the cotton. This is illustrated in Figure 1 below. Three cottons, two relatively long (A and B) and the third substantially shorter (C) according to the raw fiber data, were submitted to identical mechanical opening operations. After a few opening stages, cotton A remains the longest while cotton B (initially of similar length) is substantially shortened until its mean length is the same as the initially shortest cotton (C). Obviously, cotton B constitutes the worst-case scenario for the spinner who will obtain results considerably below the expectations based on raw fiber data.

According to these results, breeding efforts should focus not only on improving staple length (as it is measured in the bale), at the risk of producing genotypes that correspond to case B in the figure bellow. They must also focus on the processing behavior of the genotypes, e.g., their propensity to break and cleanability.

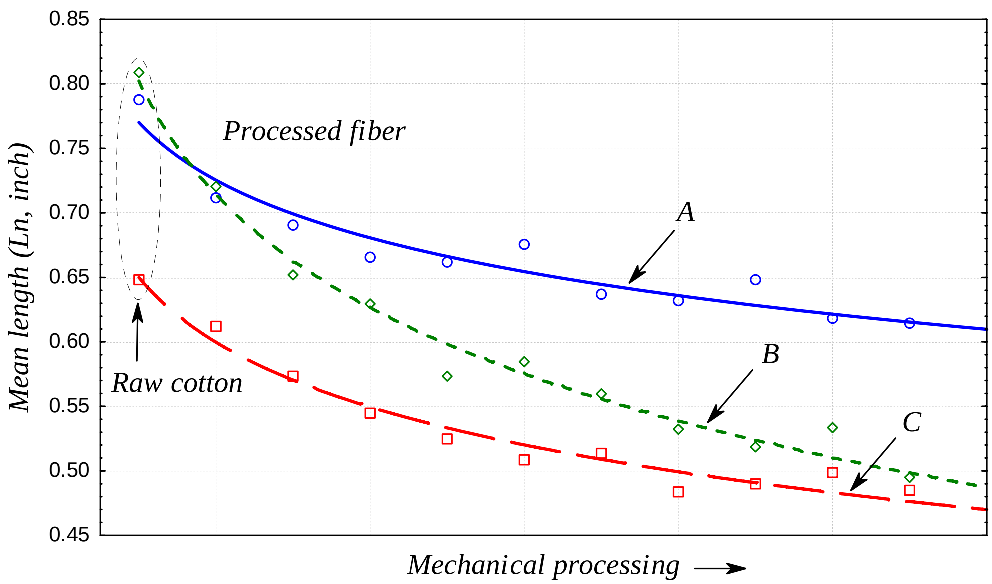

Figure 1: Variability of fiber length reduction potential among cottons.

The present research aims at developing and validating the tools necessary to objectively quantify the fiber's propensity to break and cleanability of Texas grown varieties. Such tools will help breeders and producers avoid deceiving varieties (case B in the figure). They will also help processors identify the best way to eliminate abrasive dust (in the gin and/or in the spinning mill) while minimizing length reduction.

2. OBJECTIVES

The goal of this research is to identify factors involved in excessive fiber length alteration and provide breeders and ginners with tools to reduce cotton's propensity to break and improve its cleanability, in addition to improving its staple length. Specific objectives include:

1- Apply the propensity to break and cleanability methodology to commercial cotton; provide a first assessment of the propensity-to-break and cleanability of prominent varieties grown in Texas.

2- Explore the effects of ginning treatments on the propensity to break and cleanability (with a focus on dust removal).

3- Determine the processing phases where the best cleanability (dust removal) can be achieved with minimum propensity to break. A primary focus will be on abrasive dust.

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

3. MATERIAL AND METHODS

Five varieties were selected and grown in 2005 to constitute a range of fiber properties and provide the seed-cotton samples for the 2006 trials. The selected varieties were: PM2145RR, Beltwide 28R, DPL 444, AFD Raider 271, and FM 960. The cotton was grown and stripper-harvested in the USDA-ARS facilities in Lubbock, TX. Upon harvest, the seed cotton was put though the ginning process at the Gin Lab in Lubbock. Four treatment combinations were applied at the gin (no lint cleaner, 1, 2 and 3 lint cleaners) and samples were collected at the following locations:

- seed cotton,
- ginned lint before lint cleaner,
- ginned lint after 1st lint cleaner,
- ginned lint after 2nd lint cleaner,
- ginned lint after 3rd lint cleaner,

Approximately 100 lbs of lint was obtained for each treatment combination (see Table 1 for ginning data and lint weight). The fiber, along with the seed-cotton samples (approx. 10 lbs from each lot) was delivered to the ITC. Representative fiber samples were collected from each lot and tested on HVI. The lint was then sampled and used for 3 experimental phases at the International Textile Center:

1. Evaluation of the processing behavior in spinning preparation: The cottons were processed through opening-cleaning and carding operations. Fiber samples along with all processing waste were collected for fiber testing and waste quantification. The slivers were drawn and used to conduct a dust study in open-end processing. The entire process is outlined in Figure 2. The residual dust content in the sliver used to feed the OE spinning frame, along with other fiber properties, were measured to determine the interactions among varieties, ginning treatments and spinning preparation processes.

2. Qualitative characterization of the dust throughout the process: The composition of the dust collected in the previous phase, in particular its silica content, was determined in order to assess its abrasiveness. This will allow determining the cleaning potential, from the gin to the spinning preparation, specific to the abrasive dust.

3. Evaluation of the fiber cleanability and propensity to break: The cleaning potential of the cotton (particularly for dust, but also for other types of impurities), along with its potential for length reduction (Figure 1) were examined and scrutinized based on AFIS results of samples obtained from multiple processing stages and mechanical treatment combinations. Relationships among varieties, ginning treatments and these two key processing characteristics were analyzed.

Table I: Ginning data (* LC= Lint Cleaner)

Lot No	Variety	Treatment*	Lot Wt. (lbs)	Seed Wt. (lbs)	Lint Wt. (lbs)	Mote Wt. 1 LC	Mote Wt., 2LC	Mote Wt., 3LC
1	AFD Raider 271	No LC	350	193.3	105	--	--	--
2	AFD Raider 271	1LC	360	194	101	5.2	--	--
3	AFD Raider 271	2LC	362	190.4	101	5.06	1.67	--
4	AFD Raider 271	3LC	340	182.9	94	4.97	1.54	0.82
5	Beltwide 28R	No LC	310	157	110	--	--	--
6	Beltwide 28R	1LC	337	169.4	115	6.12	--	--
7	Beltwide 28R	2LC	336	177.3	114	5.33	1.95	--
8	Beltwide 28R	3LC	350	172.9	113	5.69	2.02	0.74
9	DPL 444	No LC	322	159.6	118	--	--	--
10	DPL 444	1LC	374	176.8	125	7.4	--	--
11	DPL 444	2LC	370	178.9	125	6.79	2.18	--
12	DPL 444	3LC	404	188.9	129	6.68	2.07	0.83
13	FM 960	No LC	356	178	126	--	--	--
14	FM 960	1LC	380	188.3	137	6.7	--	--
15	FM 960	2LC	410	216	137	7.01	2.53	--
16	FM 960	3LC	416	208.7	138	7.17	2.34	1.14
17	PM2145RR	No LC	336	174.4	116	--	--	--
18	PM2145RR	1LC	352	183.3	116	6.19	--	--
19	PM2145RR	2LC	372	195.1	122	6.97	2.63	--
20	PM2145RR	3LC	418	221.4	134	7.93	3.1	1.39

The dust study mentioned above (phase 1) consists of a 4 hour spinning trial conducted on 20 rotor spinboxes. Each spinbox is thoroughly cleaned prior to testing and is fed with approximately 2 lbs of sliver. The spinning test then proceeded for 4 hours without interruption and without cleaning of the rotors. After the four hours, the machine was stopped and the yarn packages were removed and weighed. The spinboxes were then opened, and the fibers present in the rotor carefully removed. Finally, all dust residues were collected from the rotor and put in a sealable container. The dust was then weighed and expressed as a percentage of the produced yarn weight. The dust collected was then chemically analyzed to determine its silica content and thus assess its abrasiveness.

In addition to the spinning trials described above, fiber samples, as well as all processing waste, were collected at alternative stages along the spinning preparation process (Figure 2). The waste was quantified and the processed fiber samples were tested on AFIS® to measure individual fiber properties along with neps, trash and dust content.

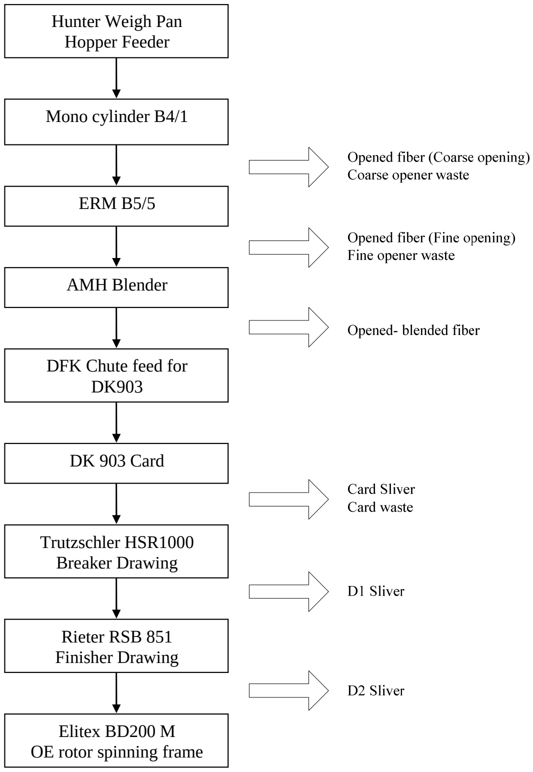

Figure 2: Outline of the spinning process.

Results presented in this report are for one single crop-season (2005), and thus should be considered as preliminary, particularly when examining complex effects and interactions involving varieties. Trials are scheduled to continue in order to conduct a multi-season study with a comprehensive analysis of cleanability and length reduction potential both at the gin and the spinning mill.

4. RESULTS AND DISCUSSION

4.1. HVI FIBER PROPERTIES

Table II summarizes HVI results obtained on the samples from all variety*ginning treatment combinations. Micronaire values averaged 3.6 and ranged from 3.1 to 4.0, with two of the varieties (DPL 444 and FM 960) showing rather low Micronaire levels. Staple length values averaged 1.11” and ranged from 1.02” to 1.21”. Variation in staple length appears mainly related to varieties. However, a clear lint cleaning effect, consisting of an expected reduction in UHML values within the same variety, is apparent from the data in the table below and is made clear on Figure 3. Lint cleaning is also associated to a decrease in length uniformity (Figure 4) and an improvement in leaf grade (Figure 5).

Table II: HVI data

Lot No	Variety	Treatment	Mic.	Length	Unif.	Strength	Elon.	Rd	+b	Leaf	CG
1	AFD Raider 271	No LC	3.8	1.205	82.9	32.1	6.6	72.6	9.0	4	41-3
2	AFD Raider 271	1LC	3.7	1.195	81.6	31.8	6.4	75.7	9.4	2	31-3
3	AFD Raider 271	2LC	3.7	1.16	80.8	31.6	6.3	76.6	9.5	1	21-4
4	AFD Raider 271	3LC	3.7	1.17	81.2	31.6	6.4	77.3	9.6	1	21-4
5	Beltwide 28R	No LC	4.0	1.145	81.6	27.0	6.3	73.0	9.0	3	41-3
6	Beltwide 28R	1LC	3.9	1.11	80.9	27.2	6.2	75.5	9.4	2	31-3
7	Beltwide 28R	2LC	3.9	1.095	79.9	27.9	6.0	77.0	9.6	1	21-4
8	Beltwide 28R	3LC	3.9	1.1	80.1	27.3	6.4	77.3	9.6	1	21-4
9	DPL 444	No LC	3.4	1.12	81.8	27.5	6.5	74.0	9.0	3	41-3
10	DPL 444	1LC	3.5	1.095	81.6	27.3	6.5	75.9	9.6	1	31-3
11	DPL 444	2LC	3.4	1.08	80.9	27.3	6.4	77.0	9.6	1	21-4
12	DPL 444	3LC	3.4	1.075	80.3	27.3	6.5	77.9	9.6	1	21-3
13	FM 960	No LC	3.2	1.15	79.9	29.8	4.8	75.0	8.2	4	41-1
14	FM 960	1LC	3.1	1.125	79.6	29.6	4.9	78.0	8.5	3	31-1
15	FM 960	2LC	3.1	1.125	80.1	30.6	5.2	78.1	8.8	2	21-2
16	FM 960	3LC	3.1	1.105	78.5	31.0	4.8	78.9	9.0	1	21-2
17	PM2145RR	No LC	4.0	1.05	82.6	29.5	6.8	71.1	8.5	5	41-4
18	PM2145RR	1LC	3.8	1.03	81.8	28.8	6.6	74.7	9.1	3	31-4
19	PM2145RR	2LC	3.7	1.02	81.3	28.4	6.6	76.2	9.5	3	31-3
20	PM2145RR	3LC	3.8	1.02	81.6	29.0	6.9	76.3	9.4	2	31-3

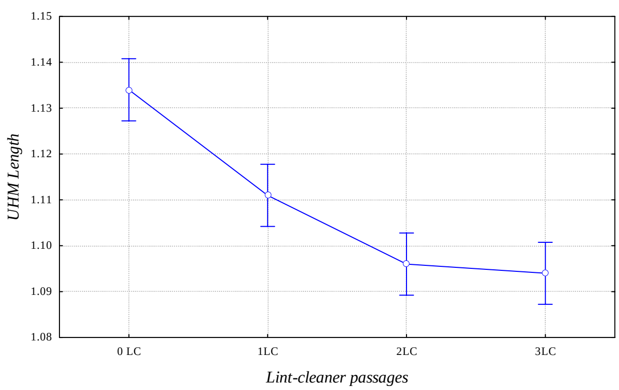

Figure 3: Staple length reduction due to lint cleaning.

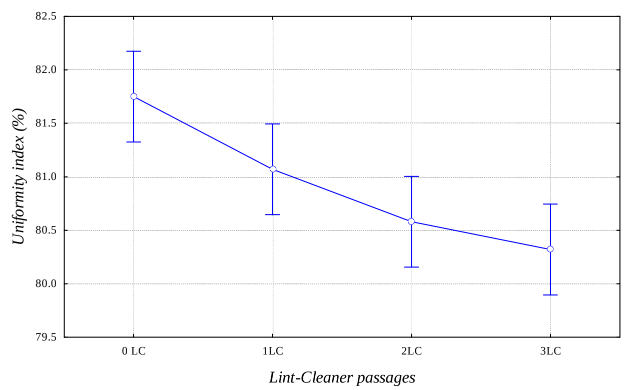

Figure 4: Length uniformity reduction due to lint cleaning..

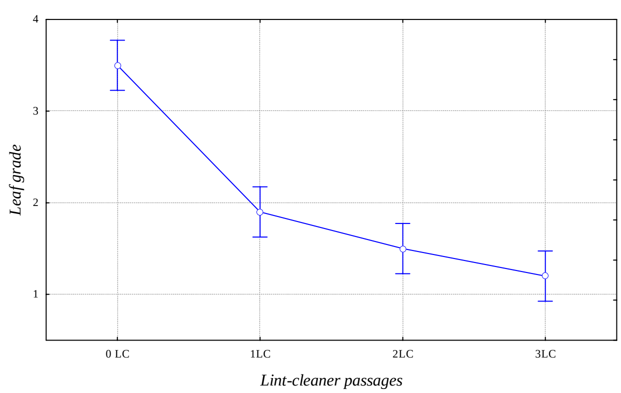

Figure 5: Leaf grade reduction due to lint cleaning.

4.2. CLEANING EFFECIENCY IN SPINNING PREPARATION

As previously stated, the effects described above are expected and the improvement of the bales' grade constitutes the very essence of lint cleaning. Our focus is now placed on the impacts these effects have on spinning preparation as determined by the waste quantification and by the analysis of the fiber samples collected throughout the process and tested on AFIS (see Figure 2).

Examination of the waste data collected during spinning preparation (Figure 6) shows that increased lint cleaning treatments at the gin, result in significantly lower amounts of waste extracted during spinning preparation. This effect is most likely related to the fact that less cleaning, and thus less waste extraction, is necessary during spinning preparation when cleaner raw cottons are delivered to the spinning mill.

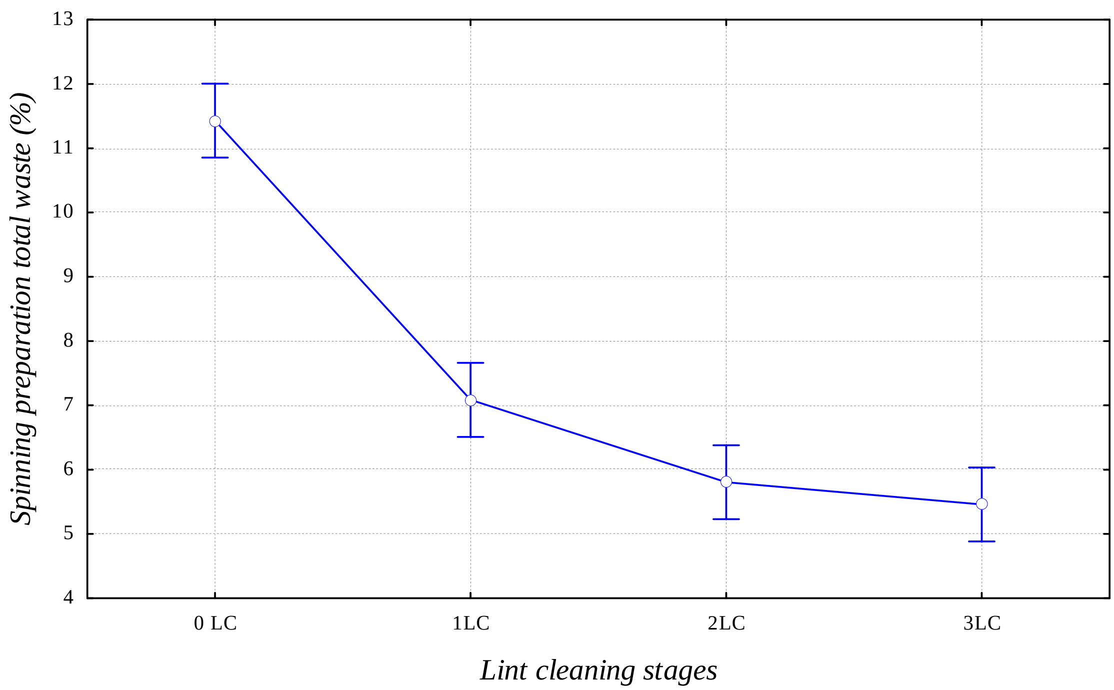

Figure 6: Lint cleaning effect on spinning preparation waste.

At first glance, the effect observed above might be attractive to spinners because of the lower amounts of waste they would have to handle as part of their operations. However, further analysis of the cleaning potential and other critical quality parameters of the cottons is necessary in order to determine the implications of these observations. These aspects are treated in the following sections.

4.2.1. *Dust and trash cleaning efficiency*

In this section, we discuss results related to cleanability issues of dust and trash particles at both the gin and the spinning mill. Figure 7 shows the variation of dust content (AFIS count/g) under the combined effects of gin and textile mill treatments. The effects of processing treatments, both at the gin and spinning mill, on dust content appear highly significant. There is a clear decrease in dust particle counts with increased lint cleaning at the gin and as the fiber progresses through the spinning preparation. These effects are of course intended and expected. Of more interest is the apparent interaction between ginning treatments and spinning preparation processes. For instance, the difference in dust content between cottons processed through an increasing number of lint cleaners is highly significant when considering raw cotton (bale samples), but diminishes quickly during spinning preparation. After carding (the last significant cleaning step in most spinning operations), all lint cleaning treatments performed at the gin show virtually no difference in dust content as detected by AFIS (particles/g).

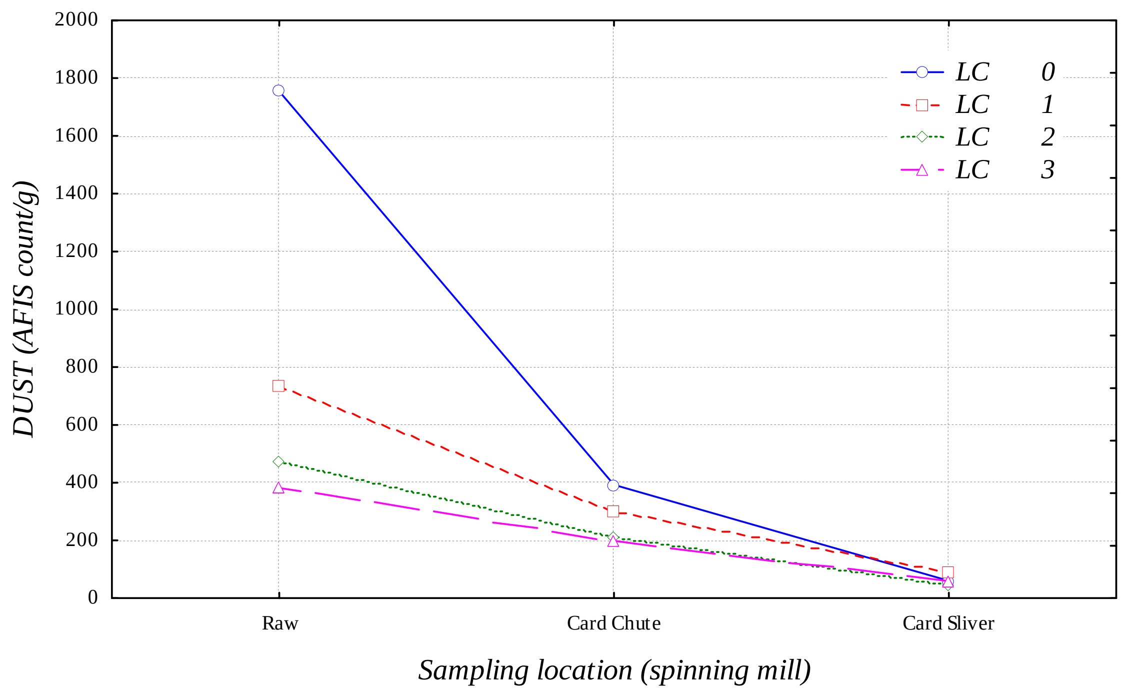

Figure 7: AFIS dust particles count as affected by the interaction among ginning treatments and spinning preparation processes (LC = number of lint cleaners).

A more detailed representation of these results is shown in Figure 8, which depicts scatter plots relating dust contents of the lint samples in the bales on one hand and after opening-cleaning and carding on the other hand. Figure 8 shows the shift of the scatter plots from the equality line (x=y) after each spinning preparation stage. It appears from these results that the two blowroom opener/cleaners significantly reduce the number of dust particles detected in the lint using the AFIS. However, the extent to which dust particles are reduced appears relatively higher for samples that were initially ranked with the highest dust contents. The scatter plots remain in the vicinity of the equality line in the range of low dust contents and stray from it in the range of high dust contents (the samples initially ranked as the cleanest show virtually no change in dust content after opening-cleaning). Despite the sizeable cleaning effect observed on both graphs (Figure 7 and Figure 8), the relationship between dust content in the bale and after each opener-cleaner appears significant, which indicates that cottons having higher dust particle counts in the bale remained the most contaminated after blowroom operations (and vice versa).

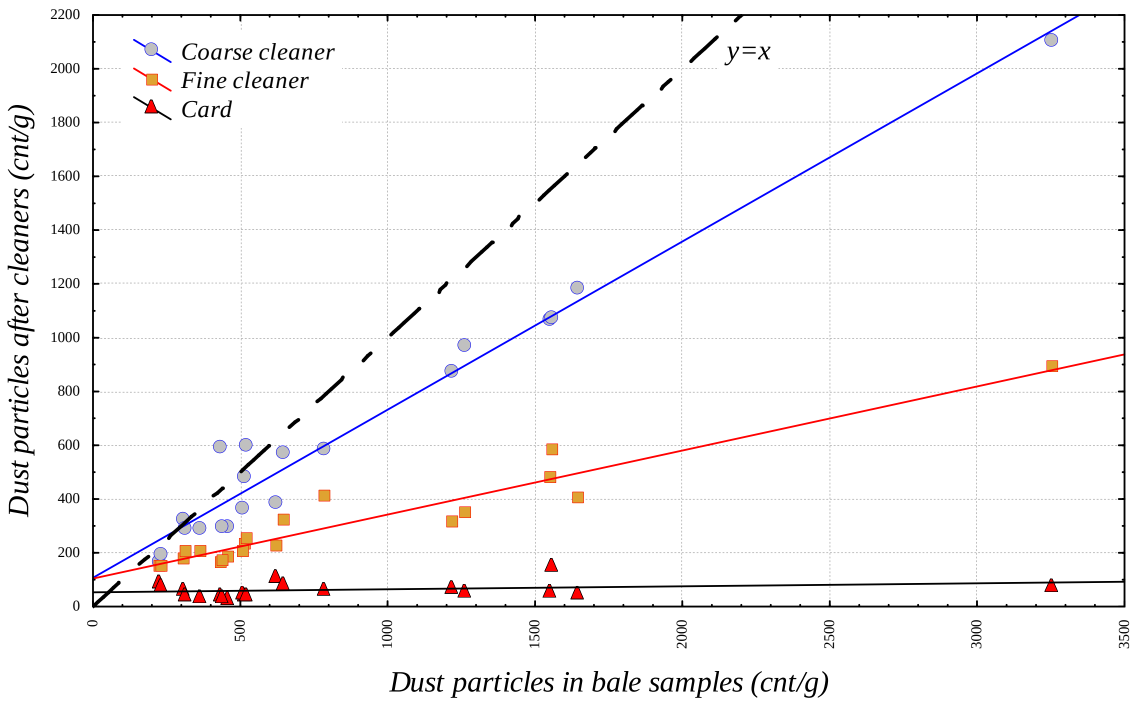

Figure 8: Relationship between dust content in bale samples and at alternative stages of spinning preparation.

Observation of the third scatter plot of Figure 8, representing the effect of carding on dust particle counts, reveals a distinctly different pattern. The scatter plot corresponding to the carding effect not only significantly strays from the equality line, but also exhibits a virtually flat pattern with no perceptible variation in the number of dust particles after carding. This pattern suggests that, as a result of the cleaning efficiency achieved in the blowroom and mainly at the card, the cleanness of the cotton entering the spinning preparation chain did not affect that of the card sliver. This also suggests that cleaning done upstream, i.e., in the gin, did not affect the cleanness of the cotton after spinning preparation (again, based on AFIS count of dust particles). Figure 9 is an illustration of the latter statement; it shows the scatter plot described above on a different y-axis scale and with distinct point markers for the different lint cleaning levels performed in the gin. It is apparent from the graph in Figure 9 that the lint cleaning treatments do not show sizeable differences in the number of dust particles in the carded material (along the y-axis).

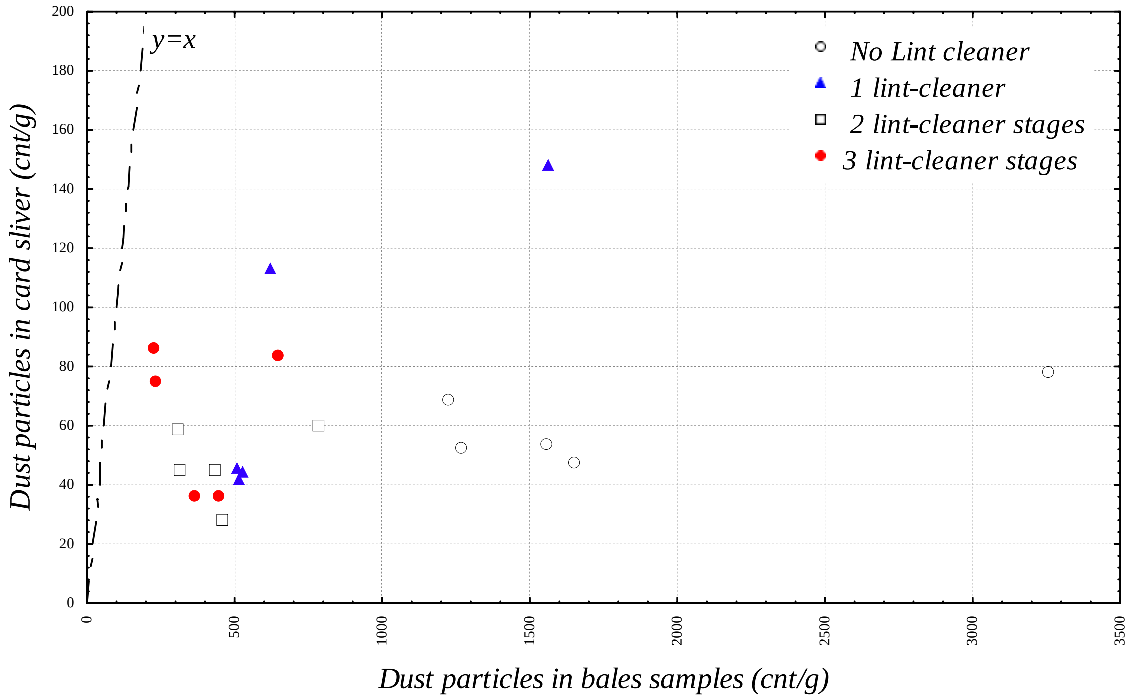

Figure 9: Relationship between dust content in bale samples and in card sliver.

Another type of particles detected in the lint and counted using the AFIS is referred to as trash and usually includes particles of diverse origins that have no fiber attached and that are larger than 500 μm in size (any particle below this size is counted as dust). Cleaning of trash particles from the gin to the spinning mill was analyzed analogously to that of dust particles described in the paragraphs above. Results are represented in Figures 10, 11 and 12, which show patterns that are very similar to those observed with dust particles. The conclusions that were put forth based on dust particle counts also apply to trash particles, i.e., cleaning at the gin did not affect the trash content of the fiber obtained after spinning preparation processes.

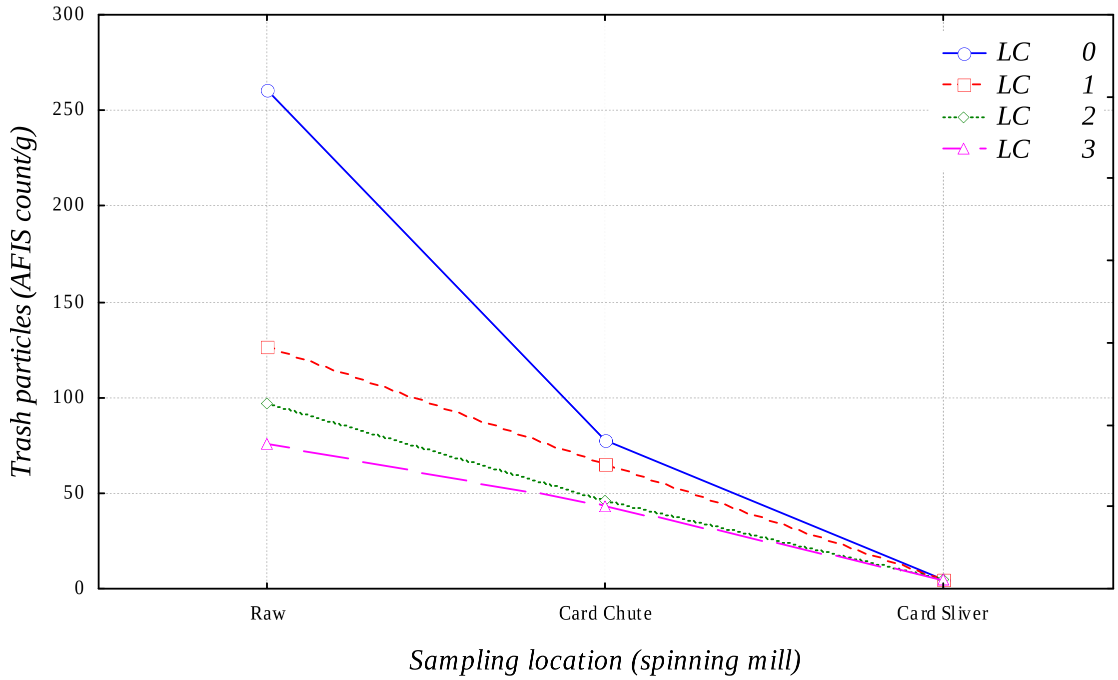

Figure 10: AFIS trash particles count as affected by the interaction among ginning treatments and spinning preparation processes (LC = number of lint cleaners).

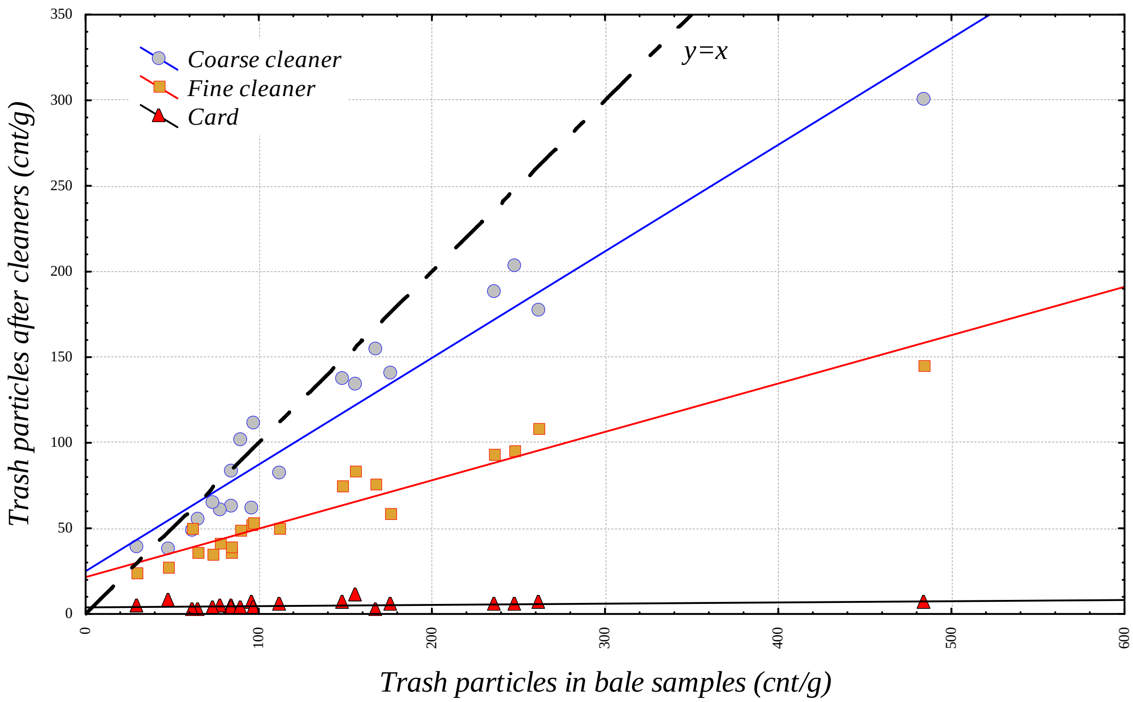

Figure 11: Relationship between trash content in bale samples and at alternative stages of spinning preparation.

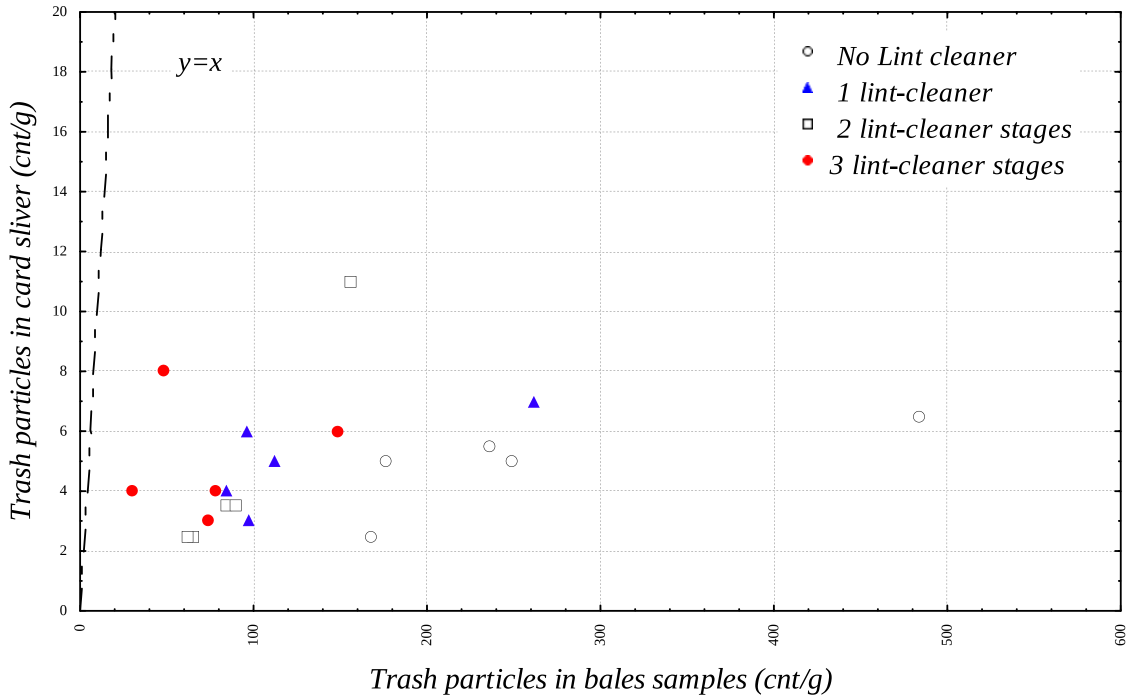

Figure 12: Relationship between trash content in bale samples and in card sliver.

The figures discussed in the paragraphs above do not show the differences among varieties with respect to cleaning efficiency. We represent individual variety data in Figures 13 and 14 for dust and trash particles, respectively. In both figures, the results are presented in separate plots for each variety we tested.

The effects discussed above are apparent and remain consistent for all the varieties. Moreover, differences between varieties are discernible when considering results observed at the early stages of the spinning preparation process. However, the difference in dust and trash contents between varieties also diminishes during spinning preparation and becomes insignificant after carding. Varietal effects will be scrutinized in further details when multi-season data is available.

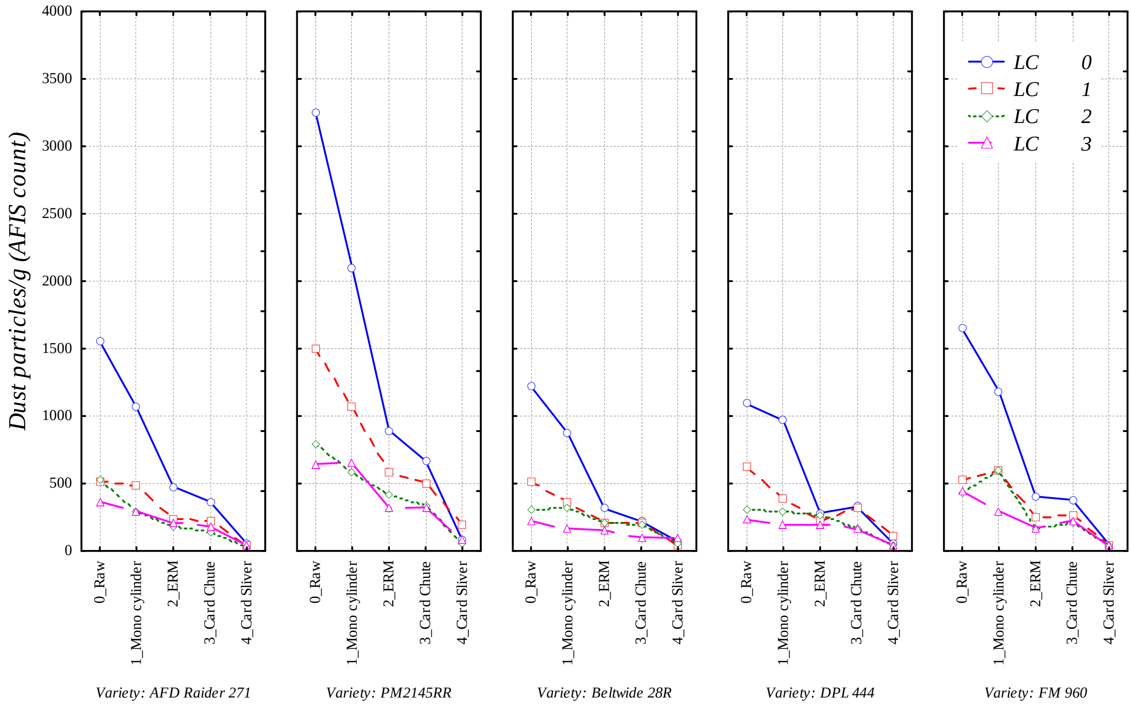

Figure 13: Dust particle count as affected by the interaction among variety, ginning treatments, and spinning preparation (LC = number of lint cleaners).

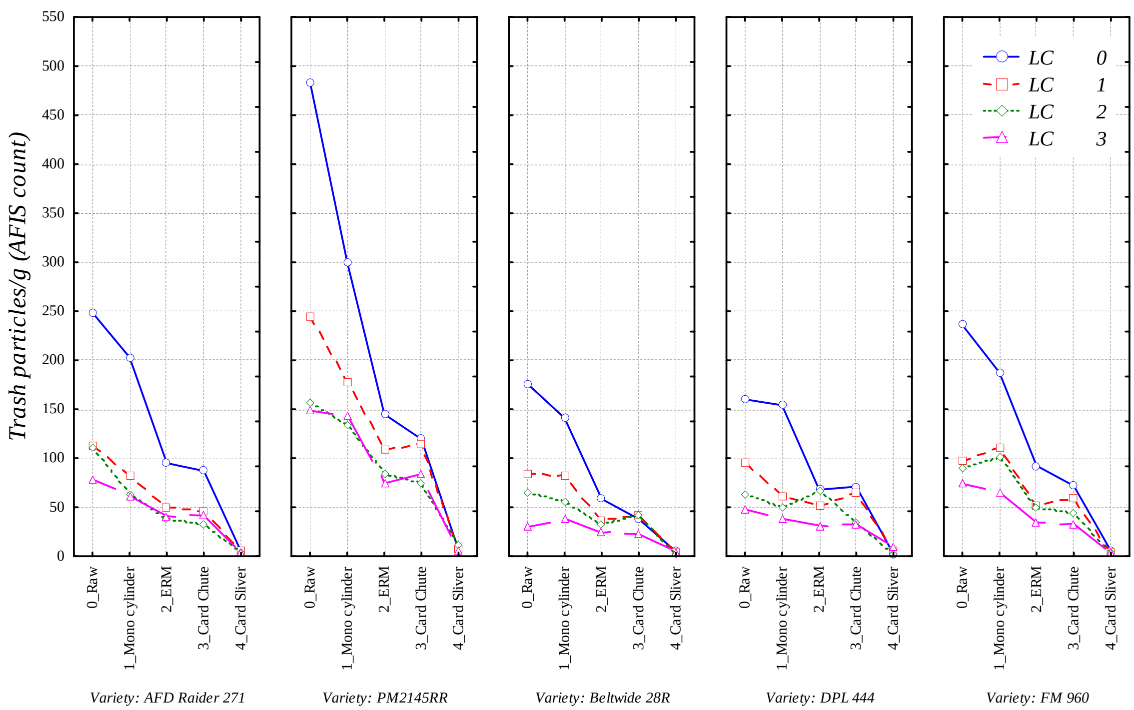

Figure 14: Trash particle count as affected by the interaction among variety, ginning treatments, and spinning preparation (LC = number of lint cleaners).

One important aspect of our research is the abrasiveness of dust particles present in the lint during spinning. Indeed, the presence of abrasive dust is detrimental to performance during spinning, particularly open-end spinning. As stated in the methods section, in addition to residual dust quantification, the dust collected from the rotors was also analyzed for its silica content. Results showing gin lint cleaning effects on dust abrasiveness, as measured by its silica content, are represented in Figure 15. The results indicate a non significant effect of lint cleaning stages on the silica content.

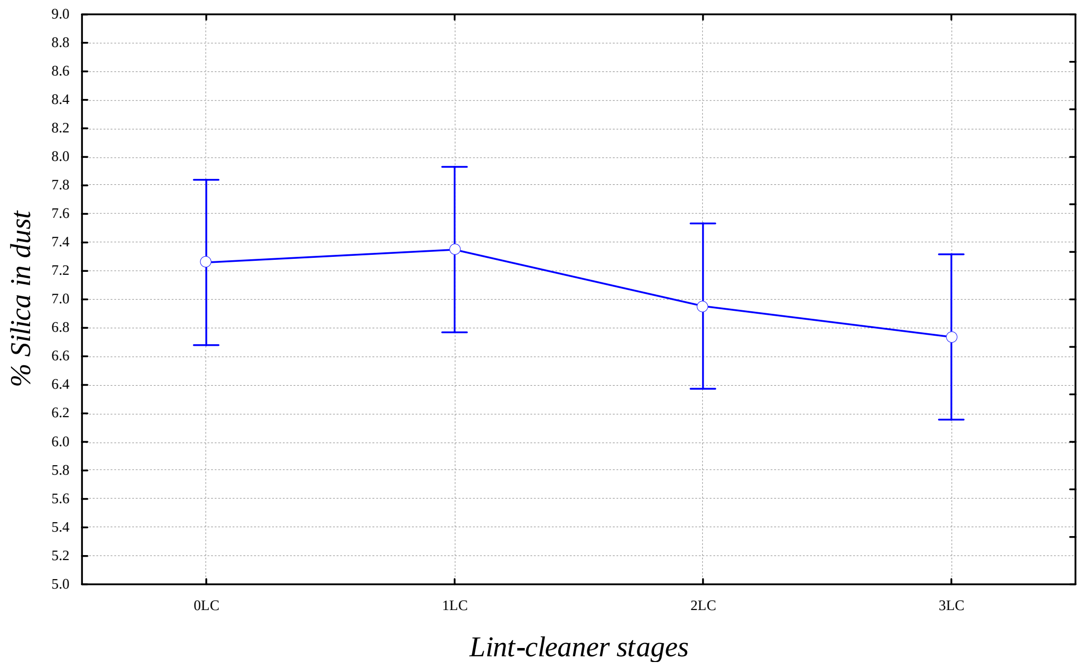

Figure 15: Lint cleaning stages effect on dust abrasiveness (silica content).

4.2.2. Neps generation / removal

Cleaning the cotton, whether in the gin or the textile mill, usually involves aggressive mechanical processes, which affect other critical quality factors that are of particular importance to the spinner. Indeed, cleaning of the cotton can also deteriorate its length properties and increase its nep content. These two aspects, i.e., length reduction and neppiness, are not currently taken into account by the classing and marketing system; nonetheless, from the spinner's perspective, they represent critical factors that determine the use-value of the cotton. The spinner's quality concerns are fundamentally determined by the way these fibers perform during processing; thus by the properties that are achievable from the cotton after spinning preparation.

We now focus on results related to the neppiness aspect (length reduction issues will be treated in a subsequent paragraph). As done for dust and trash particles, we represent the variation of nep counts detected using the AFIS under the combined effects of gin and textile mill cleaning

(Figure 16). Here the pattern is different from that observed with dust and trash. Nep counts increase with increased lint cleaning at the gin and as the cotton is processed through blowroom operations, then significantly decrease after carding. The difference between nep contents of cottons having been submitted to different numbers of lint cleaning stages also varies with further processing of the fiber, increasing in the blowroom then significantly decreasing after carding.

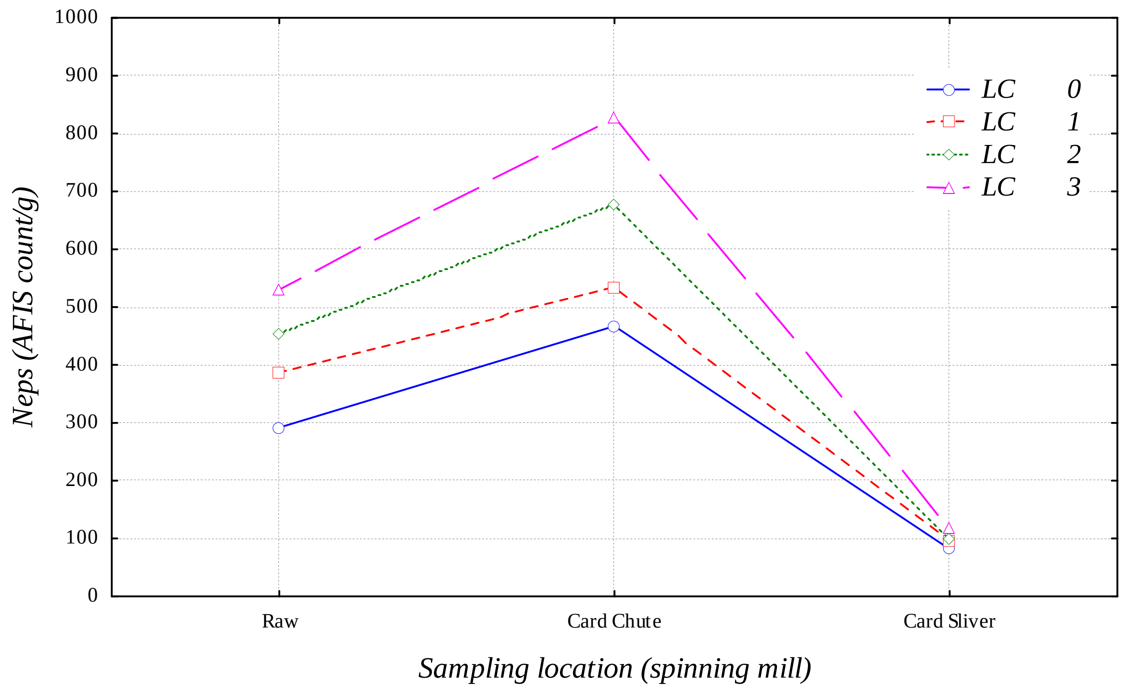

Figure 16: AFIS neps count as affected by the interaction among ginning treatments and spinning preparation processes (LC = number of lint cleaners).

Figure 17 shows scatter plots relating nep counts in the bales to those obtained after opening-cleaning and carding. The effects described above are again apparent from the scatter plots. The increase in nep counts in the blowroom appears mainly due to the effect of the fine opener/cleaner (which puts the fiber under more aggressive mechanical stresses than those of the coarse cleaner). Here too, the scatter plot representing the cumulated effect (including carding) shows little variation of the number of neps in card slivers. However, examination of this plot on a different scale and with distinct point markers for the different lint cleaning treatments (Figure 18) shows a significant relationship between nep counts obtained in bale samples and those detected in carded fiber. This indicates that, unlike trash and dust contamination, cottons that had more neps in the bales entering the spinning mill were those exhibiting the highest numbers of neps after spinning preparation (and vice versa). This also suggests that neps created by intensive cleaning at the gin may affect the cottons' neppiness even after opening-cleaning and carding (i.e., spinning preparation did not neutralize lint cleaning effects on neppiness as it did for dust and trash).

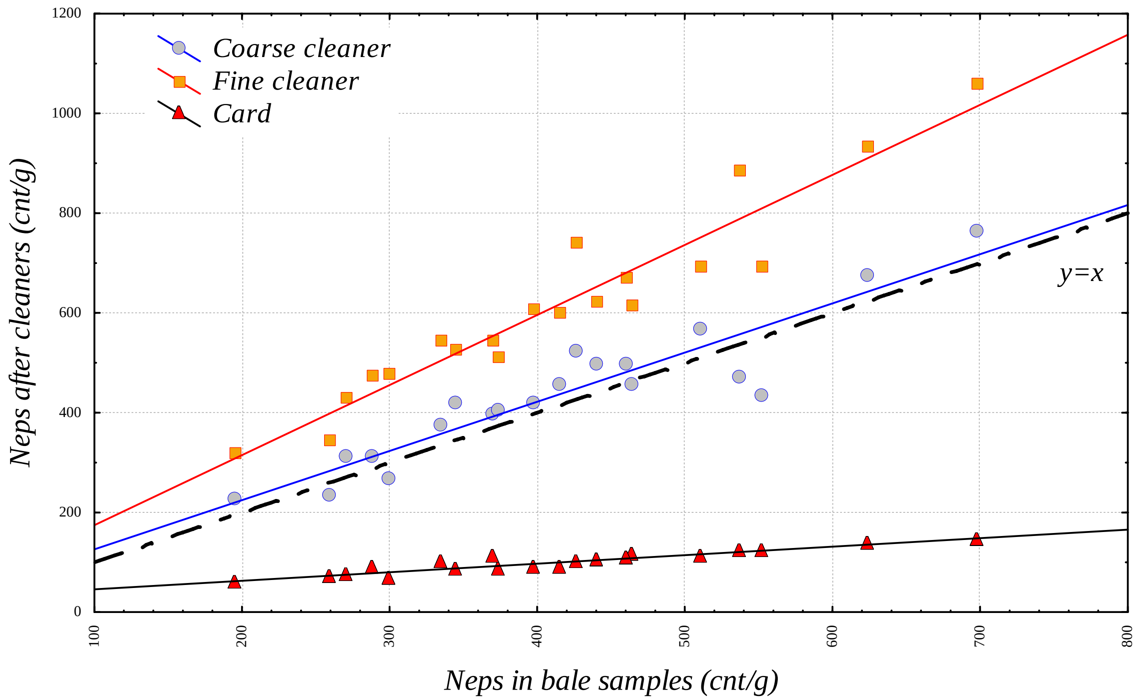

Figure 17: Relationship between neps count in bale samples and at alternative stages of spinning preparation.

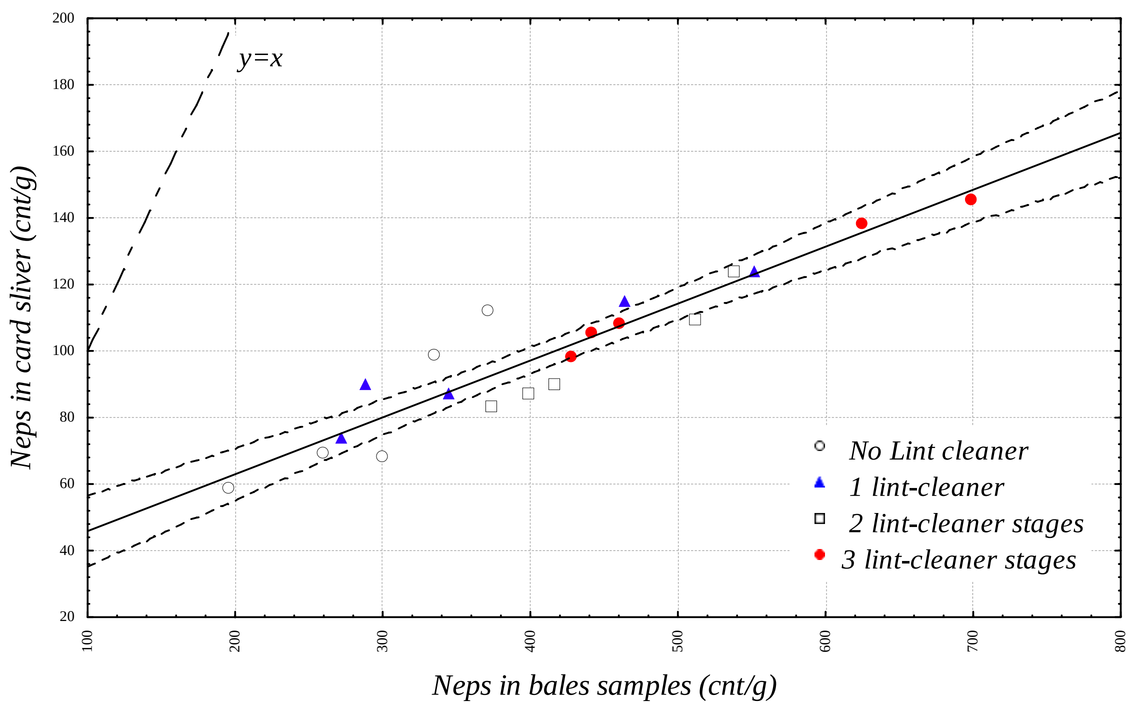

Figure 18: Relationship between neps count in bale samples and in card sliver.

In summary, it appears from these results that the intended positive effects of lint cleaning in the gin (reduction of dust and trash particles) did not survive spinning preparation and were neutralized by the cleaning efficiency of the blowroom cleaners and the card (based on AFIS counts). On the other hand, one of the negative effects typically associated with intensive cleaning at the gin (i.e., increased neppiness) remained detectable even after spinning preparation. Further analysis is currently being conducted both to confirm the results described above and to examine other critical quality issues related to length reduction and length distribution alteration, as well as to other contaminants found in the cotton (seed coat fragments).

4.3. LENGTH REDUCTION POTENTIAL

Fiber length reduction potential is a critical issue pertaining to a problem that has come to the forefront of concerns in the global cotton industry. Indeed, it is directly related to the generation of short fibers during number of cotton processing stages, from the field through the gin to the textile mill.

Factors affecting fiber length reduction and thus short fiber generation can be traced back to the field and to harvesting practices. For instance, stripper-harvested cotton (i.e., almost the entirety of West Texas crop) contains more impurities and therefore requires more cleaning at the gin. The cleaning to which the cotton is submitted in the gin is typically viewed as beneficial to the producer because it improves the classer's grade and thus increases the market value of the cotton (due to the premiums associated with cleanness). However, such intensive cleaning reduces fiber length and results in high short fiber contents.

In this section, we examine length reduction potential of the varieties we tested through the different ginning treatments. It is important to note that our approach to length reduction is not limited to static measures of the degree of fiber damage or of the short fiber content itself at a given stage of the process. Rather, it encompasses the intrinsic potential for damage and generation of short fibers at any point of the cotton processing chain.

Thus, to evaluate the length reduction potential, we examined the rate of increase of fiber damage under controlled mechanical stresses. The procedure consists of submitting the lint to repetitive opening actions (using a laboratory opener/blender) and measuring various length distribution parameters using the AFIS®. Two ginning treatment combinations were selected for the trials of this part: no lint cleaner, and two lint cleaning stages. The latter was selected because it typically represents the maximum cleaning intensity applied in industrial ginning conditions.

As mentioned above, we considered various length parameters provided by the AFIS®. For this progress report, we will use the length 2.5 percentile results (length exceeded by only 2.5% of the fibers, by number) to illustrate the observed length reduction potentials of the five varieties we tested. Because the results we have so far are for one single year, and because valid conclusions about varieties can only be drawn if observations are made over multiple crop seasons, we will not identify the varieties in the following discussion. Only codes (variety 1...5) will be provided.

Figure 19 depicts the length reduction curves of the five varieties (one variety per graph). The two plots on each graph represent the two gin lint-cleaning levels we considered (0 and 2, see legends).

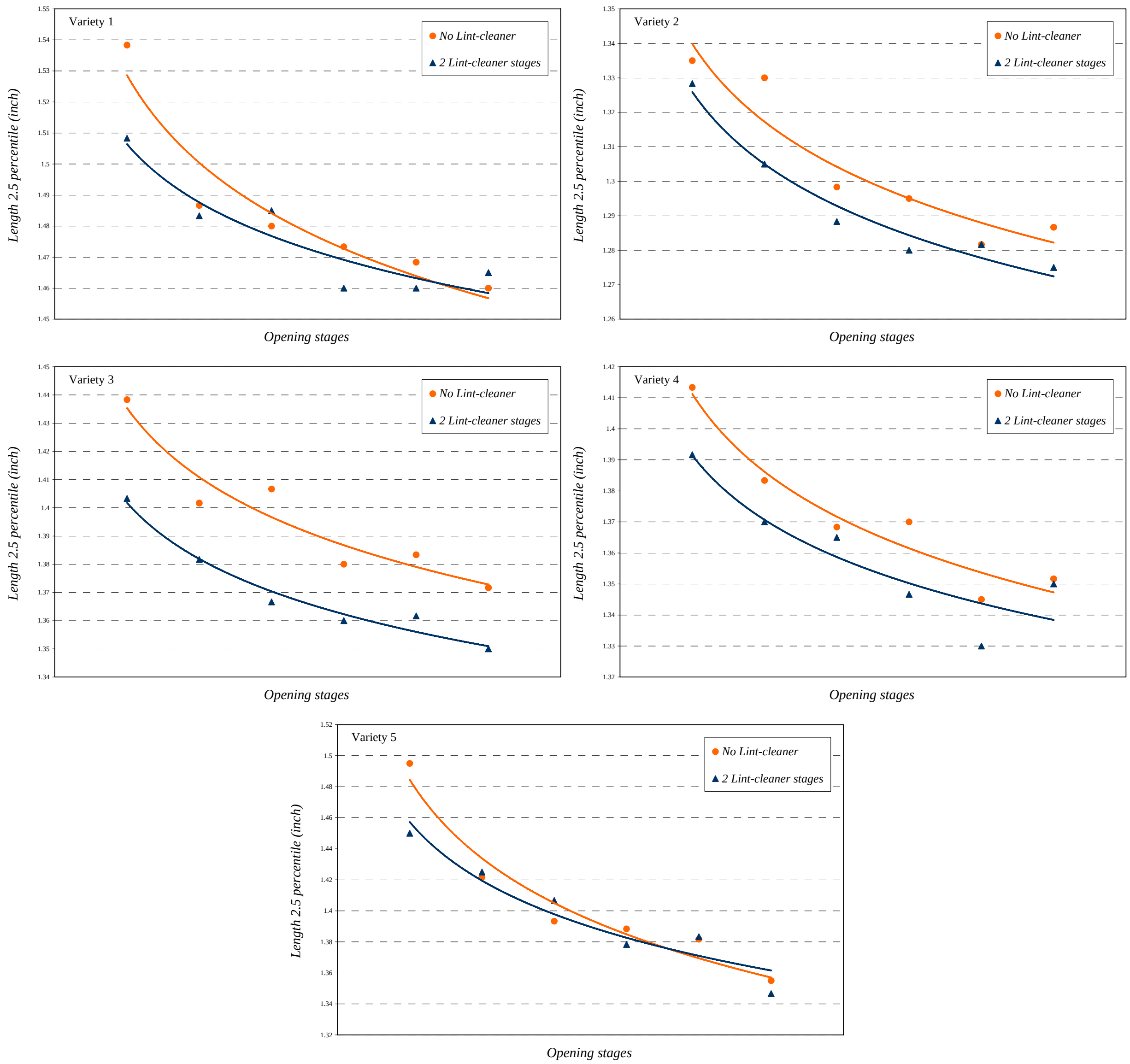

Figure 19: Length reduction behavior of the five varieties with 2 ginning treatments.

Results depicted in Figure 19 show essentially two distinct behaviors among the five tested bales. All varieties appear to be shortened by the application of the two lint cleaning passages, when examining the data before application of the successive opening stages (i.e., data points at the left end of the abscissa axis). A group of three varieties (2, 3, and 4) exhibit length reduction curves that are essentially parallel. The other two varieties (1 and 5) show length reduction curves that appear to converge towards each other after the successive opening stages.

These pattern suggests that lint cleaning treatments did not affect the fibers' length reduction potential or propensity to break, i.e., the fibers were not more sensitive to breakage phenomena because of the lint cleaning. However, differences between varieties are apparent. In particular, varieties 1 and 5 appear to converge towards a given degree of damage and thus a given length independently from the lint cleaning treatments at the gin (i.e., independently from the damage done upstream), while the length observed on the other three varieties (2, 3, and 4) remains dependent on the lint cleaning treatment even after advanced opening stages are performed on the ginned lint. These results suggest that, from a fiber length stand point, processing history is critical for the latter 3 varieties (2, 3, and 4) while it may not be as critical for varieties 1 and 5.

Figure 20 and Figure 21 show the curves for the five varieties regrouped in one graph for each ginning treatment, i.e., no lint cleaner and 2 lint cleaning passages, respectively. It is interesting to note on these figures, that ranking of the varieties with respect to length changes depending on the opening stage at which the samples are observed. This effect is especially clear in Figure 20, i.e., for the samples obtained with no lint cleaner. For those processed through two lint cleaning passages (Figure 21), a similar interaction exists but appears to impact the differences in length among varieties without changing their ranking.

Again, valid conclusions about the varieties can only be drawn if tests are conducted over several growing seasons. Therefore, the observations presented here remain preliminary and will be further scrutinized in the coming seasons. However, results obtained at the current stage of the research showed a sizeable degree of variability in the stress-damage curve among the five varieties we tested but did not show an increase in the fiber's propensity to break due to increased lint cleaning. This suggests that length reduction potential or propensity to break may be mainly related to cotton variety and does not appear to be significantly affected by gin processing history.

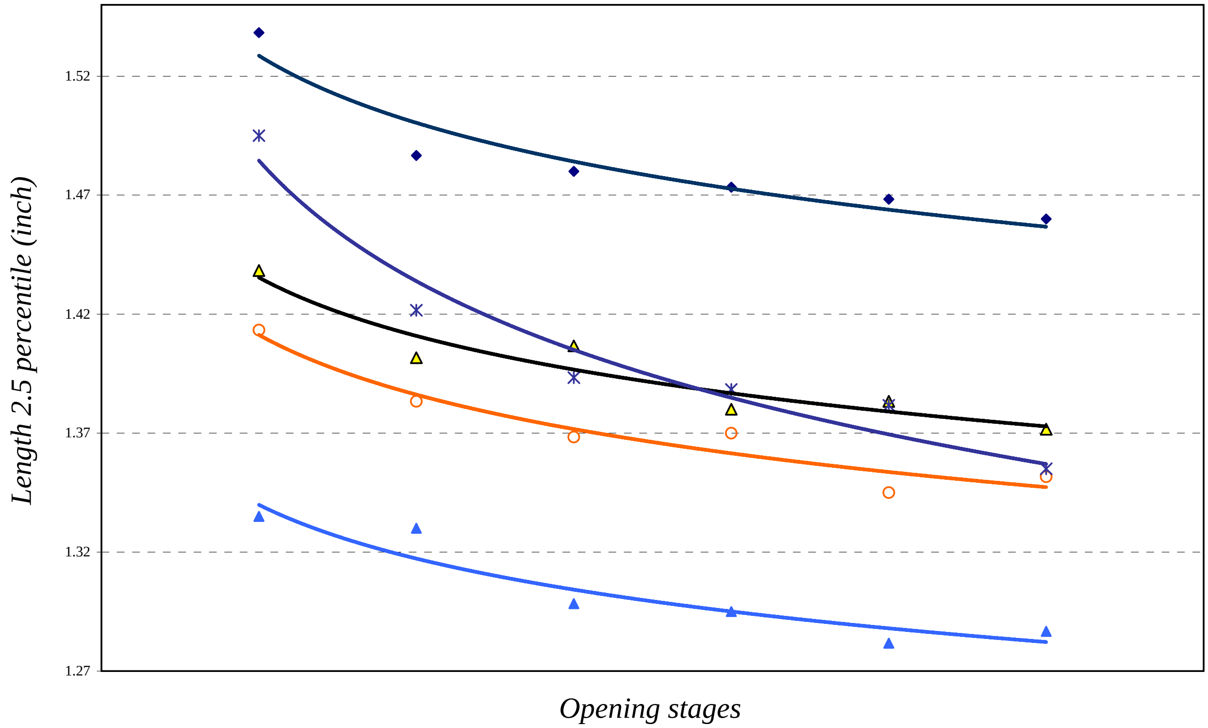

Figure 20: Length reduction behavior of the 5 varieties tested in 2006 – fiber with no lint cleaner.

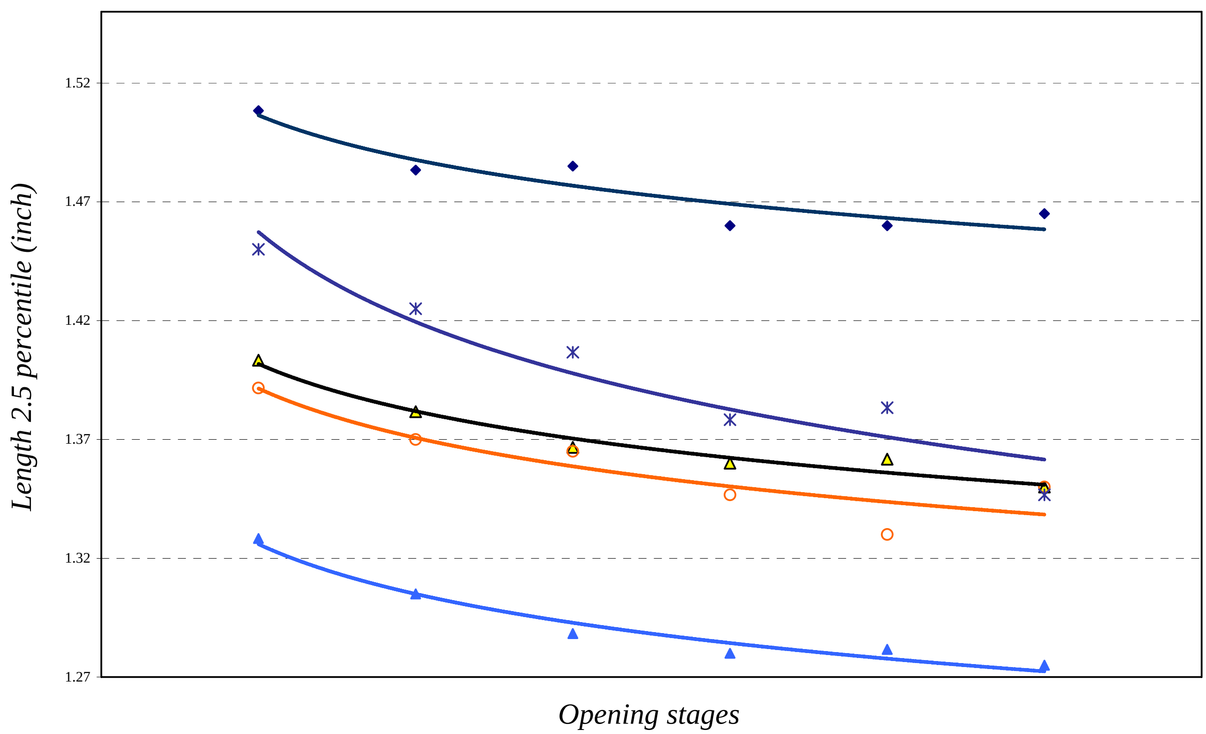

Figure 21: Length reduction behavior of the 5 varieties tested in 2006 – fiber with 2 lint-cleaner passages.

5. SUMMARY - CONCLUSIONS

Ginning and spinning preparation trials were conducted on five cotton varieties grown and stripper-harvested in Lubbock in 2005. Ginning treatments consisted of different numbers of lint cleaning stages. Fiber samples were collected throughout ginning and spinning preparation processes and were tested on AFIS for dust and trash particles, and neps (among other fiber properties). The dust abrasiveness was evaluated based on silica content chemical determination. Length reduction potential of the varieties was also evaluated using repetitive opening actions (on a laboratory opener/blender) and AFIS® measurement of fiber length distribution parameters.

Results indicated that the positive effects of lint cleaning, i.e., dust and trash removal, were neutralized by the cleaning done at the spinning mill and thus cottons having been submitted to different lint cleaning treatments at the gin did not show significant differences in dust and trash contamination after spinning preparation. Furthermore, lint cleaning did not appear to affect the amount of silica in the residual dust collected in rotor spinning.

On the other hand, cottons that had more neps as a result of more intensive lint cleaning remained more “neppy” after opening-cleaning and carding in the spinning mill. These results, if confirmed, would suggest that with the ever improving cleaning efficiency achievable with blowroom cleaners and modern cards, the benefit of extensive cleaning done at the gin may be questionable when viewed from the spinner’s perspective.

Results pertinent to fiber length reduction potential suggest cotton variety as the main influencing factor. Lint cleaning did not increase the fiber’s propensity to break for the current range of samples.

Research is continuing to further examine the quality criteria described in this report and to include other critical fiber properties that are affected by cleaning treatments both in the gin and in the textile mill. Economic factors relating to these cotton-process interactions are also being investigated.

6. LITERATURE CITED

Krifa, M., 2004. Characterizing Fiber-Machine Interactions in Cotton Processing. in Annual Progress Report to the TFFC, International Textile Center - Texas Tech University. Lubbock, TX. 73-79.

Krifa, M. and Hequet E., 2005. Experimental Assessment of Cotton Fiber Behavior During Opening and Cleaning. Proceedings of the Beltwide Cotton Conferences – Cotton Utilization / Textile Technology Symposium, January 4-7, New Orleans, LA, National Cotton Council of America. Memphis, TN, USA, pp. 2713-2716.

ANNEX

An extract of this report was presented at the 2007 Beltwide Cotton Conferences. The manuscript to appear in the proceedings is annexed hereafter.

IMPACTS OF GINNING TREATMENTS ON SPINNING PREPARATION

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Abstract

Throughout the production and manufacturing chain, cotton fibers undergo a succession of mechanical processing stages with varying degrees of aggressiveness. Some of the processes that are most decisive to the cotton's ultimate use-value and processing performance start at the gin and continue throughout spinning preparation. These are usually aimed at opening and cleaning the fiber, but they can also result in fiber damage and in entanglements of fibers or neps. This research explores both ginning and spinning preparation and examines critical interactions affecting these processes. Five cotton varieties were grown and stripper-harvested in 2005 to provide the seed-cotton samples for these trials. Ginning was done at the USDA-ARS gin lab in Lubbock with different cleaning intensities. Ginned lint was then processed through spinning preparation at the International Textile Center. Trash and dust particles, along with neps and fiber length, were quantified using the AFIS at alternative stages of the process. This paper summarizes results form the first season of the study, with a focus on the interactions among ginning and spinning preparation processes affecting cleaning efficiency and neppiness.

Introduction

Cleaning the cotton, whether in the gin or the textile mill, usually involves aggressive mechanical processes, which deteriorate its length properties and increase its nep content. The close relationship between these critical quality criteria, (i.e., cleanness, neppiness, and length properties) can be traced back to the field and to harvesting practices. For instance, stripper-harvested cotton contains more impurities and therefore requires more cleaning at the gin. The cleaning to which the cotton is submitted in the gin is typically viewed as beneficial to the producer because it improves the classer's grade and thus increases the market value of the cotton (due to the premiums associated with cleanness).

However, because of the aforementioned interactions, such cleaning in the gin may also alter fiber length distribution and affect the cotton's nepping potential. These two aspects are not currently taken into account by the classing and marketing system; nonetheless, from the spinner's perspective, they represent critical factors that determine the use-value of the cotton. The spinner's quality concerns are fundamentally determined by the way these fibers perform during processing; thus by the properties that are achievable from the cotton after spinning preparation.

This research uses quality characteristics measured on the fiber both during and after spinning preparation, in order to evaluate performance at the gin and the spinning mill. In the present report, the focus is on the interactions among ginning and spinning preparation processes affecting cleaning efficiency and neppiness. Described here are results for one single crop-season (2005). Trials are continuing in order to conduct a multi-season study with a comprehensive analysis of the fiber-machine interactions, both in the gin and the spinning mill.

Methods

Five varieties were selected and grown in 2005 to provide the seed-cotton samples for these trials. The cotton was grown and stripper-harvested in the USDA-ARS facilities in Lubbock. Upon harvest, the seed cotton was put though the ginning process at the USDA Gin Lab in Lubbock. Four treatment combinations were applied at the gin (no lint cleaner, 1, 2 and 3 lint cleaners) and samples were collected at the following locations:

- seed cotton,
- ginned lint before lint cleaner,
- ginned lint after 1st lint cleaner,
- ginned lint after 2nd lint cleaner,
- ginned lint after 3rd lint cleaner,

Approximately 100 lbs of lint was obtained for each treatment combination. Representative fiber samples were collected from each lot and tested on HVI (see Table I). The lint was submitted to spinning preparation processes as outlined in Figure 1. Fiber samples, as well as all processing waste, were collected at alternative stages along the spinning preparation process (Figure 1). The waste was quantified and all fiber samples were tested on Uster® AFIS® to measure individual fiber properties along with neps, trash and dust content.

Results

Table I summarizes HVI results obtained on bale samples from all variety*ginning treatment combinations. Micronaire values averaged 3.6 and ranged from 3.1 to 4.0, with two of the varieties (numbered 3 and 4) showing rather low Micronaire levels. Staple length values averaged 1.11" and ranged from 1.02" to 1.21". Variation in staple length appears mainly related to varieties. However, a clear lint cleaning effect, consisting of an expected reduction in UHML values within the same variety, is apparent from the data in the table. Lint cleaning is also associated to a decrease in length uniformity and an improvement in leaf grade.

As previously stated, these effects are expected and the improvement of the bales' grade constitutes the very essence of lint cleaning. Our focus is now placed on the impacts these effects have on spinning preparation as determined by the analysis of the fiber samples collected throughout the process and tested on AFIS (see Figure 1).

Figure 2 shows the variation of trash content (AFIS count/g) under the combined effects of gin and textile mill treatments. The effects of processing treatments, both at the gin and spinning mill, on trash content are highly significant. There is a clear decrease in trash particle counts with increased lint cleaning at the gin and as the fiber progresses through the spinning preparation. These effects are of course intended and expected. Of more interest is the apparent interaction between ginning treatments and spinning preparation processes. For instance, the difference in trash content between cottons processed through an increasing number of lint cleaners is highly significant when considering raw cotton (bale samples), but diminishes quickly during spinning preparation. After carding (the last significant cleaning step in most spinning operations), all lint cleaning treatments performed at the gin show virtually no difference in trash content as detected by AFIS (particles/g).

A more detailed representation of these results is shown in Figure 3, which depicts scatter plots relating trash contents of the lint samples in the bales on one hand and after opening-cleaning and carding on the other hand. Figure 3 shows the shift of the scatter plots from the equality line (x=y) after each spinning preparation stage. It appears from these results that the two blowroom opener/cleaners significantly reduce the number of trash particles detected in the lint using the AFIS. However, the extent to which trash particles are reduced appears relatively higher for samples that were initially ranked with the highest trash contents. The scatter plots remain in the vicinity of the equality line in the range of low trash contents and stray from it in the range of high trash contents (the samples initially ranked as the cleanest show virtually no change in trash content after opening-cleaning). Despite the sizeable cleaning effect observed on both graphs (Figure 2 and Figure 3), the relationship between trash content in the bale and after each opener-cleaner appears significant, which indicates that cottons having higher trash particle counts in the bale remained the most contaminated after blowroom operations (and vice versa).

Observation of the third scatter plot of Figure 3, representing the effect of carding on trash particle counts, reveals a distinctly different pattern. The scatter plot corresponding to the carding effect not only significantly strays from the equality line, but also exhibits a virtually flat pattern with no perceptible variation in the number of trash particles after carding. This pattern suggests that, as a result of the cleaning efficiency achieved in the blowroom and mainly at the card, the cleanness of the cotton entering the spinning preparation chain did not affect that of the card sliver. This also suggests that cleaning done upstream, i.e., in the gin, did not affect the cleanness of the cotton after spinning preparation (again, based on AFIS count of trash particles). Figure 4 is an illustration of the latter statement; it shows the scatter plot described above on a different y-axis scale and with distinct point markers for the different lint cleaning levels performed in the gin. It is apparent from the graph in Figure 4 that the lint cleaning treatments do not show sizeable differences in the number of trash particles in the carded material (along the y-axis).

Another type of particles detected in the lint and counted using the AFIS is dust. Cleaning of dust particles from the gin to the spinning mill was analyzed analogously to that of trash particles described in the paragraphs above. Results are represented in Figures 5 and 6, which show patterns that are very similar to those observed with trash particles. The conclusions that were put forth based on trash particle counts also apply to dust particle, i.e., cleaning at the gin did not affect the dust content of the fiber obtained after spinning preparation processes.

As noted earlier, cleaning of the cotton also affects other critical quality factors that are of particular importance to the spinner, i.e., length distribution and neps. We now focus on results related to the latter (length distribution issues will be treated in a separate report).

As done for trash and dust particles, we represent the variation of nep counts detected using the AFIS under the combined effects of gin and textile mill cleaning (Figure 7). Here the pattern is different from that observed with trash and dust. Nep counts increase with increased lint cleaning at the gin and as the cotton is processed through blowroom operations, then significantly decrease after carding. The difference between nep contents of cottons having been submitted to different numbers of lint cleaning stages also varies with further processing of the fiber, increasing in the blowroom then significantly decreasing after carding.

Figure 8 shows scatter plots relating nep counts in the bales to those obtained after opening-cleaning and carding. The effects described above are again apparent from the scatter plots. The increase in nep counts in the blowroom appears mainly due to the effect of the fine opener/cleaner (which puts the fiber under more aggressive mechanical stresses than those of the coarse cleaner). Here too, the scatter plot representing the cumulated effect (including carding) shows little variation of the number of neps in card slivers. However, examination of this plot on a different scale and with distinct point markers for the different lint cleaning treatments (Figure 9) shows a significant relationship between nep counts obtained in bale samples and those detected in carded fiber. This indicates that, unlike trash and dust contamination, cottons that had more neps in the bales entering the spinning mill were those exhibiting the highest numbers of neps after spinning preparation (and vice versa). This also suggests that neps created by intensive cleaning at the gin may affect the cottons' neppinness even after opening-cleaning and carding (i.e., spinning preparation did not neutralize lint cleaning effects on neppiness as it did for dust and trash).

In summary, it appears from these results that the intended positive effects of lint cleaning in the gin (reduction of dust and trash particles) did not survive spinning preparation and were neutralized by the cleaning efficiency of the blowroom cleaners and the card (based on AFIS counts). On the other hand, one of the negative effects typically associated with intensive cleaning at the gin (i.e., increased neppiness) remained detectable even after spinning preparation. Further analysis is currently being conducted both to confirm the results described above and to examine other critical quality issues related to length reduction and length distribution alteration, as well as to other contaminants found in the cotton (seed coat fragments).

Conclusion

Ginning and spinning preparation trials were conducted on five cotton varieties grown and stripper-harvested in Lubbock in 2005. Ginning treatments consisted of different numbers of lint cleaning stages. Fiber samples were collected throughout ginning and spinning preparation processes and were tested on AFIS for dust and trash particles, and neps (among other fiber properties).

Results indicated that the positive effects of lint cleaning, i.e., dust and trash removal, were neutralized by the cleaning done at the spinning mill and thus cottons having been submitted to different lint cleaning treatments at the gin did not show significant differences in dust and trash contamination after spinning preparation. On the other hand, cottons that had more neps as a result of more intensive lint cleaning remained more "neppy" after opening-cleaning and carding in the spinning mill. These results, if confirmed, would suggest that with the ever improving cleaning efficiency achievable with blowroom cleaners and modern cards, the benefit of cleaning done at the gin may be questionable when viewed from the spinner's perspective.

Research is continuing to further examine the quality criteria described in this report and to include other critical fiber properties that are affected by cleaning treatments both in the gin and in the textile mill, as well as economic factors.

Acknowledgement

This research is supported by the Texas State Support Committee, Cotton Inc.

Table I: HVI data

Lot No	Variety	Treatment	Micronaire	Length: UHML (inch)	Uniformity (%)	Strength (g/tex)	Elongation (%)	Rd	+b	Leaf
1	1	No LC[♣]	3.8	1.21	82.9	32.1	6.6	72.6	9.0	4
2	1	1LC	3.7	1.20	81.6	31.8	6.4	75.7	9.4	2
3	1	2LC	3.7	1.16	80.8	31.6	6.3	76.6	9.5	1
4	1	3LC	3.7	1.17	81.2	31.6	6.4	77.3	9.6	1
5	2	No LC	4.0	1.15	81.6	27.0	6.3	73.0	9.0	3
6	2	1LC	3.9	1.11	80.9	27.2	6.2	75.5	9.4	2
7	2	2LC	3.9	1.10	79.9	27.9	6.0	77.0	9.6	1
8	2	3LC	3.9	1.10	80.1	27.3	6.4	77.3	9.6	1
9	3	No LC	3.4	1.12	81.8	27.5	6.5	74.0	9.0	3
10	3	1LC	3.5	1.10	81.6	27.3	6.5	75.9	9.6	1
11	3	2LC	3.4	1.08	80.9	27.3	6.4	77.0	9.6	1
12	3	3LC	3.4	1.08	80.3	27.3	6.5	77.9	9.6	1
13	4	No LC	3.2	1.15	79.9	29.8	4.8	75.0	8.2	4
14	4	1LC	3.1	1.13	79.6	29.6	4.9	78.0	8.5	3
15	4	2LC	3.1	1.13	80.1	30.6	5.2	78.1	8.8	2
16	4	3LC	3.1	1.11	78.5	31.0	4.8	78.9	9.0	1
17	5	No LC	4.0	1.05	82.6	29.5	6.8	71.1	8.5	5
18	5	1LC	3.8	1.03	81.8	28.8	6.6	74.7	9.1	3
19	5	2LC	3.7	1.02	81.3	28.4	6.6	76.2	9.5	3
20	5	3LC	3.8	1.02	81.6	29.0	6.9	76.3	9.4	2

[♣] LC: Lint cleaner

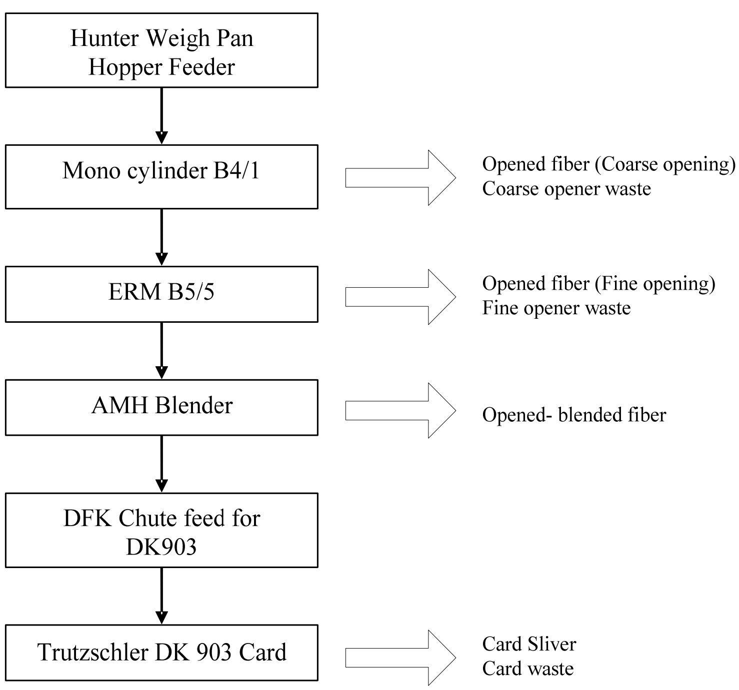

Figure 1: Outline of the spinning preparation process.

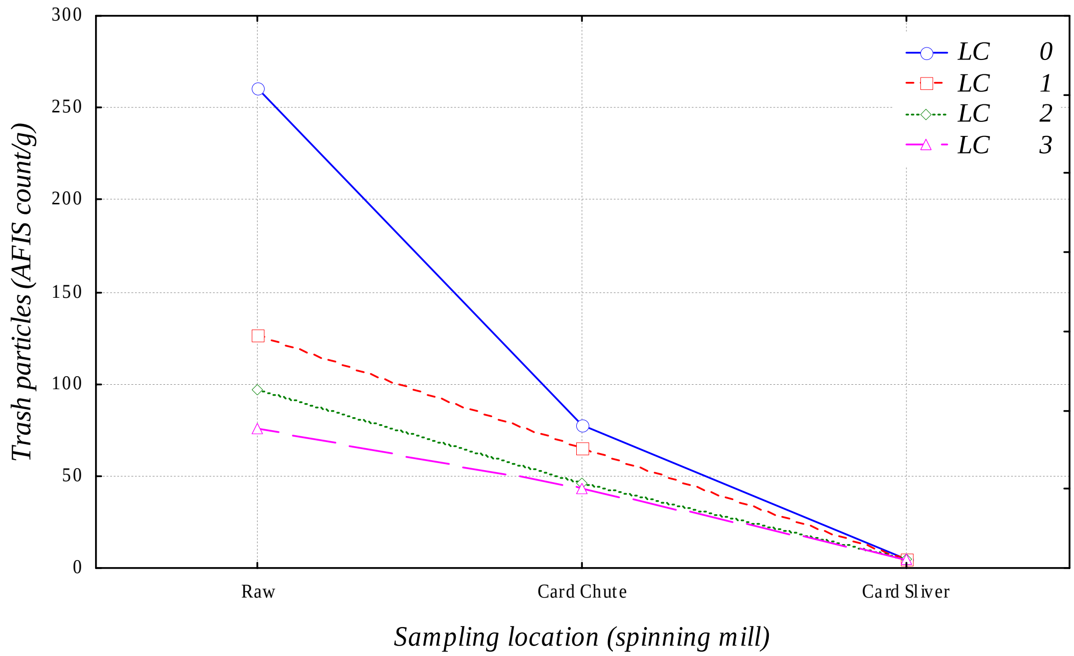

Figure 2: AFIS trash particles count as affected by the interaction among ginning treatments and spinning preparation processes (LC = number of lint cleaners).

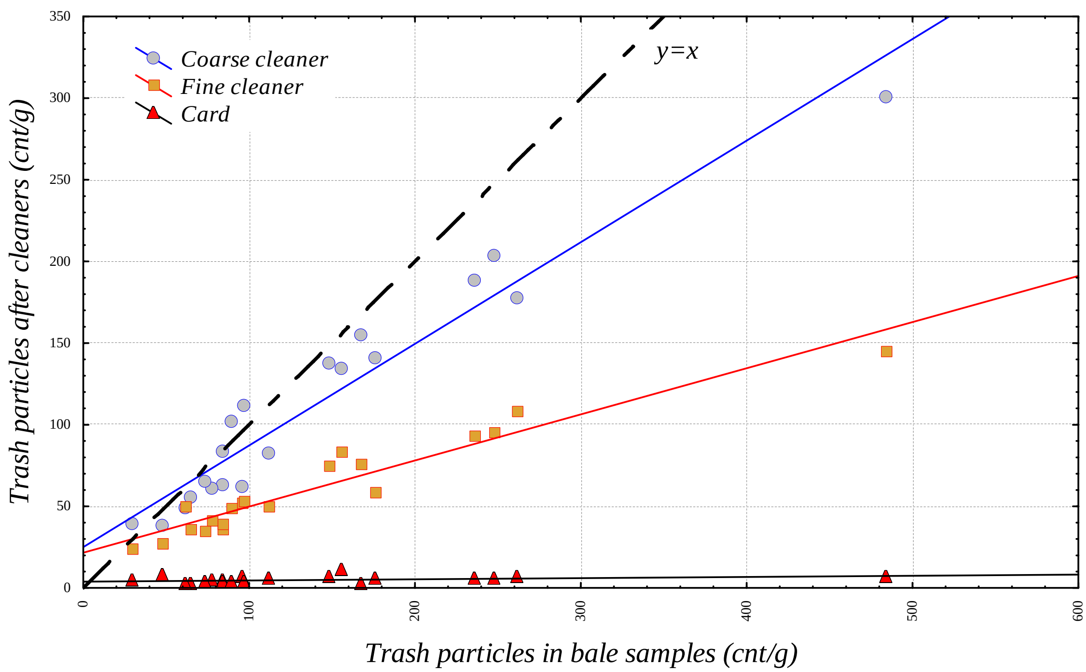

Figure 3: Relationship between trash content in bale samples and at alternative stages of spinning preparation.

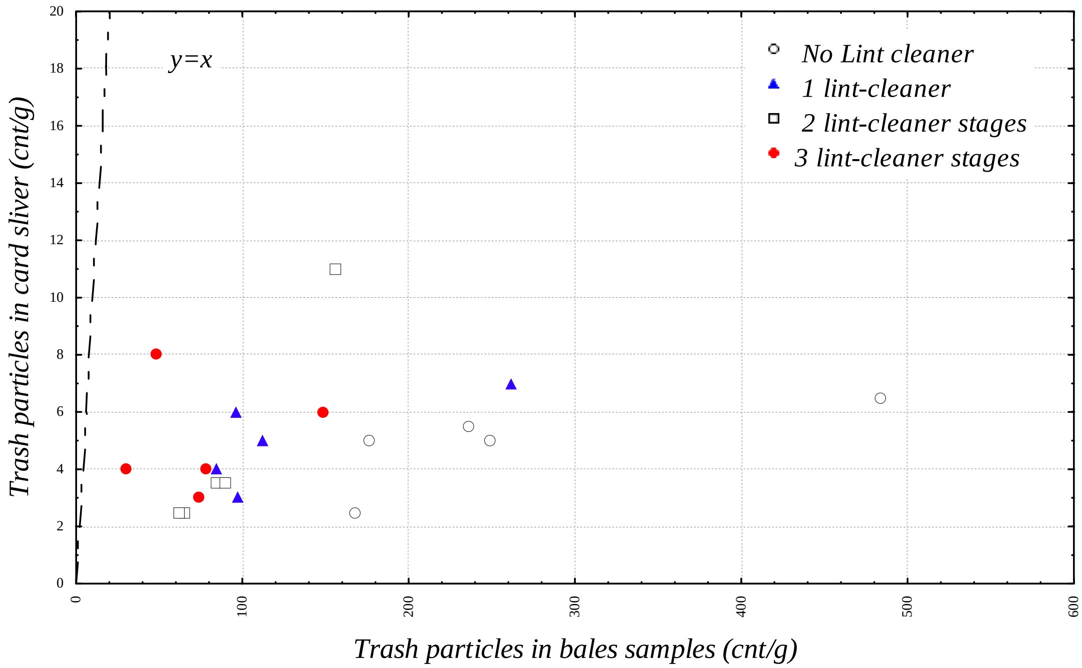

Figure 4: Relationship between trash content in bale samples and in card sliver.

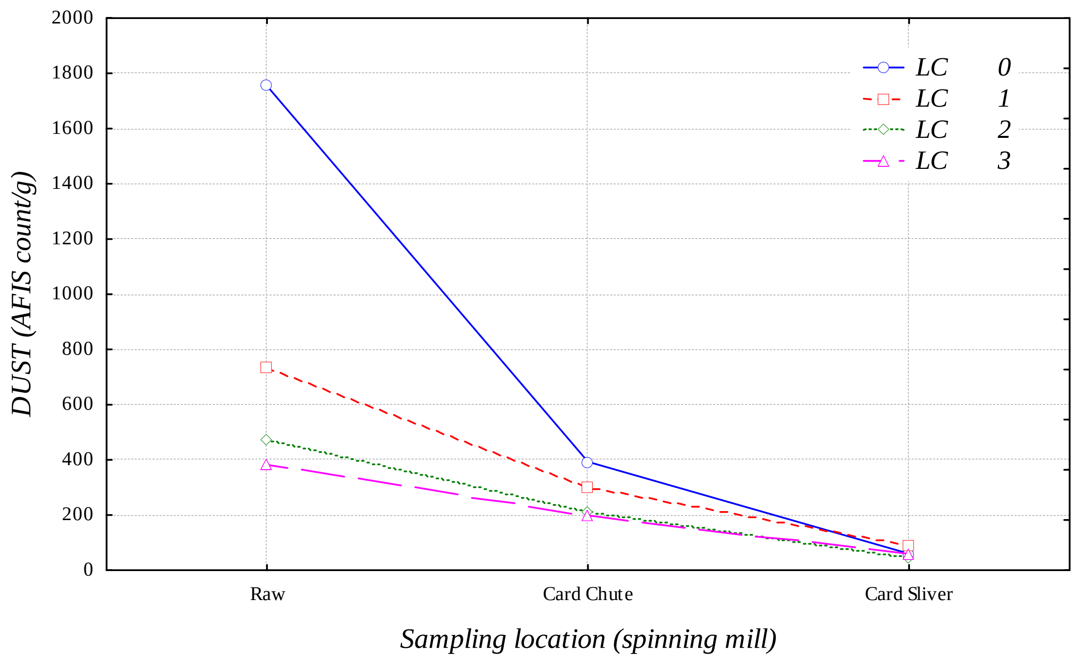

Figure 5: AFIS dust particles count as affected by the interaction among ginning treatments and spinning preparation processes (LC = number of lint cleaners).

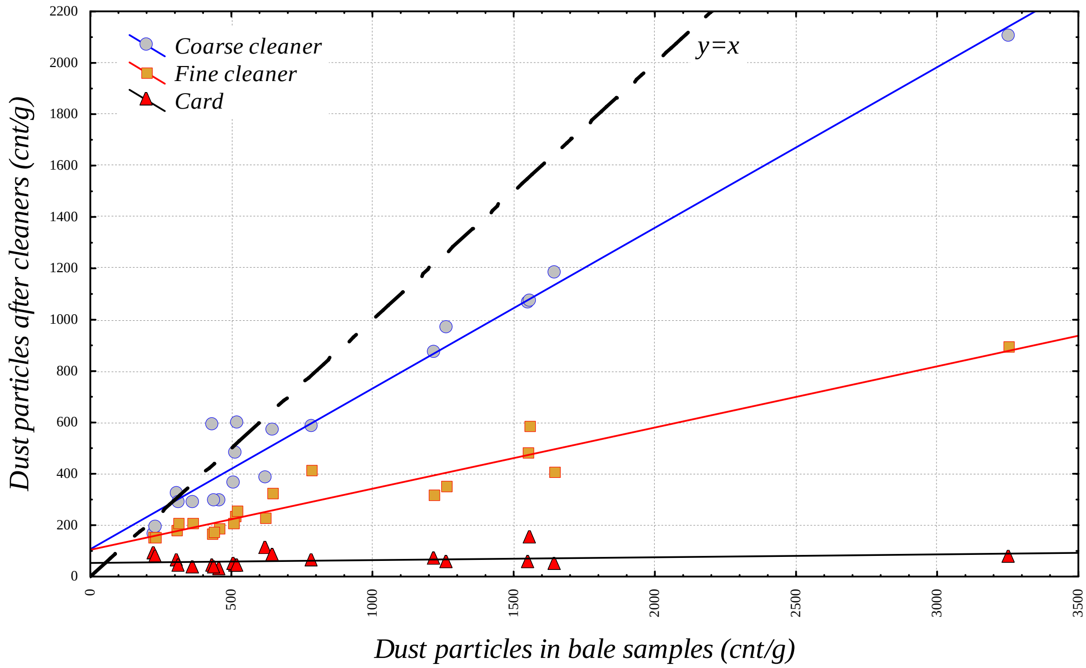

Figure 6: Relationship between dust content in bale samples and at alternative stages of spinning preparation.

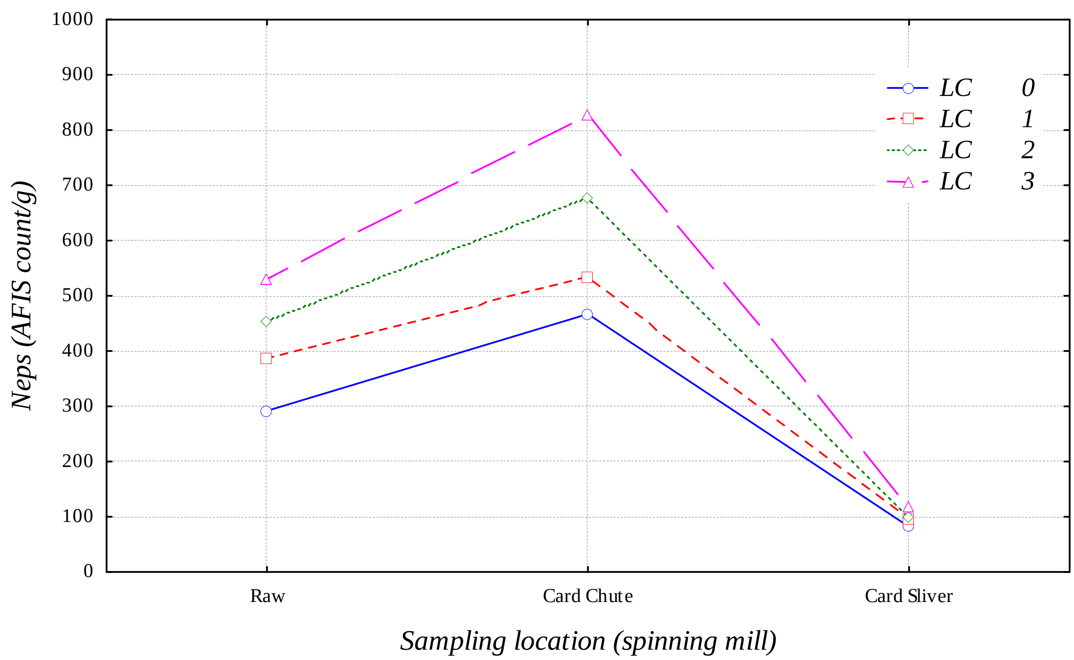

Figure 7: AFIS neps count as affected by the interaction among ginning treatments and spinning preparation processes (LC = number of lint cleaners).

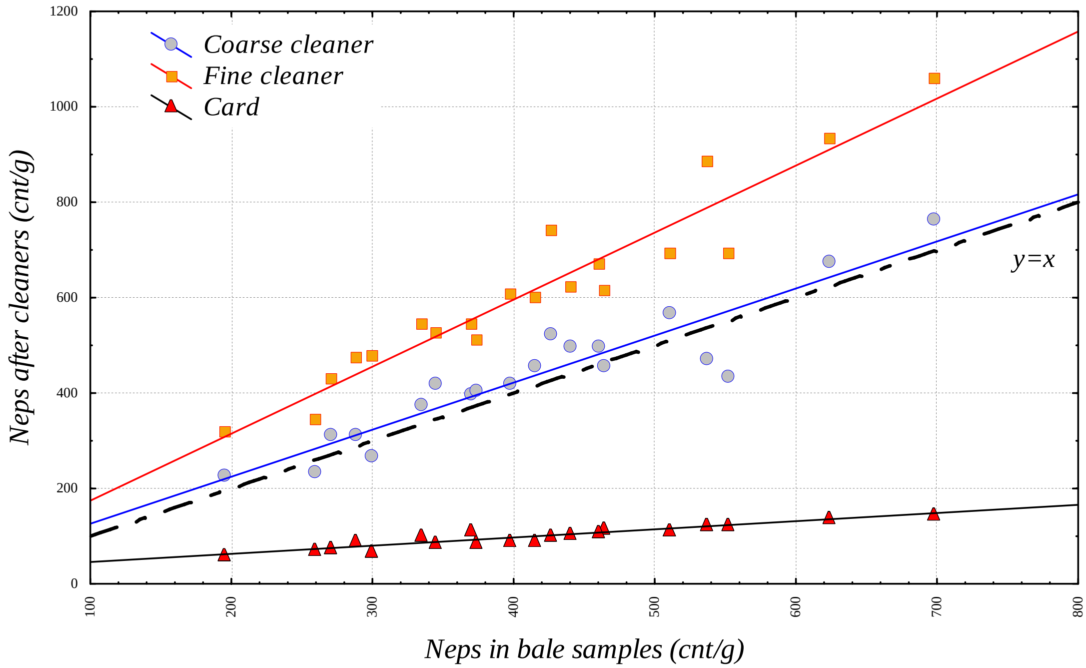

Figure 8: Relationship between neps count in bale samples and at alternative stages of spinning preparation.

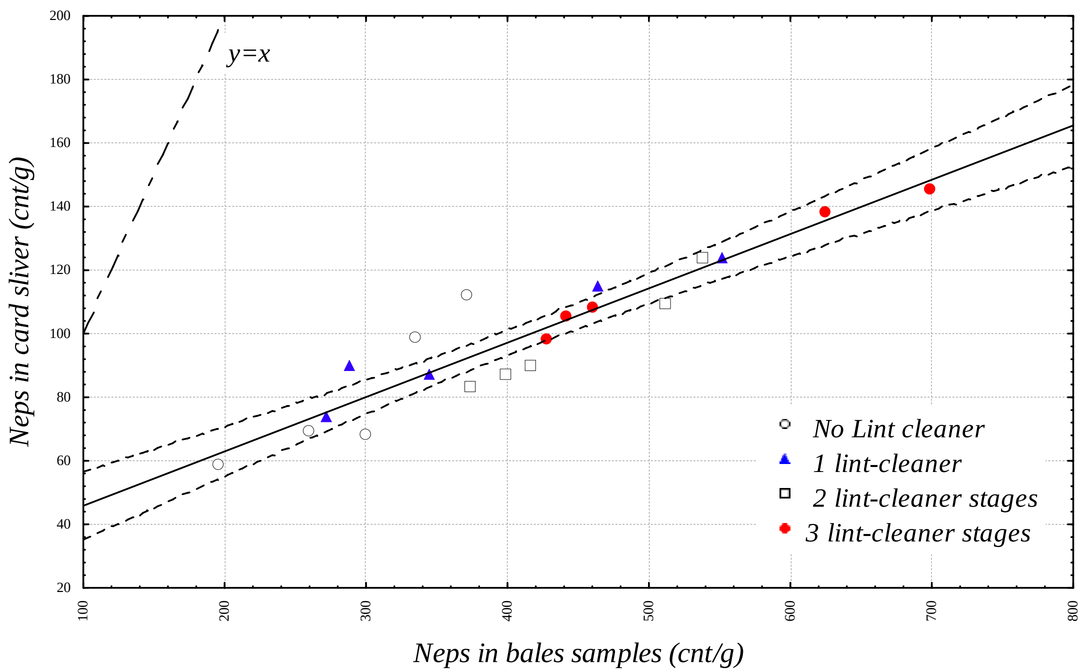

Figure 9: Relationship between neps count in bale samples and in card sliver.